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S7-1500
S7-1500 Automation System

System Manual

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Legal information

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This documentation provides important information on configuring, installing, wiring and commissioning the S7-1500 automation system.

Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Scope of validity of the documentation

This documentation applies to all products from the S7-1500 product family.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to the low pollutant content of their components. For environmentally compliant recycling and disposal of your electronic waste, please contact a company certified for the disposal of electronic waste.

Additional support

- Information about technical support can be found in the appendix to this documentation.
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide 1

Introduction

The documentation of the SIMATIC products has a modular structure and covers a range of topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of documentation for the S7-1500 automation system

The following tables list the documentation for the S7-1500 automation system.

Table 1- 1 System manual for the S7-1500 product family

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning • Maintenance

Table 1- 2 Function manuals for the S7-1500 product family

Topic	Documentation	Most important contents
Analog value processing	Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559)	• Basics of analog technology • Description / explanation of key topics, such as conversion and cycle time, basic and operational error limits, temperature sensors, connection of sensors in 2-, 3- and 4-conductor technology.
Memory concept	Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101)	• Structure • Application
System diagnostics	System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation

Topic	Documentation	Most important contents
Standard Motion Control	S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279)	• Basics • Configuring
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Basics of communication
	PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579)	• Basics of PROFIBUS • PROFIBUS functions • PROFIBUS diagnostics
	PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)	• Basics of PROFINET • PROFINET functions • PROFINET diagnostics
	Communications module PtP - Configurations for point-to-point links (http://support.automation.siemens.com/WW/view/en/59057093)	• Basics • Functions • Operation
	Web server (http://support.automation.siemens.com/WW/view/en/59193560)	
Counting and measuring	Counting and measuring (http://support.automation.siemens.com/WW/view/en/59709820)	• Counting and measuring basics
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Cycle and reaction times	Cycle and reaction times (http://support.automation.siemens.com/WW/view/en/59193558)	• Basics • Calculations

Table 1- 3 Manuals for the S7-1500 product family

Topic	Documentation	Most important contents
CPU	CPU 1511-1 PN (http://support.automation.siemens.com/WW/view/en/59402190)	• Block diagram • Wiring • Parameter assignment/addressing • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawings
	CPU 1513-1 PN (http://support.automation.siemens.com/WW/view/en/59186494)	
	CPU 1516-3 PN/DP (http://support.automation.siemens.com/WW/view/en/59191914)	

Topic	Documentation	Most important contents
Digital modules	DQ 32x24VDC/0.5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193400)	
	DQ 16x24VDC/0.5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193401)	
	DQ 8x230VAC/2A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193088)	
	DQ 8x230VAC/5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59192915)	
	DQ 8x24VDC/2A HF digital output module (http://support.automation.siemens.com/WW/view/en/59193089)	
	DI 16x230VAC BA digital input module (http://support.automation.siemens.com/WW/view/en/59193398)	
	DI 16x24VDC HF digital input module (http://support.automation.siemens.com/WW/view/en/59193001)	
	DI 16x24VDC SRC BA digital input module (http://support.automation.siemens.com/WW/view/en/59191844)	
	DI 32x24VDC HF digital input module (http://support.automation.siemens.com/WW/view/en/59192896)	
Analog modules	AQ 8xU/I HS analog output module (http://support.automation.siemens.com/WW/view/en/59193551)	
	AQ 4xU/I ST analog output module (http://support.automation.siemens.com/WW/view/en/59191850)	
	AI 8xU/I HS analog input module (http://support.automation.siemens.com/WW/view/en/59193206)	
	AI 8xU/I/RTD/TC ST analog input module (http://support.automation.siemens.com/WW/view/en/59193205)	

Topic	Documentation	Most important contents
Communication modules	CM PtP RS232 BA communication module (http://support.automation.siemens.com/WW/view/en/59057152)	
	CM PtP RS232 HF communication module (http://support.automation.siemens.com/WW/view/en/59057160)	
	CM PtP RS422/485 BA communication module (http://support.automation.siemens.com/WW/view/en/59057390)	
	CM PtP RS422/485 HF communication module (http://support.automation.siemens.com/WW/view/en/59061372)	
Technology modules	TM Count 2x24V technology module (http://support.automation.siemens.com/WW/view/en/59193105)	
	TM PosInput2 technology module (http://support.automation.siemens.com/WW/view/en/61777657)	
System power supplies	Power supply module PS 25W 24V DC (http://support.automation.siemens.com/WW/view/en/59193552)	
	Power supply module PS 60W 24/48/60V DC (http://support.automation.siemens.com/WW/view/en/59192919)	
	Power supply module PS 60W 120/230V AC/DC (http://support.automation.siemens.com/WW/view/en/59193004)	
Load power supplies	PM1507 72W (24VDC / 3A) (http://support.automation.siemens.com/WW/view/en/64161778)	
	PM1507 192 W (24VDC / 8A) (http://support.automation.siemens.com/WW/view/en/64157606)	

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview 2

2.1 What is the S7-1500 Automation System?

Introduction

The SIMATIC S7-1500 is the further development of the SIMATIC S7-300 and S7-400 automation systems.

Through the integration of numerous new performance features, the S7-1500 automation system offers the user excellent operability and the highest performance.

The new performance features are:

- Increased system performance
- Integrated Motion Control functionality
- PROFINET IO IRT
- Integrated display for machine-oriented operation and diagnostics
- STEP 7 language innovations with retention of proven functions

Field of application

The S7-1500 automation system offers the required flexibility and performance for high bandwidth controller applications in machine and plant design. The scalable configuration allows you to adapt your control system to the specific local requirements.

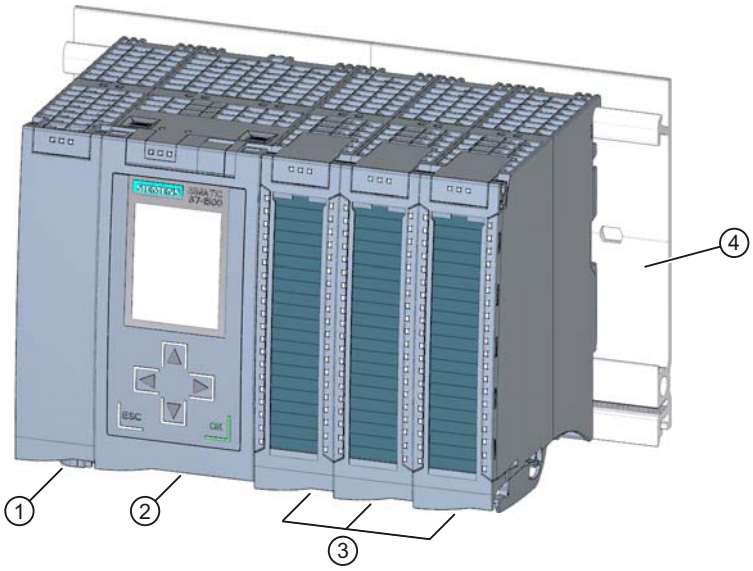
The S7-1500 automation system complies with IP20 degree of protection and is intended for installation in a control cabinet.

Configuration

The S7-1500 automation system is installed on a mounting rail and can comprise up to 32 modules. The modules are connected to each other with U connectors.

Configuration example

The following figure shows a configuration example of an S7-1500 automation system.



① System power supply module
② CPU
③ I/O modules
④ Mounting rail with integrated top-hat rail profile

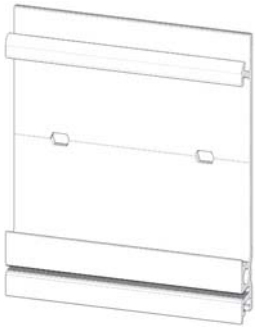
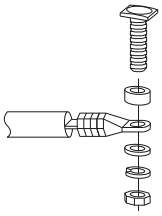
Figure 2-1 Example configuration of an S7-1500 automation system

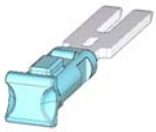
2.2 Components

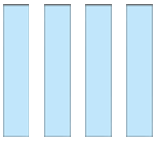
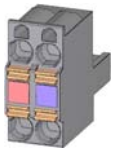
Components of the S7-1500 automation system

The following table provides an overview of the most important components of the S7-1500 automation system:

Table 2- 1 Components of the S7-1500 automation system

Components	Function	Diagram
Mounting rail	The mounting rail is the rack of the S7-1500 automation system. Components according to EN 60715 (modules from the S7-1200 and ET 200SP ranges, terminals, circuit breakers, small contactors or similar components) can be mounted directly on the integrated standard tophat profile in the lower part of the mounting rail. You can use the entire length of the mounting rail in the assembly (marginless assembly). The mounting rails may be ordered as accessories (Page 193).	
PE connection element for mounting rail	The set of screws is threaded into the mounting rail's T-profile groove, and is required for grounding the mounting rail. The set of screws is contained in the scope of delivery of the mounting rails in the standard lengths (160 to 830 mm), and may be ordered as an accessory (Page 193).	
System power supply (PS)	The system power supply is a diagnostics-capable power supply module, that can be connected with the backplane bus using a U connector. A system power supply is required, if the power fed from the CPU into the backplane bus is not sufficient to supply the connected modules with power. System power supplies are available in various models: • PS 25W 24V DC • PS 60W 24/48/60V DC • PS 60W 120/230V AC/DC A power cable connector with coding element and a U connector are included in the scope of delivery of the system power supply, and may be ordered as a spare part (Page 193).	

Components	Function	Diagram
CPU	The CPU executes the user program and uses the integrated system power supply to supply the electronics of the modules via the backplane bus. Further features and functions of the CPU: • Communication via Ethernet • Communication via PROFIBUS/PROFINET • HMI communication • Integrated web server • Integrated technology • Integrated system diagnostics • Integrated security	
I/O module	The I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are classified into the following types of modules: • Digital input (DI) • Digital output (DQ) • Analog input (AI) • Analog output (AQ) • Technology module (TM) • Communication module (CM) • Communication processor (CP) A U connector is included in the scope of delivery for each I/O module.	
U connector	The modules of the S7-1500 automation system are connected using the U connector. The U connector provides the mechanical and electrical connection between the modules. The U connector is included in the scope of delivery of all modules (exception: CPU) and may be ordered as a spare part (Page 193).	
Front connectors	The front connector serves for the wiring of the I/O modules. The front connector for technology and analog modules must be supplemented with a shielding bracket, power supply element, and shielding clamp. These components are included in the scope of delivery of the technology and analog modules, and may be ordered as accessories (Page 193). Four potential bridges and one cable tie are included in the scope of delivery of the front connector.	
Potential bridges for front connector	Two terminals can be bridged with potential bridges. The potential bridges are included in the scope of delivery of the front connector, and may be ordered as a spare part (Page 193).	

Components	Function	Diagram
Shielding bracket	The shielding bracket is an insertable bracket for modules with EMC-critical signals (e.g., analog modules, technology modules), and (together with the shielding clamp) permits the low impedance application of shielding with minimal installation times. The shielding bracket is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 193).	
Shield clamp	The shield clamps are used to attach cable shielding to the shielding bracket. The shield clamp is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 193).	
Power supply element	The power supply element is inserted in the front cable connector, and serves to supply power to modules with EMC-critical signals (analog modules, technology modules). The power supply element (connection technology: screw terminal) is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 193).	
Labeling strips for the exterior of the front cover of the I/O modules	Labeling strips can be inserted for the system-specific labeling of modules. The labeling strips can be printed, and are available in various colors. The labeling strips are included in the scope of delivery of the I/O modules. Additional labeling strips may be ordered as Accessories (Page 193).	
4-pole connection plug for supply voltage of the CPU	In the delivery condition of each CPU a 4-pole connection plug is plugged on the CPU.	
Load current supply (PM)	A load current supply supplies the S7-1500 automation system through a front connector of the CPU. A load current supply does not occupy a slot in the configuration and is not included in the system diagnostics. If you are using load current supplies, we recommend the devices from our SIMATIC series. These devices can be mounted on the mounting rail. The load current supply can be planned using STEP 7. Load current supplies are available in various models: • PM 70W 120/230V AC • PM 190W 120/230V AC	

2.3 Properties

Introduction

The most important properties of the S7-1500 automation system are described in the following tables.

Properties of the configuration

Table 2- 2 Properties of the configuration

Properties of the configuration	Explanation
Scalable configuration	• Space-saving because modules can be installed in any order • Configuration over the entire length of the mounting rail (marginless assembly possible) • Significant reduction of configuration and documentation effort
Wide range of modules	• Universal and flexible area of application
Configuration with U connectors	• Fast and simple connection of the modules • Simple extension of the system configuration
Realization of power segments	• Simple system extension by the insertion of additional system power supplies

Properties of the connection technology

Table 2- 3 Properties of the connection technology

Properties of the connection technology	Explanation
Twistable front connector	• Rapid module exchange during maintenance (cable duct remains closed)
Pre-wiring position	• More user-friendly, because the module wiring is easily accessible • No loosening of the wiring when replacing a module • No electrical damage to the module is possible, because it is not yet electrically connected
Development of a potential group by the insertion of potential bridges	• Reduced wiring effort on the front cable connector
Integrated EMC concept (power supply element, shielding bracket, and terminal element)	• Reduction of the interference emission and optimization of the interference immunity
Consistent 40-pin front connector for all modules, with a width of 35 mm	• Simplified ordering
Two snap-in positions of the front cover	• Flexible cable storage space
Automatic coding of the I/O modules and front cable connectors	• Safe replacement of modules
Large label	• Sufficient space for clear identification and user-specific labeling, e.g. symbolic addresses

Module overview 3

The following tables summarize the essential properties of the available modules. This overview should make it easier for you to select the module that is suited to your task.

3.1 Central processing units

Overview of properties

The table below shows the essential properties of the central processing units (CPUs).

Table 3- 1 Central processing units

Order no.:	6ES7511-1AK00-0AB0	6ES7513-1AL00-0AB0	6ES7516-3AN00-0AB0
Short description	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Supply voltage, permissible range	20.4 VDC to 28.8 VDC	20.4 VDC to 28.8 VDC	20.4 VDC to 28.8 VDC
Number of blocks	2000	2000	6000
Data work memory	1 MB	1.5 MB	5 MB
Code work memory	150 KB	300 KB	1 MB
Interfaces	1 x PROFINET	1 x PROFINET	2 x PROFINET 1 x PROFIBUS
Number of PROFINET ports	2	2	3
Web server supported	Yes	Yes	Yes
Isochronous operation supported	Yes	Yes	Yes

Reference

Further information on the technical specifications of the CPUs may be found in the respective manuals.

3.2 Digital input modules

Overview of properties

The table below shows the essential properties of the digital input modules.

Table 3- 2 Digital input modules

Order no.:	6ES7521-1BH00-0AB0	6ES7521-1BL00-0AB0	6ES7521-1BH50-0AA0	6ES7521-1FH00-0AA0
Short description	DI 16x24VDC HF	DI 32x24VDC HF	DI 16x24VDC SRC BA	DI 16x230VAC BA
Number of inputs	16	32	16	16
Electrical isolation between channels	No	Yes	No	Yes
Number of potential groups	1	2	1	4
Rated input voltage	24 VDC	24 VDC	24 VDC	120/230 VAC
Diagnostic error interrupt	Yes	Yes	No	No
Hardware interrupt	Yes	Yes	No	No
Isochronous operation supported	Yes	Yes	No	No
Input delay	0.05 ms to 20 ms	0.05 ms to 20 ms	3 ms	25 ms

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.3 Digital output modules

Overview of properties

The table below shows the essential properties of the digital output modules.

Table 3- 3 Digital output modules

Order no.:	6ES7522-1BH00-0AB0	6ES7522-1BL00-0AB0	6ES7522-1BF00-0AB0
Short description	DQ 16x24VDC/0.5A ST	DQ 32x24VDC/0.5A ST	DQ 8x24VDC/2A HF
Number of outputs	16	32	8
Type	Transistor	Transistor	Transistor
Electrical isolation between channels	Yes	Yes	Yes
Number of potential groups	2	4	2
Rated output voltage	24 VDC	24 VDC	24 VDC
Rated output current	0.5 A	0.5 A	2 A
Diagnostic error interrupt	Yes	Yes	Yes
Isochronous operation supported	Yes	Yes	No

Table 3- 4 Digital output modules

Order no.:	6ES7522-5HF00-0AB0	6ES7522-5FF00-0AB0
Short description	DQ 8x230VAC/5A ST	DQ 8x230VAC/2A ST
Number of outputs	8	8
Type	Relay	Triac
Electrical isolation between channels	Yes	Yes
Number of potential groups	16	8
Relay coil supply voltage	24 VDC	---
Rated output voltage	230 VAC	230 VAC
Rated output current	5 A	2 A
Diagnostic error interrupt	Yes	No
Isochronous operation supported	No	No

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.4 Analog input modules

Overview of properties

The table below shows the essential properties of the analog input modules.

Table 3- 5 Analog input modules

Order no.:	6ES7531-7KF00-0AB0	6ES7531-7NF10-0AB0
Short description	AI 8xU/I/RTD/TC ST	AI 8xU/I HS
Number of inputs	8	8
Resolution	16 bits (including sign)	16 bits (including sign)
Measurement type	Voltage Current Resistor Thermal resistor Thermocouple	Voltage Current
Electrical isolation between channels	No	No
Rated supply voltage	24 VDC	24 VDC
Maximum potential difference between inputs (UCM)	10 VDC	10 VDC
Diagnostic error interrupt	Yes, high and low limit	Yes, high and low limit
Hardware interrupt	Yes	Yes
Isochronous operation supported	No	Yes
Conversion time (per channel)	9/23/27/107 ms	125 µs, per module, regardless of number of activated channels

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.5 Analog output modules

Overview of properties

The table below shows the essential properties of the analog output modules.

Table 3- 6 Analog output modules

Order no.:	6ES7532-5HD00-0AB0	6ES7532-5HF00-0AB0
Short description	AQ 4xU/I ST	AQ 8xU/I HS
Number of outputs	4	8
Resolution	16 bits (including sign)	16 bits (including sign)
Output type	Voltage Current	Voltage Current
Electrical isolation between channels	No	No
Rated supply voltage	24 VDC	24 VDC
Diagnostic error interrupt	Yes	Yes
Isochronous operation supported	No	Yes

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.6 System power supply modules

Overview of properties

The table below shows the essential properties of the system power supply modules.

Table 3- 7 System power supply modules

Order no.:	6ES7505-0KA00-0AB0	6ES7505-0RA00-0AB0	6ES7507-0RA00-0AB0
Short description	PS 25W 24V DC	PS 60W 24/48/60V DC	PS 60W 120/230V AC/DC
Rated input voltage	24 VDC	24 VDC, 48 VDC, 60 VDC	120 VAC, 230 VAC 120 VDC, 230 VDC
Output power	25 W	60 W	60 W
Electrical isolation from the backplane bus	Yes	Yes	Yes
Diagnostic error interrupt	Yes	Yes	Yes

Reference

Further information on the technical specifications of the system power supply modules may be found in the respective product manuals.

3.7 Load current supply modules

Overview of properties

The table below shows the essential properties of the load current supplies.

Table 3- 8 Load current supply modules

Order no.:	6EP1332-4BA00	6EP1333-4BA00
Short description	PM 70W 120/230V AC	PM 190W 120/230V AC
Rated input voltage	120/230 VAC, with automatic switchover	120/230 VAC, with automatic switchover
Output voltage	24 VDC	24 VDC
Rated output current	3 A	8 A
Power consumption	84 W	213 W

Reference

Further information on the technical specifications of the load current supply modules may be found in the respective manuals.

3.8 Technology modules

Overview of properties

The table below shows the essential properties of the technology modules.

Table 3- 9 Technology modules

Order no.:	6ES7550-1AA0-0AB0	6ES7551-1AB00-0AB0
Short description	TM Count 2x24V	TM PosInput 2
Supported encoders	Incremental encoder for signals, 24 V asymmetric, Pulse encoder with/without direction signal, Pulse encoder up/down	Incremental encoder for signals to RS422 (5 V differential signal), Pulse encoder with/without direction signal, Pulse encoder up/down, Absolute encoder (SSI)
Max. count frequency	200 kHz 800 kHz with four-fold pulse	1 MHz 4 MHz with four-fold pulse
Integrated DI	3 DIs per counter channel for start, stop, capture, synchronization	2 DIs per counter channel for start, stop, capture, synchronization
Integrated DQ	2 DQs for comparators and limit values	2 DQs for comparators and limit values
Counting functions	Comparator, Adjustable counting range, Incremental position detection	Comparator, Adjustable counting range, Incremental and absolute position detection
Measuring functions	Frequency, Period, Velocity	Frequency, Period, Velocity
Diagnostic error interrupt	Yes	Yes
Hardware interrupt	Yes	Yes
Isochronous operation supported	Yes	Yes

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.9 Communication modules

Overview of properties

The table below shows the essential properties of the communication modules.

Table 3- 10 Communication modules for point-to-point linking

Order no.:	6ES7540-1AD00-0AA0	6ES7540-1AB00-0AA0	6ES7541-1AD00-0AB0	6ES7541-1AB00-0AB0
Short description	CM PtP RS232 BA	CM PtP RS422/485 BA	CM PtP RS232 HF	CM PtP RS422/485 HF
Interface	RS232	RS422/485	RS232	RS422/485
Data transmission rate	300 to 19 200 bps	300 to 19 200 bps	300 to 115,200 bps	300 to 115,200 bps
Frame length, max.	1 KB	1 KB	4 KB	4 KB
Diagnostic error interrupt	Yes	Yes	Yes	Yes
Hardware interrupt	No	No	No	No
Isochronous operation supported	No	No	No	No
Supported protocols	Freeport, 3964 (R)	Freeport, 3964 (R)	Freeport, 3964 (R), Modbus RTU master, Modbus RTU slave	Freeport, 3964 (R), Modbus RTU master, Modbus RTU slave

Table 3- 11 Communication modules for PROFIBUS and PROFINET

Order no.:	6EGK542-5DX00-0XE0	6EGK543-1AX00-0XE0
Short description	CM 1542-5	CP 1543-1
Bus system	PROFIBUS	PROFINET
Interface	RS485	RJ45
Data transmission rate	9600 bps to 12 Mbps	10/100/1000 Mbps
Functionality and supported protocols	DPV1 master/slave, S7 communication, PG/OP communication, Open User communication	ISO and TCP/IP with SEND/RECEIVE and FETCH/WRITE interface, UDP, TCP, S7 communication with/without RFC 1006, IP multicast, Web diagnostics, FDP Client/Server, SNMP, DHCP, E-mail
Diagnostic error interrupt	Yes	Yes
Hardware interrupt	No	No
Isochronous operation supported	No	No

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

Application planning

4

4.1 Hardware configuration

Introduction

The configuration of an S7-1500 automation system consists of a single-row configuration, in which all modules are installed on a mounting rail. The modules are connected by means of U connectors, and thus form a self-assembling backplane bus.

Rule

An S7-1500 automation system consists of a maximum of 32 modules, which occupy slots 0 to 31. The S7-1500 automation system supports a single-row configuration in which all modules are installed on a mounting rail.

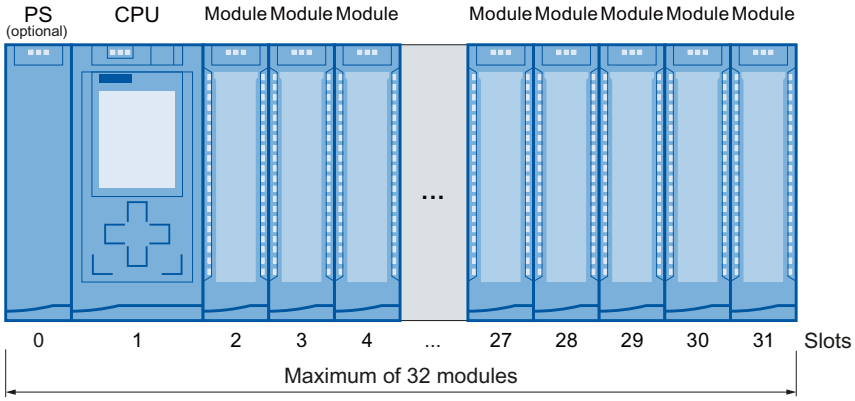


Figure 4-1 Configuration of an automation system with up to 32 modules

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Note

Placing load current supplies

Load current supplies do not have a connection to the backplane bus of the S7-1500 automation systems and therefore do not use a configurable slot. Load current supplies can be mounted to the left or right of the configured setup. If you mount a load current supply on the right of the configured setup, the heat development of the load current supply may make a gap to the configured setup necessary. For additional information, refer to the relevant manuals. The number of load current supplies that can be used is unlimited.

Appropriate modules

The following table shows which modules may be used in the various slots:

Module type	Permissible slots	Number of modules
System power supply (PS)	0; 2 - 31	Max. 3
CPU	1	1
I/O modules	2 - 31	Max. 30
Point-to-point modules	2 - 31	Max. 30
Technology modules	2 - 31	Max. 30
PROFIBUS/PROFINET modules:		
• When a CPU 1511-1 PN is used	2 - 31	Max. 4
• When a CPU 1513-1 PN is used	2 - 31	Max. 6
• When a CPU 1516-3 PN/DP is used	2 - 31	Max. 8

Special feature of the load current supply

In addition to the specified max. 32 modules, you need a load current supply to supply the modules and the input/output circuits with 24 VDC.
The number of load power supplies is unlimited.

Load current supplies can be mounted on the "S7-1500 mounting rail" but do not have a connection to the backplane bus.

Observe the installation rules and specified installation distances in the manuals of the load current supplies.

4.2 System and load power supply

In the S7-1500 automation system, you must make a distinction between two different power supplies:

- System power supply (PS)

  The system power supply has a connection to the backplane bus (U-connector) and supplies solely the internally required system voltage for the backplane bus. This system voltage supplies parts of the module electronics and the LEDs. A system power supply can also supply CPUs or interface modules if these are not connected to a 24 VDC load current supply.

- Load current supply (PM)

  The load current supply feeds the input/output circuits of the modules, as well as the sensors and actuators. In addition, you need a load current supply in order to supply the CPU and the system power supply with 24 VDC. The supply of the CPU with 24 VDC is optional if you supply the voltage for the backplane bus via a system power supply.

  If you are using load current supplies, we recommend the devices from our SIMATIC series. These devices can be mounted on the mounting rail.

  The load current supplies listed below are developed specially for the S7-1500 automation system in the same design. Use of a load current supply is not imperative since, for example, a SITOP module can be used alternatively.

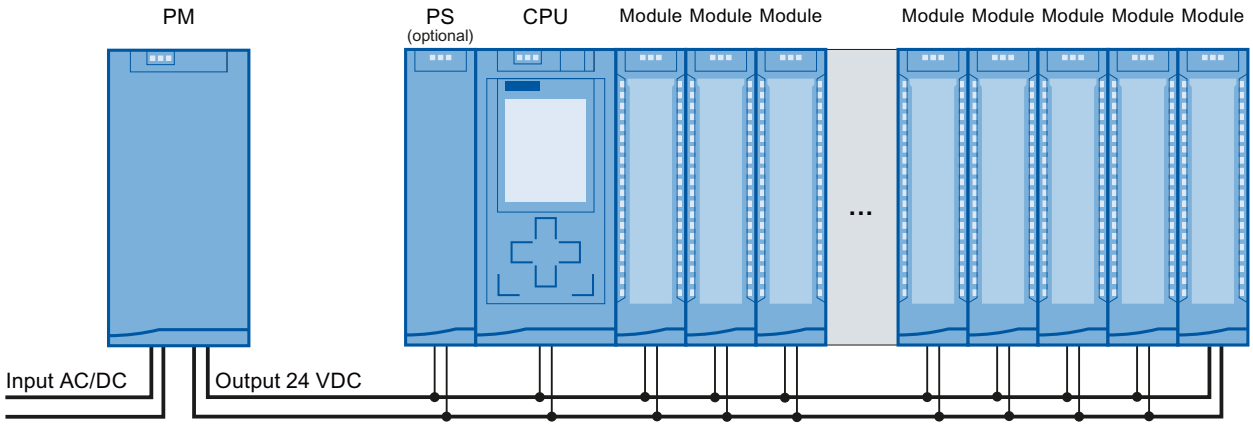


Figure 4-2 Total configuration with load current supply (PM) and system power supply (PS)

System power supplies

- PS 25W 24V DC: Supply with 24 VDC and 25 W of power
- PS 60W 24/48/60V DC: Supply with 24/48/60 VDC and 60 W of power
- PS 60W 120/230V AC/DC: Supply with 120/230 VAC and 60 W of power

Load power supplies

- PM 70W 120/230 V AC: Supply with 120/230 VAC and 70 W of power
- PM 190W 120/230 V AC: Supply with 120/230 VAC and 190 W of power

4.2.1 Use of system power supplies

System power supplies are required, if the power fed from the CPU into the backplane bus is not sufficient to supply all connected modules with power. In addition, you can use the system power supply with 120/230 VAC and supply the CPU through the backplane bus. The CPU then does not have to be supplied with 24 VDC.

Whether you need an additional system power supply for your configuration depends on the power that the modules consume from the backplane bus. The power provided by the CPU and the system power supplies via the backplane bus must be greater than the power required by the I/O modules.

When planning with STEP 7, the supplied and required power are compared. If the required power is too high, you receive a corresponding message from STEP 7.

Using system power supplies

The following slots may be used for system power supplies:

- A system power supply in slot 0, to the left of the CPU
- Up to 2 system power supplies in the slots to the right of the CPU (power segments)

Power segment

By using additional system power supplies on the right, next to the CPU, you divide the configuration into power segments.

Configuration variants

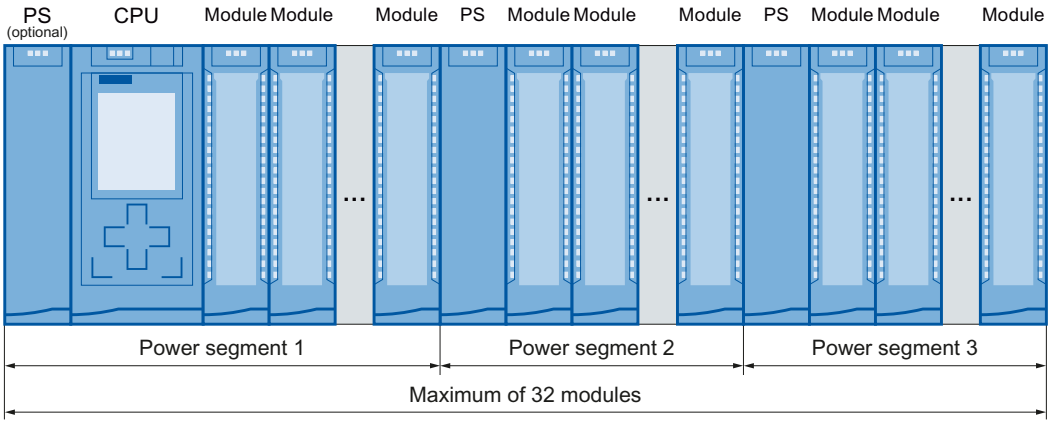


Figure 4-3 Configuration variants with 3 power segments

Reference

Information about the required lines is available in the section Power balance calculation (Page 35).

Further information on the performance values (power feed, power consumption) of the CPU, of the system power supply, and of the I/O modules can be found in the Manuals (http://support.automation.siemens.com/WW/view/en/57251228) of the respective modules.

4.2.2 Special considerations for the use of a system power supply in the first power segment

There are three options for the infeed of the system power supply:

- Infeed via CPU
- Infeed via CPU and system power supply
- Infeed via system power supply only

Infeed via CPU

Infeed via the CPU generally suffices for small and medium hardware configurations. The power consumption of the connected modules must not be greater than 10 or 12 W (depending on the CPU used).

In this configuration variant, supply the CPU with 24 VDC from a load current supply.

Parameter assignment of the CPU: Select the "Connection to supply voltage L+" option in STEP 7 in the "Properties" tab in the "System power supply" area navigation so that the power balance of STEP 7 can be calculated correctly.

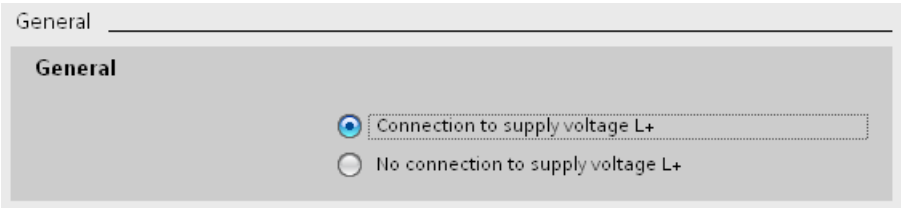


Figure 4-4 Supply voltage via CPU only

Infeed via CPU and system power supply

For larger hardware configurations, infeed into the backplane bus by the CPU alone no longer suffices. If then modules in total consume more than 10 or 12 W, insert an additional system power supply.

Supply the system power supply with the permissible supply voltage and the CPU with 24 VDC from a load current supply.

Both the system power supply and the CPU feed current into the backplane bus. The supplied power is summed.

Power addition: "System power supply infeed power" + "CPU infeed power"

Parameter assignment of the CPU: Select the "Connection to supply voltage L+" option in STEP 7 in the "Properties" tab in the "System power supply" area navigation so that the power balance of STEP 7 can be calculated correctly.

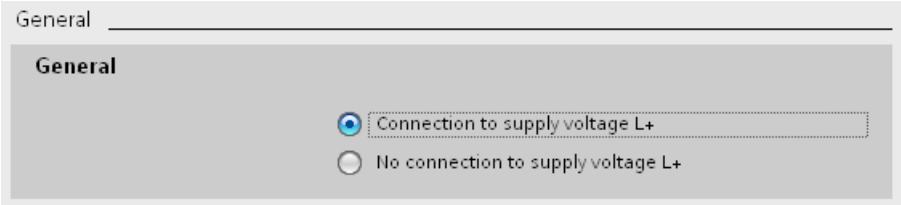


Figure 4-5 Supply voltage via the CPU and system power supply

Infeed via system power supply only

As a further possibility you can feed the required power into the backplane bus using only a system power supply. In this case, the CPU is not supplied with 24 VDC, and draws its supply from the backplane bus. Insert the system power supply next to the CPU, on the left.

In general you can use system power supplies with AC or DC infeed for the configuration. If the first power segment is to be supplied directly with 230 VAC, an infeed via only one system power supply makes sense, for example if no 24 VDC supply voltage is available.

Parameter assignment of the CPU: Select the "No connection to supply voltage L+" option in STEP 7 in the "Properties" tab in the "System power supply" area navigation so that the power balance of STEP 7 can be calculated correctly.

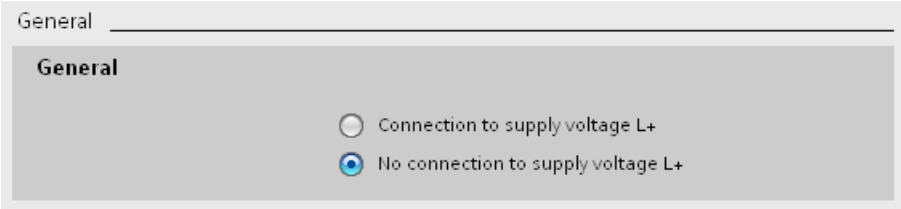


Figure 4-6 No infeed into the backplane bus through the CPU

4.3 Power balance calculation

Introduction

In order to ensure the supply of the modules from the backplane bus, the infed power is compared with the required power. In a power balance calculation the system checks whether the power provided by the system power supplies including CPU is greater than or equal to the power used by the consumers (modules).

In order to operate the configuration with its used modules, the power balance must be positive for each power segment in use.

Negative power balance: The infed power is less than the power consumed by the modules in the power segment.

Positive power balance: The infed power is greater than the power consumed by the modules in the power segment.

Take care even during planning, that the power fed into the backplane bus is always greater than or equivalent to the power drawn.

The power fed into the backplane bus from the CPU and system power supply is listed in the technical data of the CPU in the corresponding Manual (http://support.automation.siemens.com/WW/view/en/57251228).

The power drawn from the backplane bus by an I/O module or the CPU is listed in the technical data of the CPU in the corresponding Manual (http://support.automation.siemens.com/WW/view/en/57251228).

The power balance calculation is performed:

- During planning with STEP 7
- During operation by the CPU

Power balance calculation during planning with STEP 7

Compliance with the power balance is reviewed during planning by STEP 7.

Proceed as follows to evaluate the power balance calculation:

1. Configure the configuration of the S7-1500 with all the required modules.
2. In the network view, select the CPU or the system power supply.
3. Open the "Properties" tab in the inspector window.
4. Select the "System power supply" entry in the area navigation.
5. Check the "Power balance calculation" table, so see whether the power balance is positive. If the power balance is negative, the underpowered modules will be marked in red.

Power segment overview

Module	Slot	Supply/consumption
PS 25W 24V DC_1	0	25.00W
PLC_1	1	-8.30W
DI 32x24VDC HF_1	2	-1.10W
DQ 8x230VAC/5A ST_1	3	-0.80W
AI 8xU/I/RTD/TC ST_1	4	-0.70W
AQ 4xU/I ST_1	5	-0.60W
	Summary	13.50W

Figure 4-7 Example of a power balance calculation with STEP 7

Power balance check by the CPU for overload

Compliance with a positive power balance is monitored by the CPU:

- At every POWER ON
- At every change of the installed hardware

Causes for overload

An overload can still occur despite a positive power balance during planning. The cause for overload can be a hardware configuration that does not correspond to the planning in STEP 7 (TIA Portal), for example:

- More I/O modules are inserted in the actual configuration than were planned
- A system power supply that is necessary for operation is not inserted
- A system power supply that is necessary for operation is not switched on (power cable connector and on/off switch)
- A system power supply that is necessary for operation has no U connector inserted

Response to negative power balance or failure of power supplies

As soon as a negative power balance/overload is detected by the CPU in a power segment, the following actions are executed:

- CPU stores the retentive data
- CPU enters the event in the diagnostics buffer
- CPU carries out a restart and repeats this until the cause of the negative power balance is resolved

4.4 Use of load power supplies

The system power supply (PS), central modules (CPU), input and output circuits of the I/O modules and, if applicable, the sensor technology and final controlling elements are supplied with 24 VDC through the load current supply (PM).

The load current supply (PM) is available in the following versions:

- PM 70W AC 120/230 V (automatic switchover), 24 VDC / 3 A
- PM 190W AC 120/230 V (automatic switchover), 24 VDC / 8 A

Several load current supplies (PM) can be used as follows for higher output currents:

- Parallel connection of two load current supplies
- Every load current supply feeds independent 24 VDC load lines.

Alternatively an external 24 V power supply from the SITOP spectrum can be used.

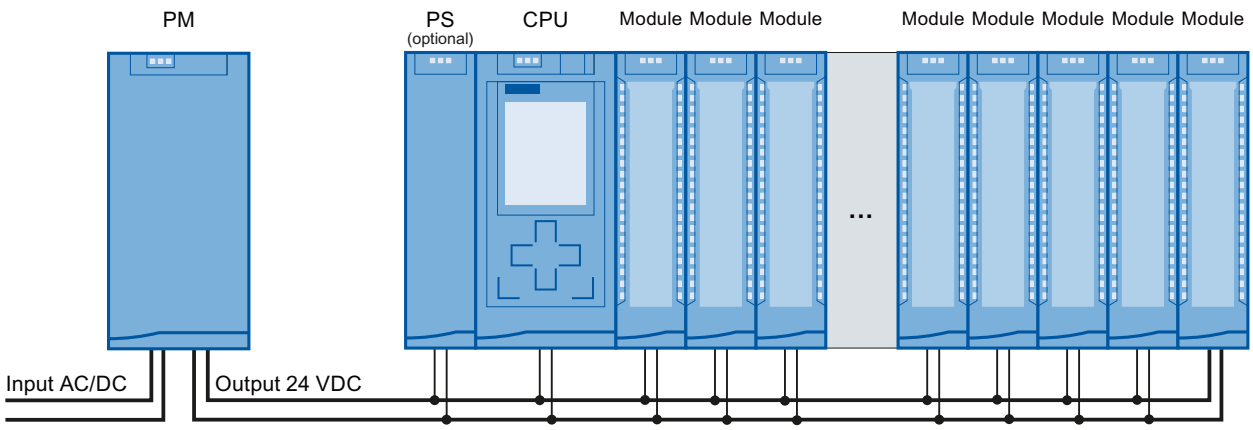


Figure 4-8 Supply of the modules from 24 VDC load power supply

Reference

Further information on load power supplies can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and/or in the online ordering system.

Installation 5

5.1 Basics

Introduction

All modules of the S7-1500 automation system are unenclosed equipment. This means that you may only install this system in housings, cabinets or electrical operating rooms. These housings, cabinets or electrical operating rooms must only be accessible with a key or tool. Access may only be possible for instructed or authorized personnel.

Installation position

The S7-1500 automation system can be used in a horizontal installation for ambient temperatures up to 60 °C and in vertical installation for ambient temperatures up to 40 °C. Additional information can be found in the chapter Mechanical and climatic ambient conditions (Page 171).

Mounting rail

In addition to the S7-1500 modules, components to EN 60715 can be mounted on the S7-1500 mounting rail, for example modules from the S7-1200 and ET 200SP spectrum, terminals, circuit breakers, small contactors or similar components.

These components can influence the installation dimensions for the cable duct.

Modules can be mounted up to the outer edge of the mounting rail (marginless assembly).

These mounting rails are available in various lengths. You can order them via the online catalog or the online ordering system. The deliverable lengths and order numbers can be found in the Accessories/spare parts (Page 193) section.

Minimum clearances

Modules can be mounted up to the outer edge of the mounting rail. Maintain the following minimum clearances at the top and bottom when installing or removing the S7-1500 automation system.

① Upper edge of the mounting rail

Figure 5-1 Minimum clearances in the control cabinet

Installation rules

- The installation begins on the left side with a CPU, or a power supply module.
- The modules are connected to each other with U connectors.
- Note that no U connector protrudes from the first and last module.

Note

Only insert modules when the power is switched off.

5.2 Installing the mounting rail

Introduction

The mounting rails are delivered in five lengths:

- 160 mm
- 482.6 mm (19 inches)
- 530 mm
- 830 mm
- 2000 mm

The order numbers can be found in the Accessories/spare parts (Page 193) section.

The mounting rails (from 160 to 830 mm) come with two drill holes for fixing screws. A set of screws for grounding the mounting rail is provided.

The 2000 mm mounting rail is provided for assemblies with special lengths and does not have holes for fixing screws. No set of screws for grounding is enclosed with the mounting rail (can be ordered as an accessory (Page 193)).

The specifications of the maximum offsets between two drill holes can be found in the table, "Dimensions for the drill holes".

Tools required

- Commercially available hacksaw
- Drill ∅ 6.5 mm
- Screwdriver
- Size 10 adjustable screw-wrench or socket wrench for grounding cable connection
- Adjustable screw-wrench, matching the selected fixing screws
- Stripping tool and crimp tool for the grounding cable

Required accessories

You can use the following screw types for fastening of the mounting rails:

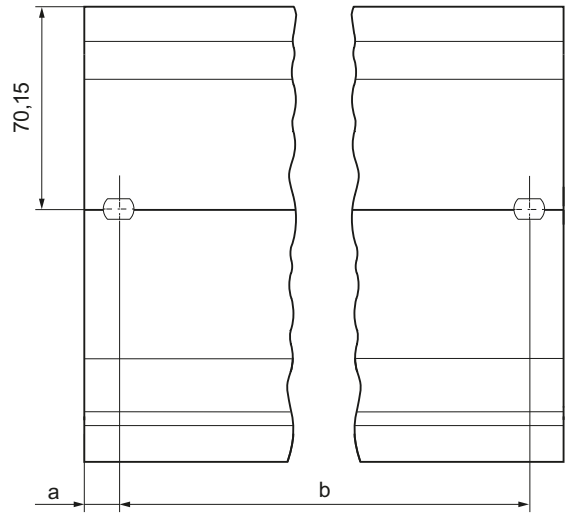
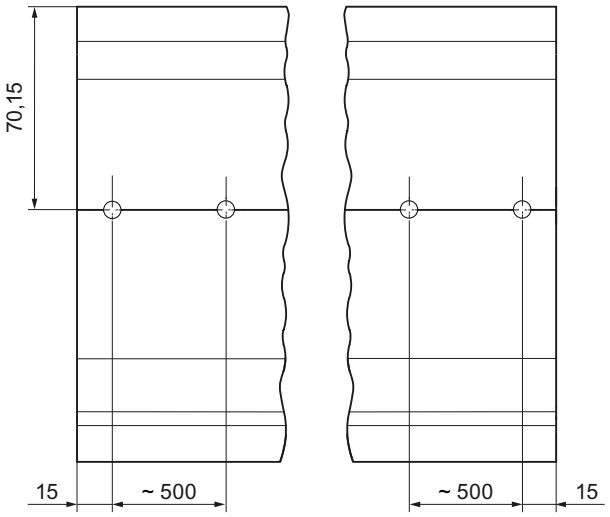
Table 5- 1 Required accessories

For ...	you can use ...	Explanation
• outer fixing screws • additional fixing screws (for mounting rails > 482.6 mm)	M6 fillister head screws according to ISO 1207/ISO 1580 (DIN 84/DIN 85)	Choose a suitable screw length for your assembly.
	M6 hexagon head screws according to ISO 4017 (DIN 4017)	You also need washers for cylinder head screws with an internal diameter of 6.4 mm and an external diameter of 11 mm in accordance with ISO 7092 (DIN 433).

Dimensions for the drill holes

The following table contains the dimensions for the mounting rail drill holes.

Table 5- 2 Dimensions for the drill holes

"Standard" mounting rails			"Longer" mounting rails
			
Length of the mounting rail	Distance a	Distance b	
160 mm	10 mm	140 mm	
482.6 mm	8.3 mm	466 mm	
530 mm	15 mm	500 mm	
830 mm	15 mm	800 mm	

Additional fixing screws (for mounting rails > 530 mm)

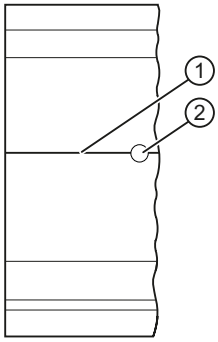
For mounting rails > 530 mm, we recommend setting additional fixing screws at intervals of ≤ 500 mm on the identification groove.

Preparing the 2000 mm mounting rail for installation

1. Cut the 2000 mm mounting rail to the required length.
2. Mark the holes. The necessary dimensions can be found in the above-mentioned table "Dimensions for the drill holes":
   - Two drill holes at the beginning and end of the mounting rail
   - Additional drill holes at equal intervals of 500 mm maximum, along the identification groove
3. Drill the marked holes according to the selected type of fastening.
4. Ensure that there are no burrs or shavings on the mounting rail.

Note

In order to ensure a secure installation of the modules, make sure that the drill holes are located centrally on the identification groove, and that only screws of the maximum size are used (see the above-mentioned table).



① Identification groove for additional drill holes

② Additional drill hole

Figure 5-2 Preparing the 2000 mm mounting rail for installation

Installing the mounting rail

Place the mounting rail such that sufficient space remains for installation of and heat dissipation from the modules. Note the figure Minimum clearances in the control cabinet (Page 40).

Screw the rail onto the mounting surface.

Attaching the protective conductor

The S7-1500 automation system has to be connected to the protective conductor system of the electrical system to ensure electrical safety.

1. Strip the grounding conductor with a minimum diameter of 10 mm^2 and attach a ring terminal for size M6 bolts with the crimping pliers.
2. Slide the enclosed bolt into the T profile groove.
3. Insert the spacer, ring terminal with the grounding connector, flat washer, and lock washer onto the bolt (in that order). Thread the hexagon head nut, and fasten the components in place with the nut (torque 4 Nm).

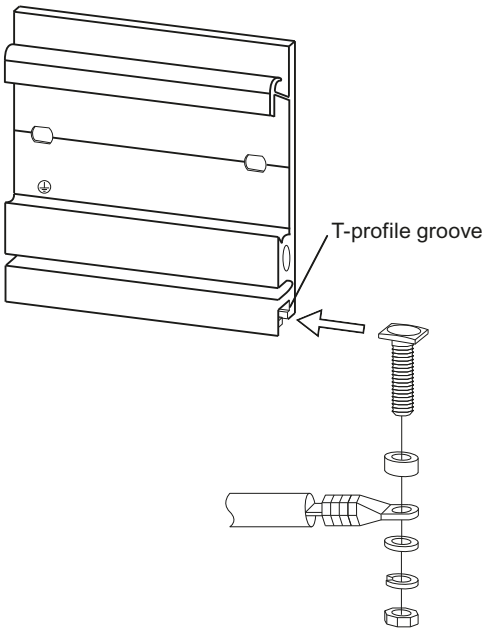


Figure 5-3 Attaching the protective conductor

4. Connect the opposite end of the grounding cable to the central grounding point / protective conductor busbar (PE).

Reference

Additional information on the precise dimensions of the mounting rails can be found in the Dimension drawings of the mounting rails (Page 175) section.

5.3 Mounting a system power supply module

Introduction

The system power supply module has a connection to the backplane bus and supplies the configured modules with the internal supply voltage.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Mounting a system power supply module

1. Insert the U-connector into the back of the system power supply.
2. Install the system power supply on the mounting rail.
3. Swivel the system power supply to the rear.

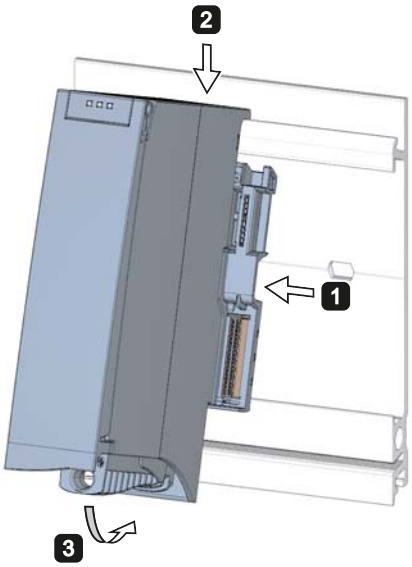


Figure 5-4 Mounting a system power supply module

4. Open the front cover.
5. Disconnect the power cable connector from the system power supply.
6. Screw the system power supply tight (torque 1.5 Nm).
7. Insert the already wired-up power cable connector into the system power supply.

For a description on how to wire the power cable connector refer to the section Connecting the system power supply and load current supply modules (Page 62).

Dismantling a system power supply module

The system power supply is wired up.

1. Turn off the fed supply voltage.
2. Open the front cover.
3. Shut down the system power supply.
4. Disconnect the power cable connector, and remove the connector from the system power supply.
5. Undo the power supply module's fixing screw(s).
6. Swivel the system power supply out of the mounting rail.

Reference

Further information can be found in the Manuals for the system power supplies.

5.4 Mounting a load current supply module

Introduction

Load current supplies do not have a connection to the backplane bus of the S7-1500 automation systems and therefore do not use a configurable slot. The system power supply, CPU, input and output circuits of the I/O modules and, if applicable, the sensor technology and final controlling elements are supplied with 24 VDC through the load current supply.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Mounting a load current supply module

1. Install the load current supply on the mounting rail.
2. Swivel the load current supply to the rear.

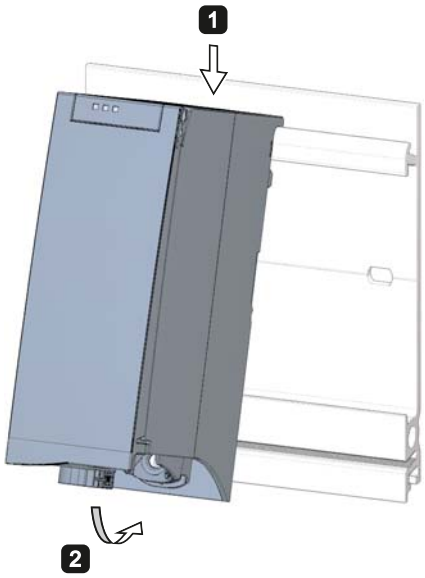


Figure 5-5 Mounting a load current supply module

3. Open the front cover.
4. Disconnect the power cable connector from the load current supply.
5. Screw the load current supply tight (torque 1.5 Nm).
6. Insert the already wired-up power cable connector into the load current supply.

For a description on how to wire the power cable connector refer to the section Connecting the system power supply and load current supply modules (Page 62).

Note

Load current supplies can be mounted to the left or right of the configured setup. If you mount a load current supply on the right of the configured setup, the heat development of the load current supply may make a gap to the configured setup necessary. For additional information, refer to the relevant manuals. The number of load current supplies that can be used is unlimited.

Dismantling the load current supply

The load current supply is wired up.

1. Turn off the fed supply voltage.
2. Open the front cover.
3. Shut down the load current supply.
4. Disconnect the power cable connector, and remove the connector from the load current supply.
5. Undo the power supply module's fixing screw(s).
6. Swivel the load current supply out of the mounting rail.

Reference

Further information can be found in the Manuals for the load current supplies.

5.5 Installing the CPU

Introduction

The CPU executes the user program and uses the integrated system power supply to supply the electronics of the modules via the backplane bus.

Requirements

The following preconditions have to be fulfilled to mount a CPU:

- The mounting rail is installed.
- In a system power supply located on the left next to the CPU, a U connector is inserted on the back right.

Tools required

Screwdriver with 4.5 mm blade

Installing the CPU

1. Insert a U-connector into the back right on the CPU.
2. Install the CPU on the mounting rail and slide the CPU up to the left-hand system power supply.
3. Ensure that the U-connector is inserted at the system power supply. Swivel the CPU in to the rear.
4. Fasten the CPU (torque 1.5 Nm).

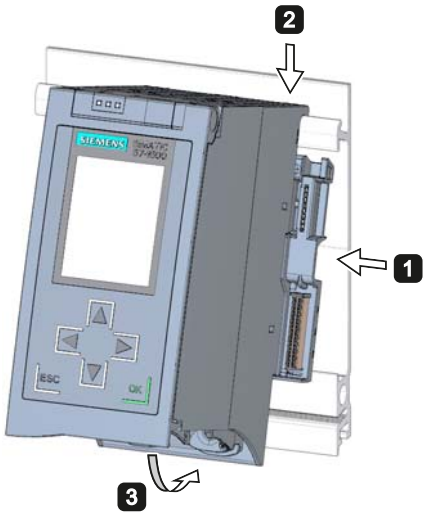


Figure 5-6 Installing the CPU

Uninstalling the CPU

The CPU is wired, and is followed by additional modules.

1. Open the front cover.
2. Switch the CPU into STOP mode.
3. Turn off the fed supply voltage.
4. Pull off the connector for the supply voltage.
5. Loosen the bus connectors for PROFIBUS / PROFINET with the screwdriver, and remove them from the CPU.
6. Undo the CPU's fixing screw(s).
7. Pivot the CPU out of the mounting rail.

5.6 Installing I/O modules

Introduction

The I/O modules are installed following the CPU. I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions.

Requirements

The following preconditions have to be fulfilled to mount an I/O module:

- The mounting rail is installed.
- The CPU is installed.
- In the module / CPU located on the left next to the I/O module, a U-connector is inserted on the back right.

Tools required

Screwdriver with 4.5 mm blade

Installing I/O modules

Proceed as follows to install an I/O module:

1. Insert a U-connector into the back right on the I/O module.
   Exception: the last I/O module in the assembly.
2. Install the I/O module on the mounting rail and slide the I/O module up to module on the left.
3. Pivot the I/O module towards the back.
4. Fasten the I/O module (torque 1.5 Nm).

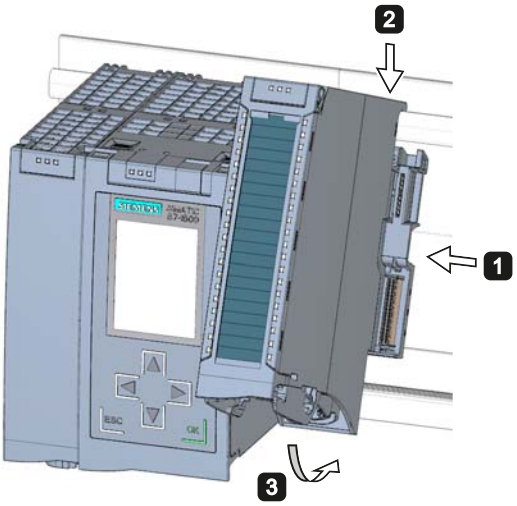


Figure 5-7 Installing I/O module

Uninstalling I/O modules

The I/O module is wired.

Proceed as follows to dismantle an I/O module:

1. Turn off all fed supply voltages.
2. Open the front cover.
3. For communication modules: Loosen and remove the connector from the module.

   At I/O modules: Pull the front connector out of the I/O module using the unlocking strap.
4. Loosen the fixing screw of the I/O module.
5. Pivot the I/O module out of the mounting rail.

Wiring 6

6.1 Rules and regulations for operation

Introduction

As part of plants and/or systems, the S7-1500 automation system requires adherence to special rules and regulations, depending on the field of application.

This section provides an overview of the most important rules that must be observed for the integration of the S7-1500 CPU in a plant or system.

Specific application

Please observe the safety and accident prevention regulations applying to specific applications (e.g., machine protection guidelines).

EMERGENCY-STOP devices

"EMERGENCY-STOP" devices in accordance with IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

Excluding hazardous plant states

No dangerous operating states may occur when

- The CPU starts up again after a voltage dip or a power failure
- The bus communication is resumed after a fault

If necessary, EMERGENCY-STOP must be forced!

An uncontrolled or undefined startup is not permitted after the EMERGENCY STOP is unlocked.

Line voltage

Below is described, what you must pay attention to with respect to the supply voltage (see the section Statements on insulation tests, protection classes, degree of protection, and rated voltage (Page 173)):

- For fixed plants or systems without multipole circuit breaker, a mains disconnection device (multipole) must be available in the building installation.
- For all power circuits of the S7-1500 CPU, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 VDC supply

The following describes what you must pay attention to in terms of the 24 VDC supply:

- Power supply units for the 24 VDC supply have to have a safe electrical isolation in accordance with IEC 60364-4-41.
- Overvoltage arresters are to be used as protection against lightning and overvoltages.

  Suitable components for the lightning and overvoltage protection are specified in the Defining interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Protection against electrical shock

The mounting rail of the S7-1500 automation system has to be connected conductively with the protective conductor as protection against electrical shock.

Protection against external electrical influences

The following describes what you must pay attention to in terms of protection against electrical influences and/or faults:

- For all plants or systems in which an S7-1500 CPU is integrated, you must ensure that the plant or the system is connected to a protective conductor with sufficient cross-section for conducting electromagnetic disturbances.
- For supply, signal and bus lines, you must ensure that the laying of the lines and the installation is correct.
- For signal and bus lines, you must ensure that a wire/cable breakage or a cross-wire does not lead to undefined states of the plant or system.

Reference

Additional information can be found in the function manual, Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

6.2 Operating the S7-1500 on grounded infeed

Introduction

The following provides information on the overall configuration of an S7-1500 on a grounded infeed (TN-S network). The specific subjects discussed are:

- Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113).
- Load power supplies and load circuits.

Grounded infeed

In the case of grounding incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical isolation (SELV/PELV in accordance with IEC 60364-4-41)

Load current supply modules / power supply modules with safe electrical isolation are necessary for operating the S7-1500. This protection is designated as SELV (Safety Extra Low Voltage)/PELV (Protective Extra Low Voltage) in accordance with IEC 60364-4-41.

Reference potential of the controller

The reference potential of the S7-1500 automation system is connected with the mounting rail through a high-resistance RC combination. In this way, high-frequency interference currents are conducted and electrostatic charges are avoided. Despite the grounded mounting rail, the reference potential of the S7-1500 automation system has to be considered as ungrounded due to the high-resistance connection.

If you want to configure the S7-1500 automation system with grounded reference potential, connect the reference potential of the controller (M connection of the CPU) galvanically with the protective conductor.

A simplified representation of the potential relationships is available in the chapter Electrical configuration of the S7-1500 (Page 58).

Short-circuit and overload protection

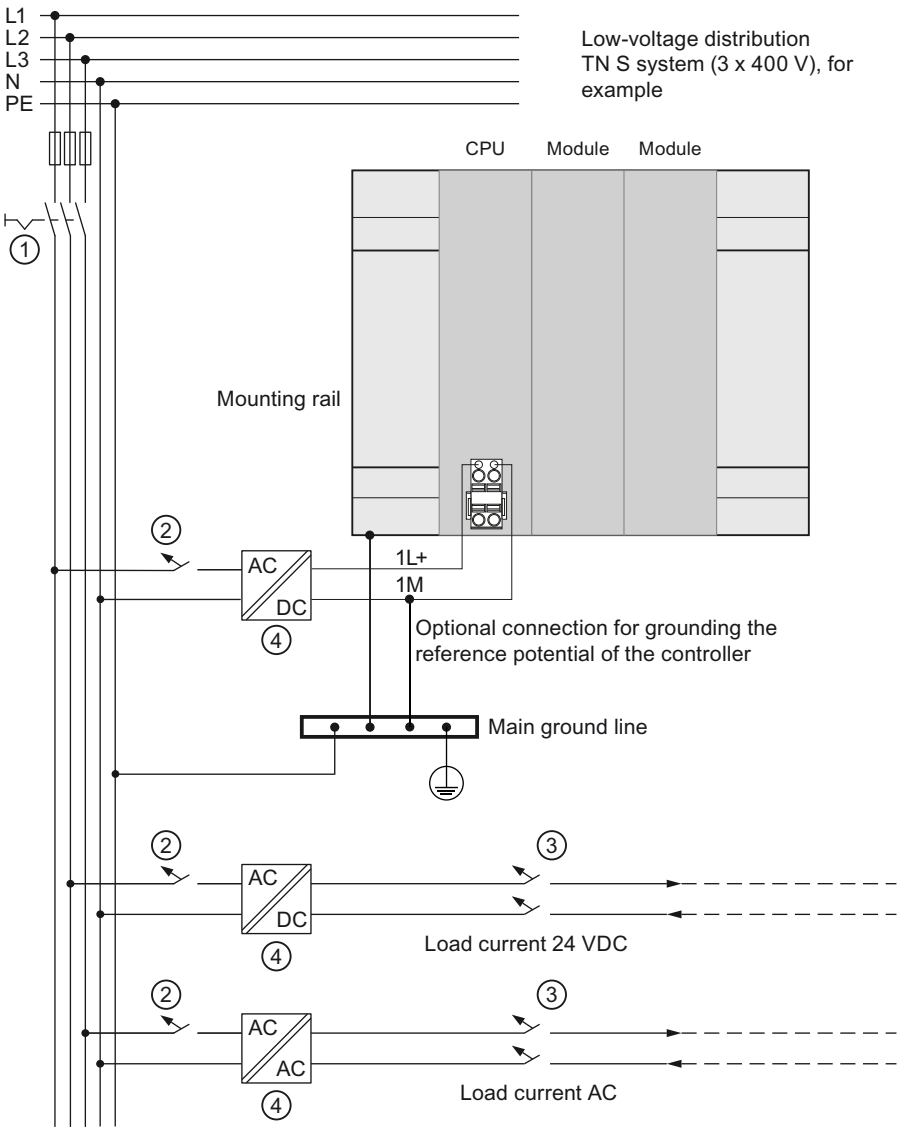
Various measures as protection against short-circuits and overloads are required for setting up a full installation. The nature of the components and the degree to which the required measures are binding depends on the IEC (DIN VDE) regulation applicable to your plant configuration. The table refers to the following figure and compares the IEC (DIN VDE) regulations.

Table 6- 1 Components and required measures

	Reference to following figure	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Shut-off device for control system, sensors, and actuators	①	Main switch	Disconnector
Short-circuit and overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	• With grounded secondary circuit: fuse **unipolar** • otherwise: fuse **all poles**
Load power supply for AC load circuits with more than five electromagnetic devices	④	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

S7-1500 in the overall configuration

The figure below shows the overall configuration of the S7-1500 (load voltage supply and grounding concept) with infeed from a TN-S network.



① Main switch
② Short-circuit and overload protection on the primary side
③ Short-circuit and overload protection on the secondary side
④ The load current supply (galvanic isolation)

Figure 6-1 Operating the S7-1500 with grounded reference potential

6.3 Electrical configuration of the S7-1500

Electrical isolation

With the S7-1500, there is electrical isolation between:

- The primary side of the system power supply (PS) and all other circuit components
- the (PROFIBUS/PROFINET) communication interfaces of the CPU and all other circuit components
- The load circuits / process electronics and all other circuit components of the S7-1500 components

High-frequency interference currents are conducted and electrostatic charges are avoided through integrated RC combinations or integrated capacitors.

The following figure shows a simplified representation of the potential relationships of the S7-1500 automation system.

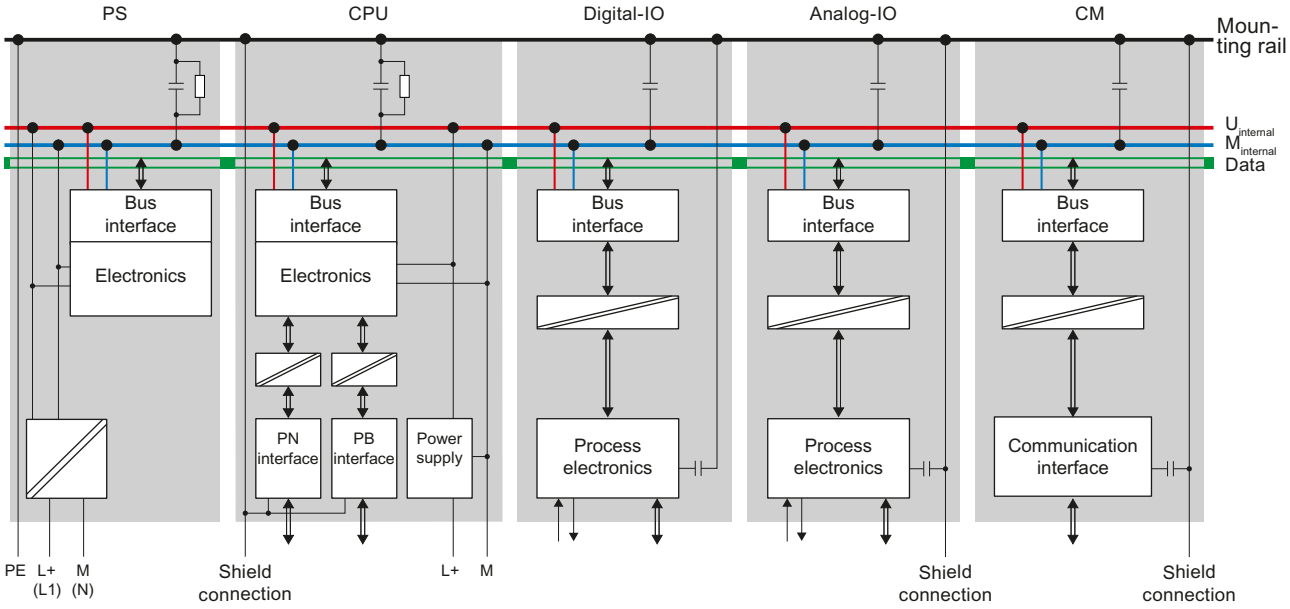


Figure 6-2 Potential relationships for S7-1500 with CPU 1516-3 PN/DP

6.4 Wiring rules

Wiring rules

Table 6- 2 Wiring rules

Wiring rules for...		CPU	40-pin front connector (screw-type connection)	System power and load current supply
Connectible conductor cross-sections for solid wires		-	up to 0.25 mm^2	-
		-	AWG*: up to 24	-
Connectible conductor cross-sections for stranded wires	Without end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	1.5 mm^2
		AWG*: 24 to 16	AWG*: 24 to 16	AWG*: 16
	With end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	1.5 mm^2
		AWG*: 24 to 16	AWG*: 24 to 16	AWG*: 16
Number of wires per connection		1	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1
Length of stripped wires		10 to 11 mm	10 to 11 mm	7 to 8 mm
End sleeves according to DIN 46228	without plastic sleeve	Design A, 10 mm long	Design A, 10 mm and 12 mm long	Design A, 7 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E, 10 mm long	Design E, 10 mm and 12 mm long	Design A, 7 mm long
Sheath diameter		-	-	8.5 mm
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection technology		Push-in terminal	Screw terminal	Screw terminal
Tightening torque		-	from 0.4 Nm to 0.7 Nm	from 0.5 Nm to 0.6 Nm

* American Wire Gauge

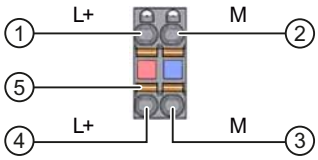
6.5 Connect supply voltage to the CPU

Introduction

The supply voltage of the CPU is supplied by means of a 4-pole cable connector, which is located on the front of the CPU.

Connection for supply voltage

The connections of the 4-pole connector have the following meaning:



① + 24 V DC of the supply voltage
② Mass of the supply voltage
③ Mass of the supply voltage for looping (current limited to 10 A)
④ + 24 V DC of the supply voltage for looping (current limited to 10 A)
⑤ Spring opener (one spring opener per terminal)

Figure 6-3 Connection for supply voltage

The maximum connector cross-section is 1.5 mm^2. The cable connector offers you the option of looping the supply voltage uninterrupted, even when it is unplugged.

Requirements

- Only wire the cable connector when the supply voltage is turned off.
- Follow the wiring rules (Page 59).

Tools required

3 to 3.5 mm screwdriver

Tool-free connection of cables: multi-wire (stranded), with end sleeve or ultrasonic compressed

1. Strip 8 to 11 mm of the wires.
2. Seal or crimp the wire with end sleeves.
3. Insert the wire into the push-in terminal as far as it will go.
4. Push the wired connection plug into the plug socket of the CPU.

Connection of wires: multi-wire (stranded), without end sleeve, unprocessed

1. Strip 8 to 11 mm of the wires.
2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.
3. Pull the screwdriver out of the spring release.
4. Push the wired connection plug into the plug socket of the CPU.

Loosening a wire

Push with the screwdriver as far as it will go into the spring release. Remove the wire.

Uninstalling the connection plug

To uninstall the connection plug, you need a screwdriver. With the screwdriver, pry the connection plug out of the CPU.

6.6 Connecting the system power supply and load current supply modules

Introduction

In the delivery state of the system power supply and load current supply modules, power connectors are inserted. The modules and the associated power connectors are coded. The coding is effected by means of two coding elements - one coding element is located in the module, and the other in the power connector. The system power supply and load current supply modules use identical power connectors for the voltage connection.

The coding element prevents the insertion of a power connector into a different type of power supply module / load current supply module.

Tools required

3 to 3.5 mm screwdriver

Connecting the supply voltage to the system power supply and load current supply modules

1. Swing the front cover of the module up until the front cover latches.
2. Unlock the power connector and remove it from the module by pulling it forward. For this purpose, press the unlocking button down (Figure 1).
3. Loosen the screw on the front of the connector. This loosens the housing latch and the cable relief. With a tightened screw the connector's cover can't be removed (Figure 2).
4. Pry off the connector cover using a suitable tool (Figure 3).

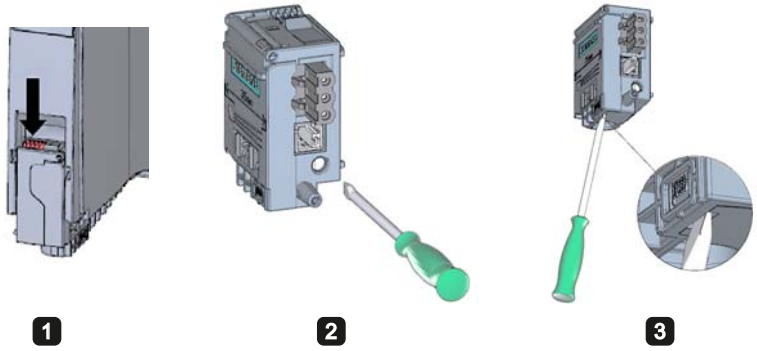


Figure 6-4 Connecting the supply voltage to the system power supply and load current supply modules (1)

5. Strip the cable sheathing to a length of 35 mm and the conductors to a length of 7 to 8 mm, and bring them up to the end sleeves.

6. Connect the wires in the connector according to the connection diagram (Figure 4).
7. Close the cover (Figure 5).
8. Retighten the screw (Figure 6). This effects a strain relief on the lines.

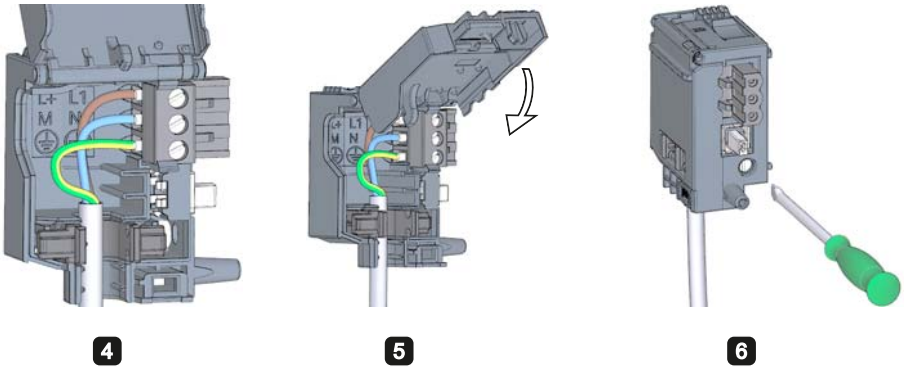


Figure 6-5 Connecting the supply voltage to the system power supply and load current supply modules (2)

9. Insert the power connector into the module, until the latch engages.

Reference

Further information about connecting the 24 VDC output voltage of the load voltage supply modules is available in the Manuals of the corresponding modules.

6.7 Connect interfaces for communication

Communication interfaces of the S7-1500 modules are connected using standardized connectors.

Use prefabricated connecting cables for the connection. If you want to prepare communication cables yourself, the interface assignment is specified in the Manuals of the corresponding modules. Observe the mounting instructions for the connectors.

6.8 Front connector for the I/O modules

6.8.1 Characteristics of the front connector

Introduction

The sensors and actuators of your plant are connected to the S7-1500 automation system by means of front connectors. Wire the sensors and actuators to the front connector and then plug it into the I/O module. Wire the front connector in the "pre-wiring position" that makes convenient wiring possible before you insert it into the I/O module.

The completely wired front connector can be removed easily from the I/O module and replaced without a lot of effect when a module is replaced.

Characteristics of the front connector

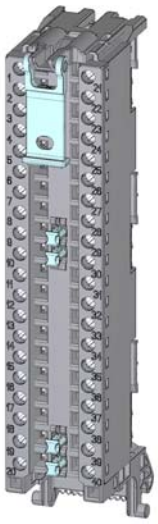


Figure 6-6 Front connectors

The front connector is characterized by the following:

- 40 clamping points each
- Clamping technology: Screw
- If you want to supply load groups with the same potential (non-isolated), use the potential bridges supplied for the front connector. In four locations: 9 and 29, 10 and 30, 19 and 39, 20 and 40, the terminals can be bridged by means of potential bridges. Advantage: Reduction of the wiring effort.

Note

Note that the potential bridges may only be deployed with a maximum rated voltage of 24 VDC! The current capacity per potential bridge is 8 A maximum.

- In the delivery state a coding element is located in the module. When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. If the front connector is removed from the I/O module, one half of the coding element remains in the front connector, and the other part of the coding element remains in the I/O module. The insertion of a front connector that is not suited to the module is thereby mechanically prevented. This ensures, for example, that the front connector with the coding element of a digital module cannot be inserted into an analog module. Further information about the coding element is also available in the chapterCoding element at the I/O module and at the front connector (Page 116).

Reference

Further information on the use of the potential bridges can be found in the manual for the respective I/O module.

6.8.2 Wiring front connectors for I/O modules without shield contact element

Requirements

- The supply voltages are turned off.
- The wires are prepared according to the utilized clamping technology, take the wiring rules (Page 59) into account for this purpose.

Tools required

3 to 3.5 mm screwdriver

Preparing and wiring front connectors for I/O modules without shield contact element

Proceed as follows to wire the front connector:

1. As needed, switch off the load power supply.
2. Swing the front cover of the wired I/O module up until the front cover latches (Figure 1).
3. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel the front connector upward until the front connector latches (Figure 2).

   Result: In this position, the front connector still protrudes from the I/O module (Figure 3). However, front connector and I/O module are not yet electrically connected. By means of the pre-wiring position, you can easily wire the front connector.

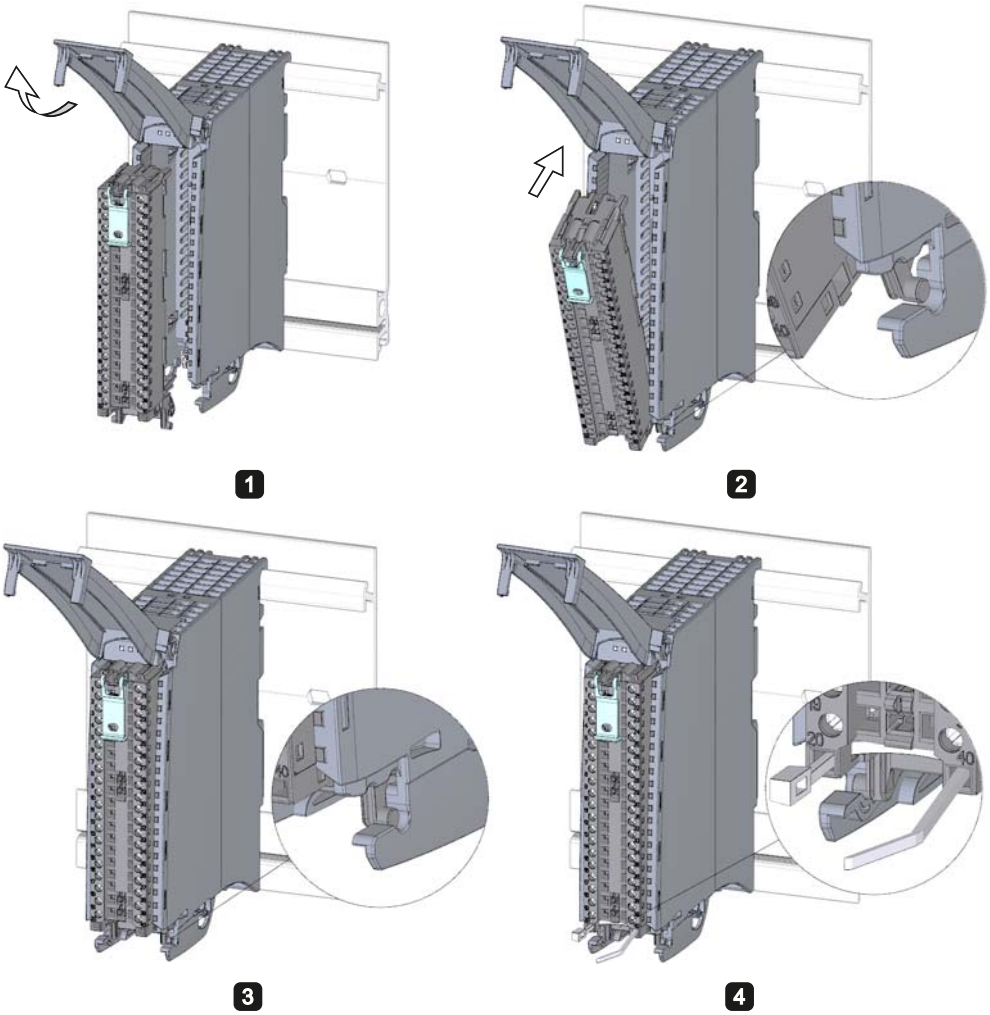


Figure 6-7 Wiring front connectors for I/O modules without shield contact element

4. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 4).
5. Begin to completely wire the front connector.
6. Put the strain relief around the cable harness, and pull the strain relief for the cable harness tight.

Use of the potential bridges at digital modules

With the delivered potential bridges, for digital modules with a maximum rated voltage of 24 V DC, you can bridge the terminals for the voltage supply and thus reduce the wiring effort. The bridges are used to connect respectively the facing terminals 9 and 29, 10 and 30, 19 and 39 as well as 20 and 40.

Reference

Further information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

6.8.3 Wiring front connectors for I/O modules with shield contact element

Requirements

- I/O modules are installed on the mounting rail.
- The supply voltage is turned off.
- The wires are prepared according to the utilized clamping technology, take the wiring rules (Page 59) into account to this purpose.

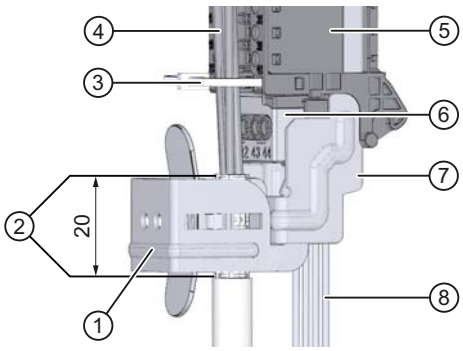
Tools required

- 3 to 3.5 mm screwdriver
- Flat pliers

Details view

The shielding bracket, the power supply element, and the shielding clamp are included in the scope of delivery for the analog and technology modules.

The following figure shows the details view of a front connector with shield connection element:



①	Shield clamp	⑥	Power supply element
②	Cable sheathing removed (approx. 20 mm)	⑦	Shielding bracket
③	Strain relief (cable tie)	⑧	Supply lines
④	Signal cables	①+⑦	Shield contact
⑤	Front connectors		

Figure 6-8 Details view for front connectors with shield connection elements

Preparing front connectors for I/O modules with shield contact element

1. Remove the connection separator from the lower part of the connector (Figure 1).
2. Insert the power supply element (Figure 2).
3. Insert the shielding bracket from below into the guiding groove of the front connector until it latches into place (Figure 3).
4. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 4).

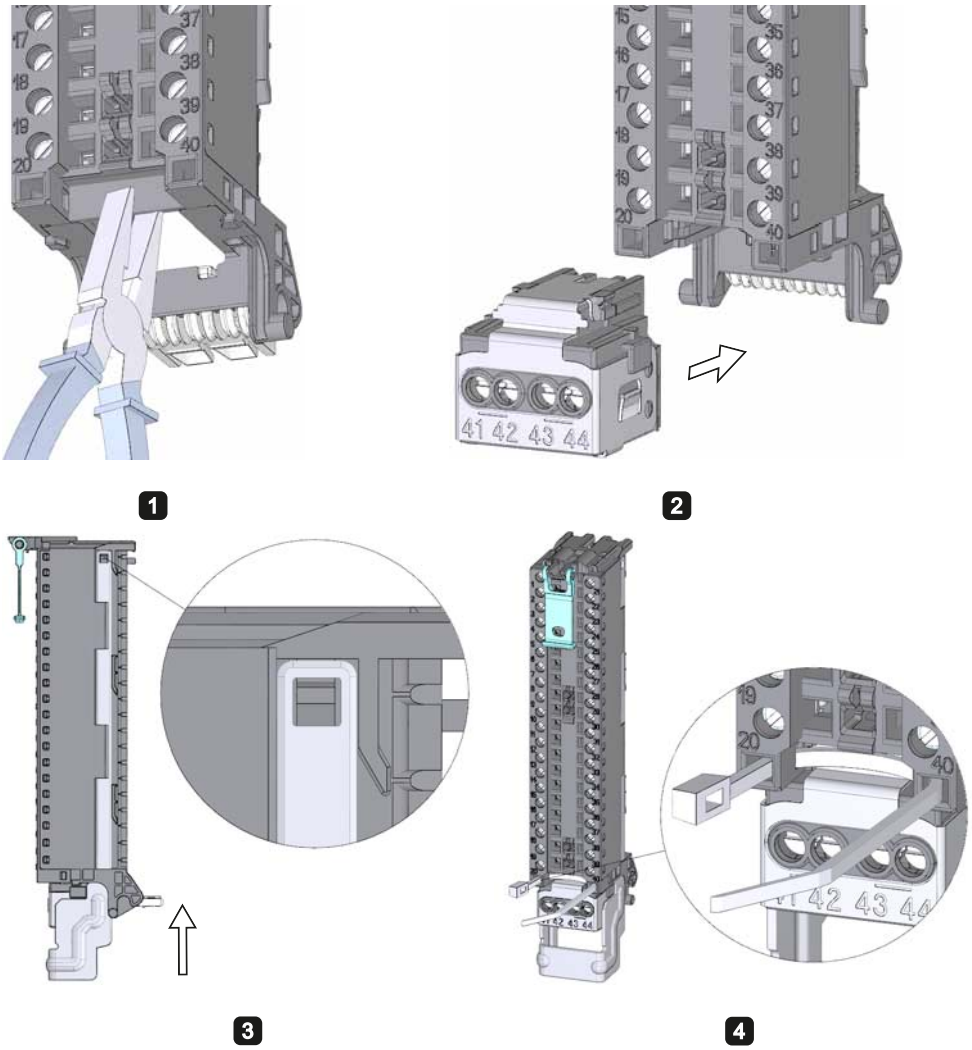


Figure 6-9 Preparing front connectors for I/O modules with shield contact element (1)

5. Swing the front cover up until the front cover latches (Figure 5).

6. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel it upwards until the front connector latches (Figure 6).

   Result: In this position, the front connector still protrudes from the I/O module (Figure 7). However, front connector and I/O module are not yet electrically connected.

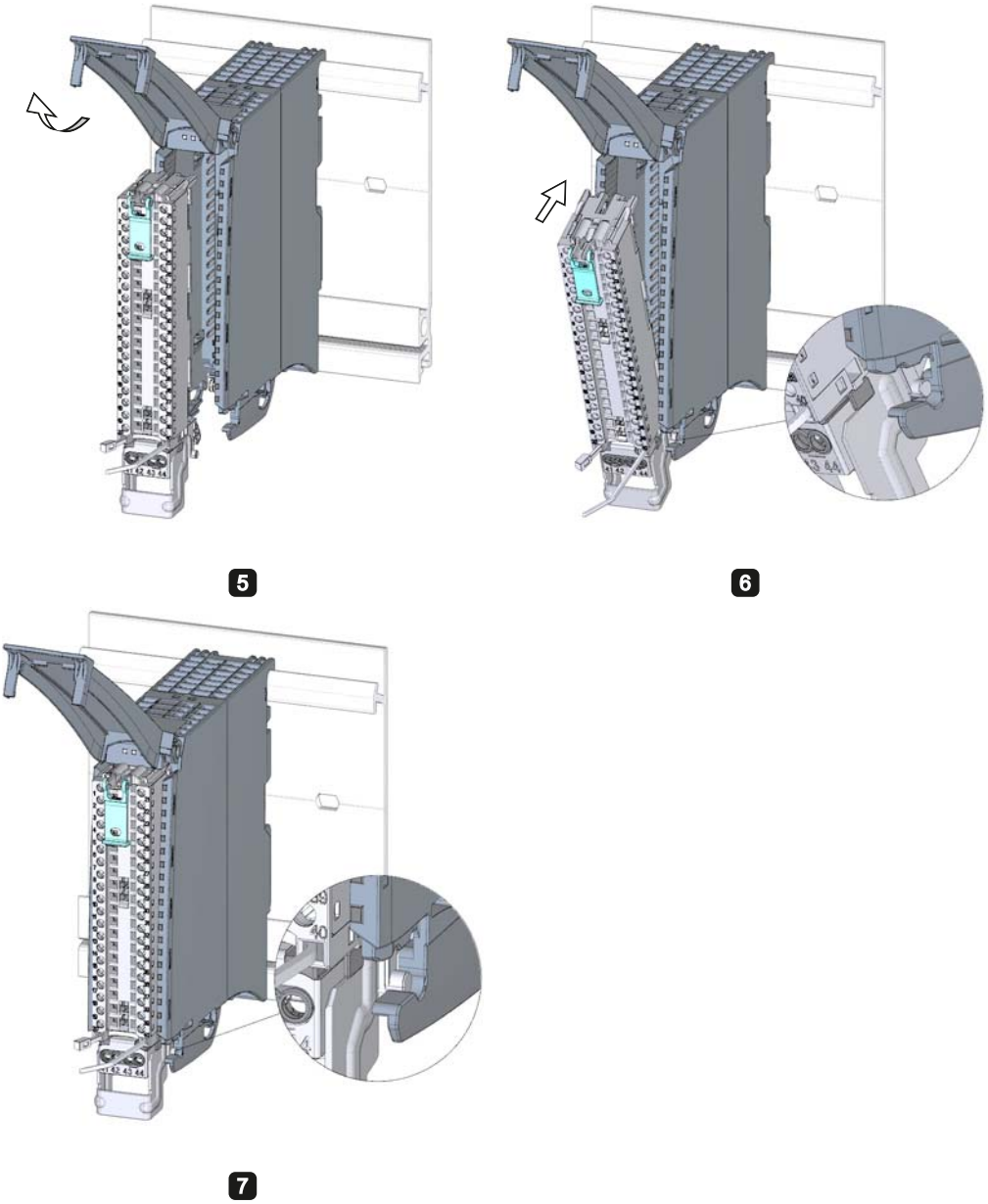


Figure 6-10 Preparing front connectors for I/O modules with shield contact element (2)

7. Wire the power supply element (Figure 8).
   Terminals 41/42 and 43/44 are galvanically connected to each other. If you connect the supply voltage to 41 (L+) and 44 (M), then with terminals 42 (L+) and 43 (M) you can loop the potential to the next module.

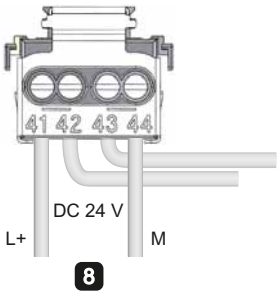
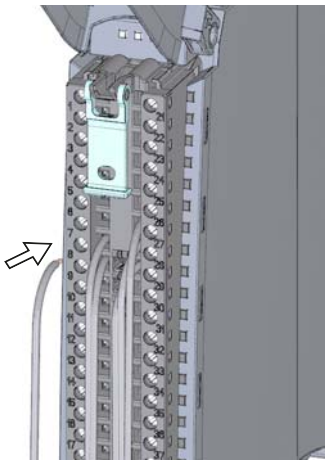


Figure 6-11 Preparing front connectors for I/O modules with shield contact element (3)

Wiring front connectors for I/O modules with shield contact element

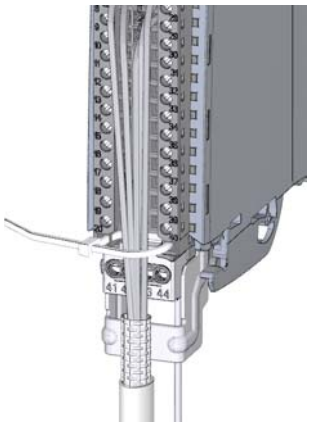
1. Strip the cable shielding.
2. Begin to completely wire the front connector (Figure 1).



1

Figure 6-12 Wiring front connectors for I/O modules with shield contact element (1)

3. Put the strain relief (cable tie) around the cable harness, and pull the strain relief for the cable harness tight (Figure 2).



2

Figure 6-13 Wiring front connectors for I/O modules with shield contact element (2)

4. Insert the shield clamp from below into the shielding bracket in order to connect the cable shielding (Figure 3).

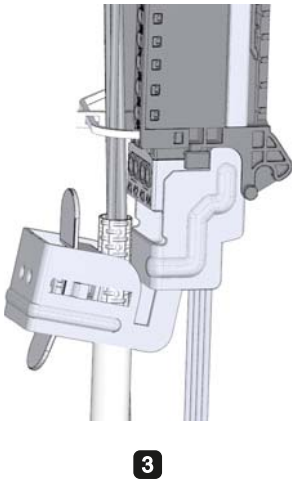


Figure 6-14 Wiring front connectors for I/O modules with shield contact element (3)

Functions of the shield contact

The shield contact:

- Is needed to fit cable shields (e.g., for analog modules).
- Interference currents on cable shields are diverted from the shield connection to ground via the mounting rail. The shielding connection is not required at cable entry into the switchboard.

Reference

Further information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

6.8.4 Bringing the front connector into final position

Bring the front connector from the pre-wiring position into final position

Proceed as follows to bring the front connector from the pre-wiring position into final position:

1. Grip the front connector by the unlocking strap.
2. Pull on the strap until the front connector is released from its latched position.
3. Tilt the top section of the front connector and raise it slightly. The front connector slides over the guide channel into its final position.

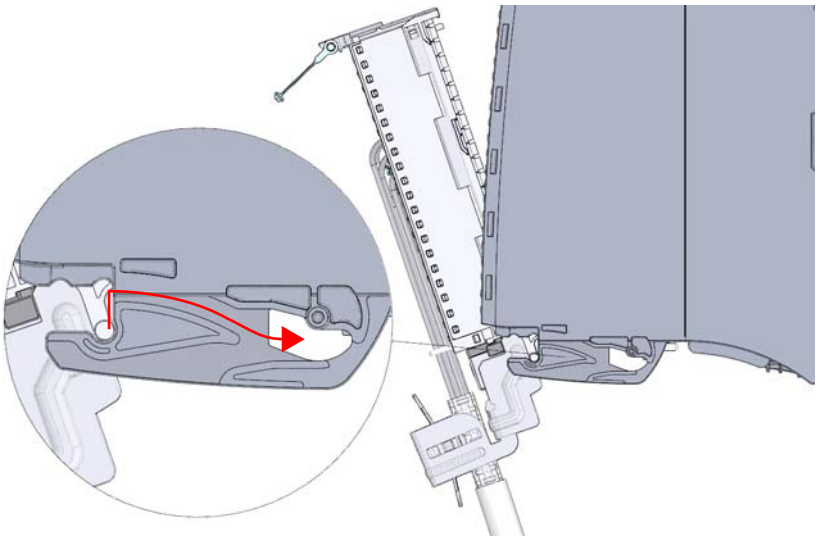


Figure 6-15 Bring the front connector from the pre-wiring position into final position

4. Push the front connector back into the I/O module until it latches. The front connector is now electrically connected with the I/O module.
5. Swivel the front cover down into place. Depending on the space requirement of the cable harness, various latch positions are possible, so that the required cable storage space can grow as needed.

Bringing the front connector directly into final position

Proceed as follows to bring the front connector directly into final position:

1. Grip the front connector by the unlocking strap.
2. Push the guide pin of the front connector into the guide channel that has been displaced downwards. The front connector slides over the guide channel into its final position.

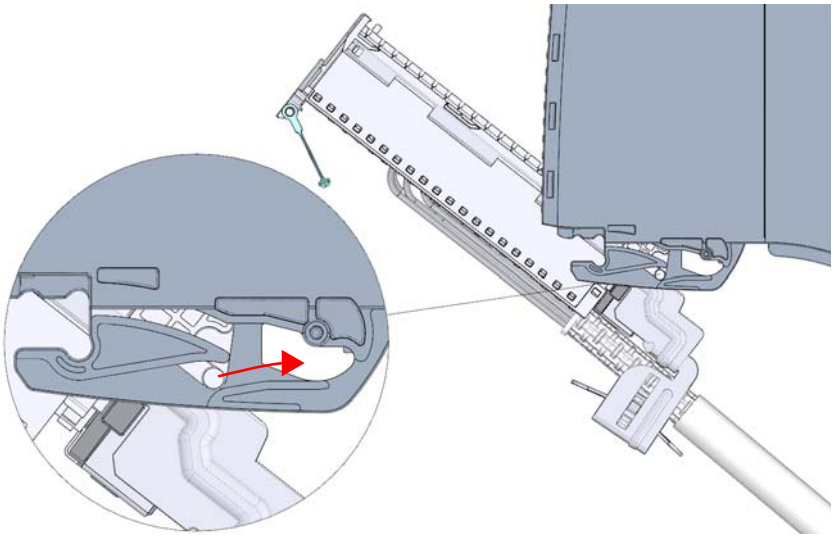


Figure 6-16 Bringing the front connector directly into final position

3. Tilt the front connector and press it into the I/O module until it latches. The front connector is now electrically connected with the I/O module.
4. Swivel the front cover down into place. Depending on the space requirement of the cable harness, various latch positions are possible, so that the required cable storage space can grow as needed.

6.9 Marking the I/O modules

6.9.1 Labeling strips

Introduction

Mark the pin assignment of the I/O modules using labeling strips. The labeling strip can be written on as desired, and is slid into the outside of the front cover.

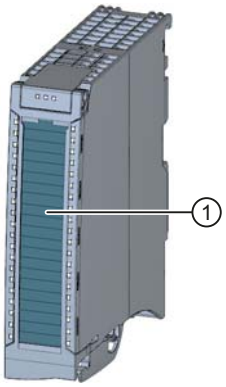
The labeling strips are available in the following models:

- Pre-prepared strips that are included with the I/O module as delivered.
- DIN A4 sheets, pre-perforated strips for machine printing. See the chapter Accessories/Spare Parts (Page 193).

Preparing and installing the labeling strip

Proceed as follows to prepare and install the labeling strips:

1. Label the labeling strip.
2. With a pre-perforated strip: Separate the labeling strip from the sheet.
3. Slide the labeling strip into the outside of the front cover.



① Labeling strips

Figure 6-17 Marking with labeling strips

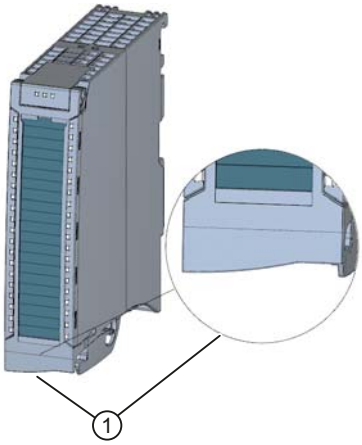
6.9.2 Optional marking

Introduction

On the I/O modules there is free space on the front cover, that permits an additional labeling or marking on the part of the customer.

Optional marking

The front cover provides about 30 mm x 10 mm of space in its lower part for an optional identifier label.



① Free space for example for equipment identifiers

Figure 6-18 Optional marking

Configuring 7

In order that the S7-1500 automation system knows how it is to be configured (preset configuration) and how it is to operate, you must configure the individual hardware components, assign parameters to them, and connect them to each other. The work needed for this is undertaken in the device and network view in STEP 7.

Configuring" is understood to mean arranging, setting and networking devices and modules within the device or network view. Modules and module carriers are graphically represented. Just like "real" module carriers, the device view allows the insertion of a defined number of modules.

When the modules are plugged, STEP 7 automatically assigns the addresses and a unique hardware identifier. The addresses can be changed subsequently. However, the hardware identifiers cannot be changed.

When the automation system is started, the CPU compares the configured planned configuration with the system's actual configuration. You can carry out parameter assignment of the response of the CPU to errors in the hardware configuration.

"Parameter assignment" is understood to mean setting the properties of the components used. The hardware parameters and the settings for data exchange are thereby assigned:

- Properties of the modules to which parameters can be assigned
- Settings for data exchange between components

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules can be replaced with ease since the parameters set are automatically loaded into the new module during startup.

Reading out the configuration of an existing station

When a connection exists to a CPU, you can load the configuration of this CPU (including possibly present modules) from the device into your project.

To do this, create a new project and configure an "Unspecified CPU".

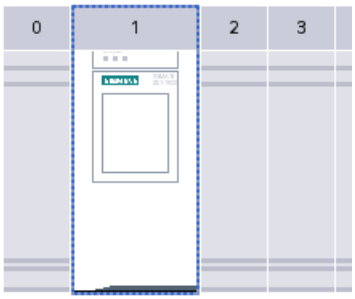


Figure 7-1 Unspecified S7-1500 CPU in the device view

In the device view (or in the network view), select the "Hardware detection" command in the "Online" menu.

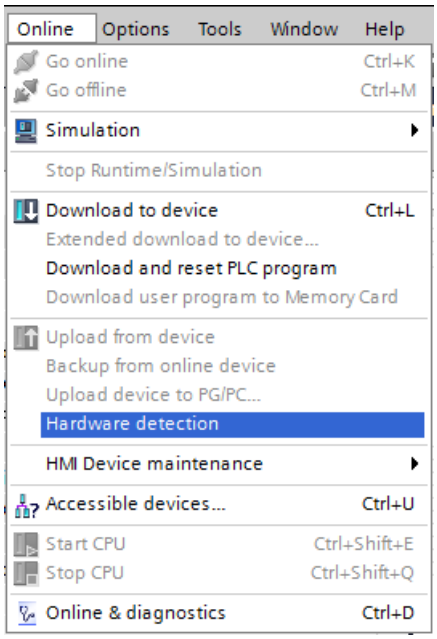


Figure 7-2 Hardware detection in the Online menu

Or double-click the CPU and click "detect" in the alarm .

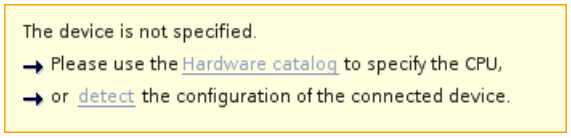
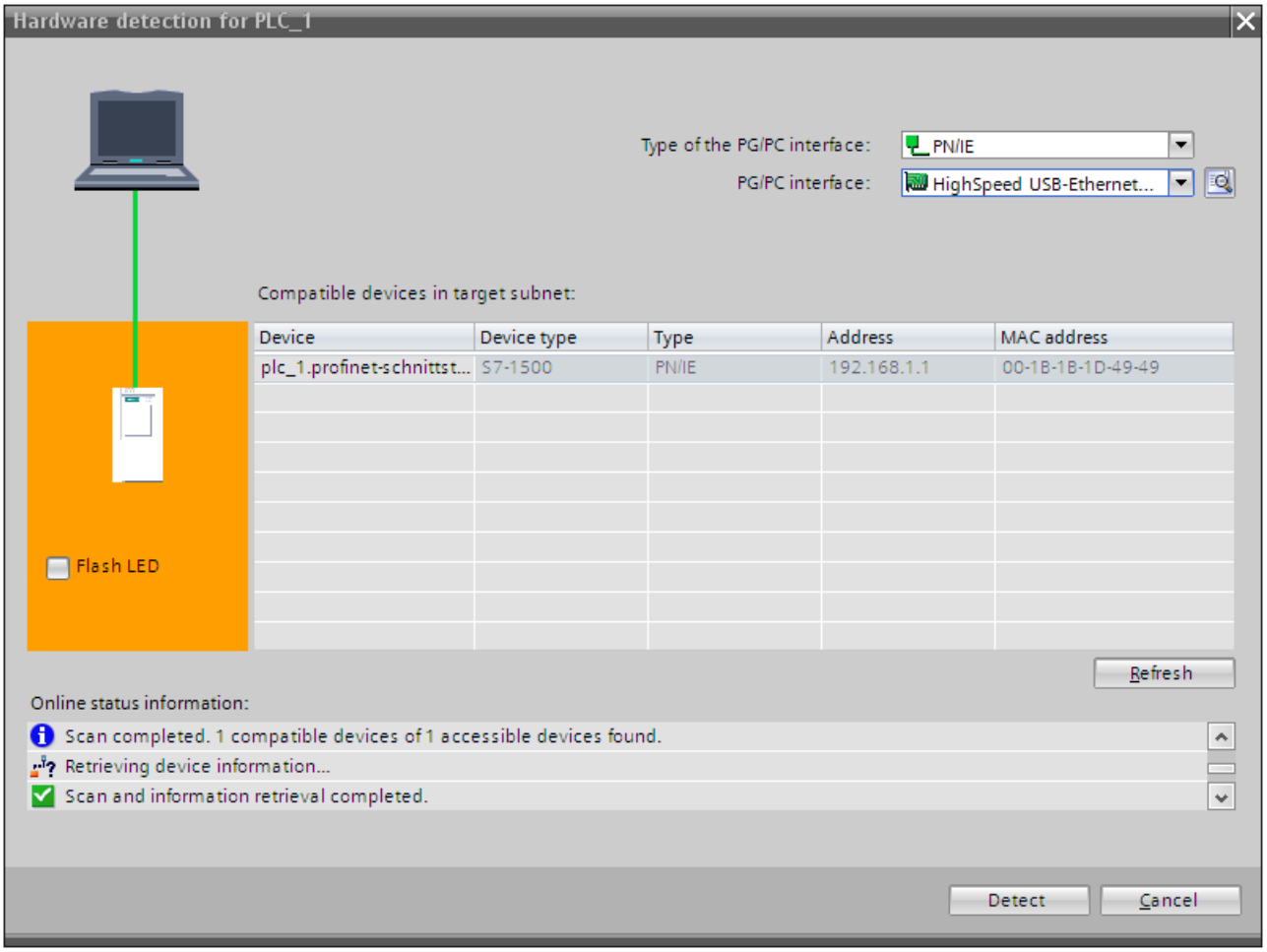


Figure 7-3 Alarm for hardware detection in the device view

After you have selected the CPU in the "Hardware detection for PLC_x" dialog, and have clicked the "Detect" button, STEP 7 loads the hardware configuration (including modules) from the CPU into your project.



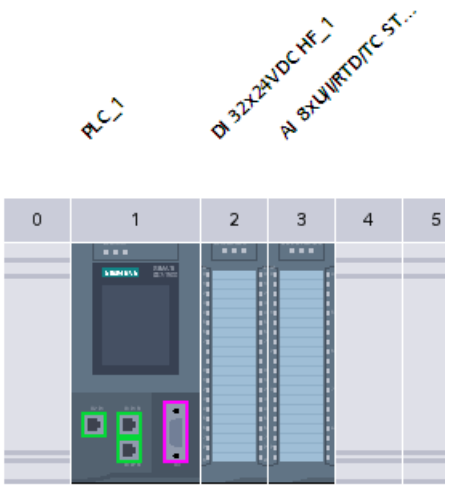


Figure 7-4 Result of the hardware detection in the device view

STEP 7 assigns a valid default parameter assignments for all modules. You can change the parameter assignment subsequently.

Properties of central modules

The properties of the CPUs have special significance for system behavior. You can set the following, for example, at a CPU in STEP 7:

- Startup behavior
- Parameter assignment of the interface(s), for example IP address, subnet mask
- Web server, e.g., activation, user administration, and languages
- Cycle times, e.g., maximum cycle time
- Properties for the operation of the display
- System and clock memory
- Protection level for access protection with assigned password parameter
- Clock time settings (daylight saving time/standard time)

The properties that can be set and the respective value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the online help and in the manual of the respective CPU.

7.1 Address assignment

7.1.1 Addressing - Overview

Introduction

In order to address the automation components or I/O modules, unique addresses must be assigned to them. The various address areas are explained below.

I/O address

I/O addresses (input/output addresses) are required to read inputs and set outputs in the user program.

Input and output addresses are assigned automatically by STEP 7 when modules are inserted. Each module uses a continuous area in the input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q address	Type	Order no.
	0	0				
▶ PLC_1	0	1			CPU 1516-3 PN/DP	6ES7 516-3AN00-0AB0
DI 16x24VDC HF_1	0	2	0...1		DI 16x24VDC HF	6ES7 521-1BH00-0AB0
DQ 32x24VDC/0.5A ST_1	0	3		0...3	DQ 32x24VDC/0.5A...	6ES7 522-1BL00-0AB0
AI 8xU/I HS_1	0	4	2...17		AI 8xU/I HS	6ES7 531-7NF10-0AB0
AQ 8xU/I HS_1	0	5		4...19	AQ 8xU/I HS	6ES7 532-5HF00-0AB0

Figure 7-5 Example with input / output addresses from STEP 7

The address areas of the modules are assigned by default to the Process image partition 0 ("Automatic updating"). This process image partition is updated in the main cycle of the CPU.

Device address (e.g., Ethernet address)

Device addresses are addresses of programmable modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required in order to address the various devices on a subnet, e.g., in order to download a user program.

Hardware identifier

In addition to the I/O addresses, a hardware identifier (Hardware identifier), which is used to identify the module, is assigned automatically by STEP 7. Such a Hardware identifier is also assigned to submodules.

The Hardware identifier consists of an integer and is output at diagnostic messages by the system. This identifies the faulty module or the functional unit.

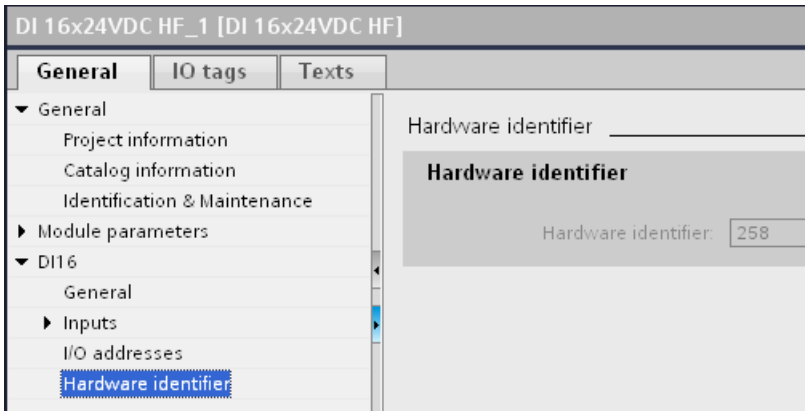


Figure 7-6 Example of a Hardware identifier from STEP 7

You also use the Hardware identifier for a series of instructions in order to identify the module to which the instruction should be applied.

The Hardware identifier cannot be changed.

The Hardware identifier is assigned automatically when components are inserted in the device or network view, and entered in the "Default tag table" of the PLC tags. A name is also assigned automatically for the Hardware identifier. These entries in the "Default tag table" of the PLC tags cannot be changed either.

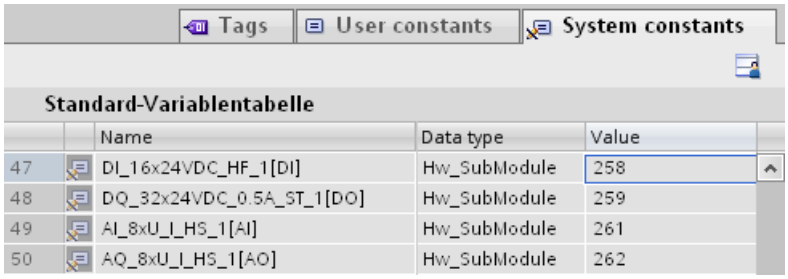


Figure 7-7 Example of a default tag table from STEP 7

7.1.2 Addressing digital modules

Introduction

The addressing of digital modules is described below. In your user program, you require the addresses of the channels of the digital module.

Digital module addresses

The address of a digital module's input or output is composed of the byte address and the bit address. The channels of the digital module are assigned bit addresses.

If you enable the value status for a digital module, then additional bytes are allocated in the input address area. Each bit is assigned to a channel and returns information about the validity of the digital value (0 = incorrect value).

The value status is a binary additional information of a digital input signal. The value status is entered simultaneously with the process signal in the process image input and provides information about the validity of the signal.

Example: I 1.2

The example consists of:

I	Input	-
1	Byte address	The byte address depends on the module start address
2	Bit address	You read the bit address from the module

When you insert a digital module into a free slot, STEP 7 assigns a default address. You can change the proposed default address in STEP 7.

Example for the assignment of channel addresses (digital module)

The following figure shows how the addresses of the individual channels of the digital input module (e.g., 6ES7521-1BL00-0AB0) are determined.

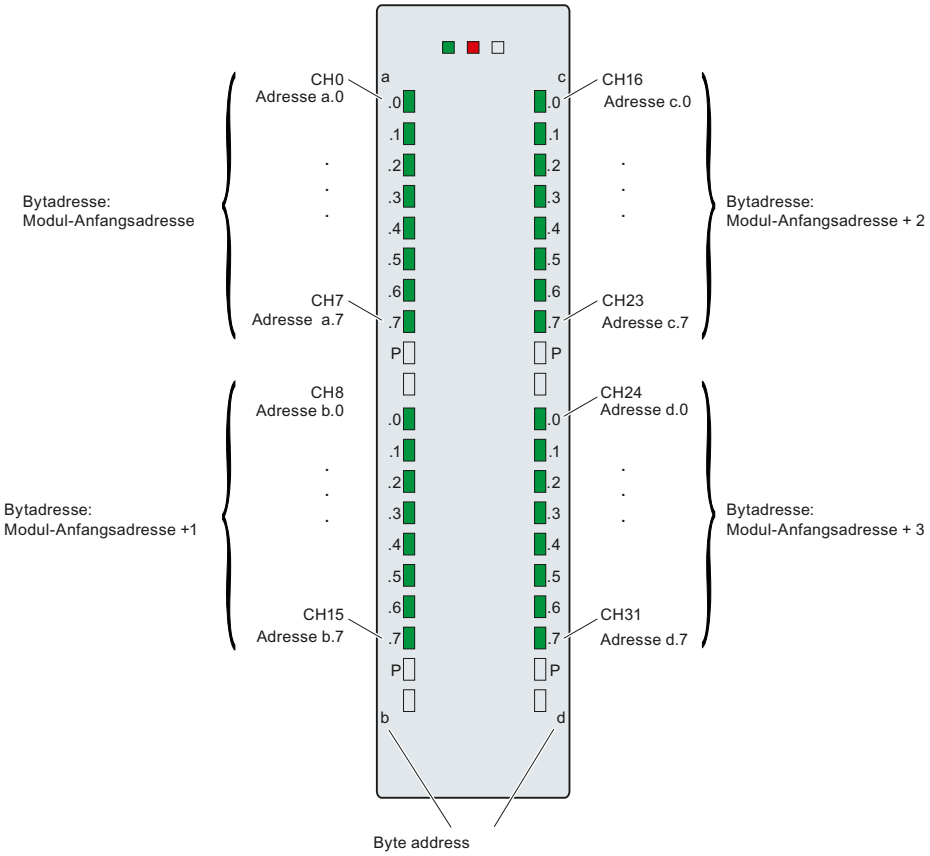


Figure 7-8 Example for the assignment of channel addresses (digital module)

Note

You can also assign symbolic names to the addresses in STEP 7's PLC tag table.

Reference

Additional information on addressing and address allocation with value status can be found in the manuals of the digital modules, and in the online help for STEP 7.

7.1.3 Addressing analog modules

Introduction

The addressing of analog modules is described below. In your user program, you require the addresses of the channels of the analog module.

Analog module addresses

The address of an analog channel is always a word address. The channel address depends on the module start address. The channel addresses are automatically assigned during configuration in STEP 7. Based on the module start addresses, the assignment of the channel addresses occurs in increasing sequence (in the following figure, the module start address is 256).

When you insert an analog module into a free slot, STEP 7 assigns a default address. You can change the assigned default address in STEP 7.

If you enable the value status for an analog module, then additional bytes are allocated in the input address area. Each bit in this byte is assigned to a channel and returns information about the validity of the analog value (0 = incorrect value).

Example for the assignment of channel addresses (analog module)

The following figure shows how the addresses of the of the individual channels of the analog input module (e.g., 6ES7531-7NF10-0AB0) are determined, when the module has the start address 256.

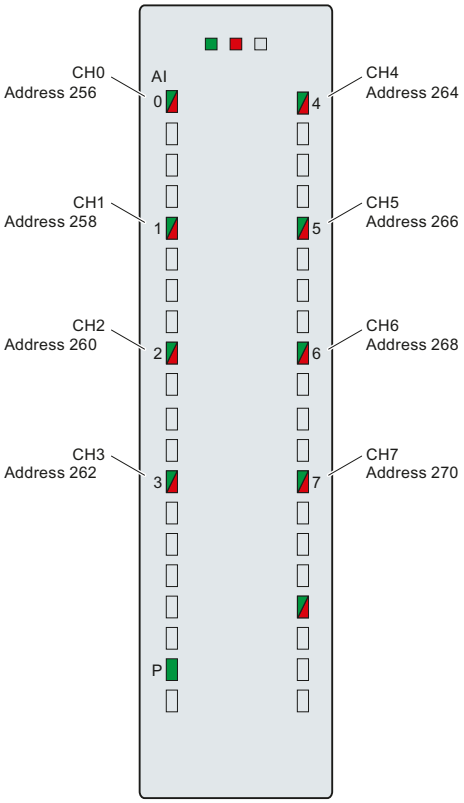


Figure 7-9 Example for the assignment of channel addresses (analog module)

Note

Names are assigned to the addresses in STEP 7's PLC tag table.

Reference

Additional information on addressing and address allocation with value status can be found in the manuals of the analog modules, and in the online help for STEP 7.

7.2 Process images and process image partitions

7.2.1 Process image - overview

Process image of the inputs and outputs

When the user program addresses the input (I) and output (O) operand areas, it does not query the signal states directly from the I/O modules. Instead, it accesses a memory area of the CPU. This memory area contains an image of the signal states and is called the process image.

Advantages of the process image

A process image offers the advantage that you can access a consistent image of process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The process image is not updated until the next cycle.

You can only assign the addresses of a module to a single process image partition.

32 process image partitions

In the S7-1500 automation system, the overall process image is subdivided into up to 32 process image partitions (PIP).

PIP 0 (automatic update) is automatically updated in each program cycle and is assigned to OB 1.

Process image partitions PIP 1 through PIP 31 can be assigned to the other OBs. This assignment occurs in the TIA Portal when configuring the I/O modules.

7.2.2 Automatically update process image partitions

One process image partition can be assigned to each organization block. In this case, the process image partition is automatically updated. The exceptions are PIP 0 and isochronous OBs.

Update process image partition

The process image partition is divided into two parts:

- Process image partition of the inputs (PIPI)
- Process image partition of the outputs (PIPQ)

The process image partition of the inputs (PIPI) is always read in/updated before the processing of the associated OB. The process image partition of the outputs (PIPQ) is always output at the end of the OB.

The following figure illustrates the updating of the process image partitions.

PIPIx read in	Processing of the program in the called OB	PIPQx output

Figure 7-10 Update process image partitions

7.2.3 Update process image partitions in the user program

As an alternative to the automatic updating of process image partitions, you can update process images with the "UPDAT_PI" instruction or the "UPDAT_PO" instruction. In STEP 7, these instructions are available on the "Instructions" Task Card under "Extended instructions" and may be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

- The process image partitions may not be assigned to any OB, i.e. they may not be automatically updated.
- PIP 0 (automatic update) can likewise not be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: Update the process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: Update the process image partition of the outputs

With this instruction you transmit the process image partition of the outputs to the output modules.

Reference

Additional information on process image partitions is available found in the function manual, Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

Commissioning 8

8.1 Commissioning S7-1500 - overview

Introduction

In this section you will find summary information about the necessary steps for commissioning an S7-1500.

Commissioning requirements

Note

You must ensure the safety of your plant. Therefore, you must perform a complete functional test and the necessary safety checks before commissioning a plant.

Also allow for any possible foreseeable errors in the tests. In this way, you avoid endangering persons or plants during operation.

8.2 Review before the first power-on

Review before the first power-on

Before the first power-on check the installation and the wiring of the S7-1500 automation system.

Questions for the review

The following questions provide guidance for the review of your S7-1500 automation system in the form of a checklist.

Racks

- Are the mounting rails firmly installed on the wall, in the framework, or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Has the connection between reference ground and ground been correctly made on all mounting rails?
- Are the required equipotential bonding cables connected with low impedance to the affected analog parts?

Module installation and wiring

- Are all the modules inserted / installed in accordance with the mounting plan and corresponding to the configuration with STEP 7 and screwed firmly to the mounting rail?
- Are all the front connectors wired according to the circuit diagram, in the final position, and inserted on the correct module?
- Are the correct modules installed and connected to each other with U connectors?
- Are U-connectors projecting either at the left-hand or right-hand over the outer modules at the S7-1500 automation system?

System power supply or load current supply

- Are all the system power supply and load current supply modules switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

8.3 Commissioning procedure

Requirements

The following requirements must be met:

- CPU that is in the "Factory settings" state or has been reset to Factory settings (Page 125)
- SIMATIC memory card that is in the delivered condition and formatted

Commissioning procedure

For the first commissioning of an S7-1500 automation system, we recommend the following procedure:

Action	Remark
Configure hardware in STEP 7 and perform power balance calculation (see also "Special considerations: CPU as bus device")	See the Power balance calculation (Page 35) section.
Create user program	See the STEP 7 online help
Insertion of all required modules	See the Installation (Page 39) section
Wiring of the assembly (power supply modules, front connectors, ...)	See the Wiring (Page 53) section
Insertion of the SIMATIC memory card into the CPU	See the section, Insertion/removal of the SIMATIC memory card (Page 97)
First power-on	Switch on the CPU and power supply module. See the First power-on (Page 98) section
LED check	Notes on the meaning of the LEDs can be found in the manuals of the modules, and in the System Diagnostics Function Manual (http://support.automation.siemens.com/WW/view/en/59192926).
Evaluate information on the CPU's display	See the section, Display of the CPU (Page 141)
Configure hardware in STEP 7 and upload to the CPU	See the "Online and diagnostics" functions in the TIA Portal
Test the inputs and outputs	The following functions are helpful: Monitoring and controlling tags, testing with program status, forcing, controlling the outputs in STOP mode. See the Test functions and fault resolution (Page 129) section

Special considerations: CPU as bus device

For the operation of a CPU, the following requirements must be noted:

- PROFIBUS interface (only at CPU 1516-3 PN/DP)
  - The integrated PROFIBUS interface of the CPU is configured using STEP 7 (participant IP address and bus parameters configured).
  - The CPU is connected to the subnet.
  - The terminating resistors at the segment boundaries are switched on.

  See the PROFIBUS Function Manual (http://support.automation.siemens.com/WW/view/en/59193579)
- PROFINET interface
  - The integrated PROFINET interface of the CPU is configured using STEP 7 (IP address and device name configured).
  - The CPU is connected to the subnet.

  See the PROFIBUS Function Manual (http://support.automation.siemens.com/WW/view/en/49948856)

8.3.1 Removing/inserting the SIMATIC memory card

Requirements

The CPU only supports pre-formatted SIMATIC memory cards. As applicable, delete all previously stored data before using the SIMATIC memory card. Additional information about deleting the contents of the SIMATIC memory card can be found in the section, SIMATIC memory card - overview (Page 135).

In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. For this purpose, slide the slider out of the lock position.

Insertion of the SIMATIC memory card

1. Open the front cover of the CPU.
2. Ensure that the CPU is either switched off, or in the STOP mode.
3. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.

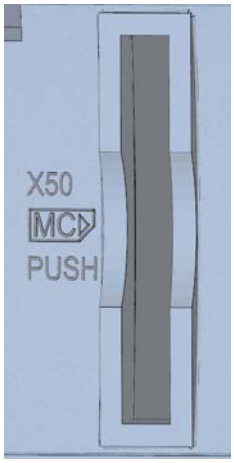


Figure 8-1 Slot for the SIMATIC memory card

4. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removal of the SIMATIC memory card

1. Open the front cover.
2. Switch the CPU into STOP mode.
3. Press the SIMATIC memory card into the CPU with light pressure. After audible unlatching of the SIMATIC memory card, remove it.

Reactions after removing/inserting the SIMATIC memory card

When inserting and removing the SIMATIC memory card, the CPU automatically performs memory reset, and then goes into STOP mode.

The CPU evaluates the SIMATIC memory card, and indicates this by flashing the RUN/STOP LED.

Reference

Additional information on the SIMATIC memory card can be found in the SIMATIC memory card (Page 135) section.

8.3.2 First power-on

Introduction

The following procedure describes the commissioning of the CPU.

Requirements

- An S7-1500 automation system is installed and wired
- SIMATIC memory card has been inserted into the CPU

First power-on of a CPU

Switch on the system power supply and load power supply.

Result:

The CPU executes a flash test:

- All LEDs flash at 2 Hz
- RUN/STOP LED flashes alternately yellow/green
- ERROR LED flashes red
- MAINT LED flashes yellow

This is followed by system initialization with evaluation of the SIMATIC memory card:

- RUN/STOP LED flashes yellow at 2 Hz

After the system initialization has been completed, the CPU goes to STOP mode:

- The RUN/STOP LED lights up yellow

8.4 Operating modes

Introduction

Operating modes describe the states of the CPU. The following operating states are possible via the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, e.g. via the PN/IE interface.

The status LEDs on the front side of the CPU indicate the current operating mode.

Reference

You can find additional information in the STEP 7 online help.

8.4.1 Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:

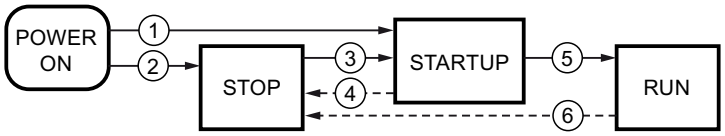


Figure 8-2 Operating modes and operating mode transitions

The following table shows the conditions under which the operating modes change:

Table 8- 1 Operating mode conditions

No.	Operating mode transitions	Conditions
①	POWER ON → STARTUP	After switching on, the CPU goes into "STARTUP" mode, if: • The hardware configuration and program blocks are consistent. • The start-up type "Warm restart RUN" is set or the start-up type "Warm restart operating mode before POWER OFF" is set and was in RUN mode before POWER OFF. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
②	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are consistent or • the "No restart" startup type is set. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
③	STOP → STARTUP	The CPU goes into the "STARTUP" operating mode, if: • The hardware configuration and program blocks are consistent. • The CPU is set to "RUN" by the programming device or via the display and the mode selector are in the RUN position or • the mode selector is switched from STOP to RUN. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
④	STARTUP → STOP	The CPU returns to the "STOP" operating mode in the following cases of "START-UP": • An error is detected during start-up. • The CPU is set to "STOP" mode from the programming device. • A STOP command is executed in the Startup OB.
⑤	STARTUP → RUN	The CPU goes to the "RUN" mode in the following cases of "START-UP": • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.
⑥	RUN → STOP	The CPU returns to the "STOP" operating mode in the following cases of "RUN": • An error is detected that prevents continued processing. • A STOP command is executed in the user program. • The CPU is set to "STOP" mode from the programming device, the display or the mode selector.

Setting the startup behavior

Proceed as follows to set the startup behavior:

1. In the device view of the STEP 7 hardware network editor, select the CPU.
2. In the properties under "General" select the "Startup" area.

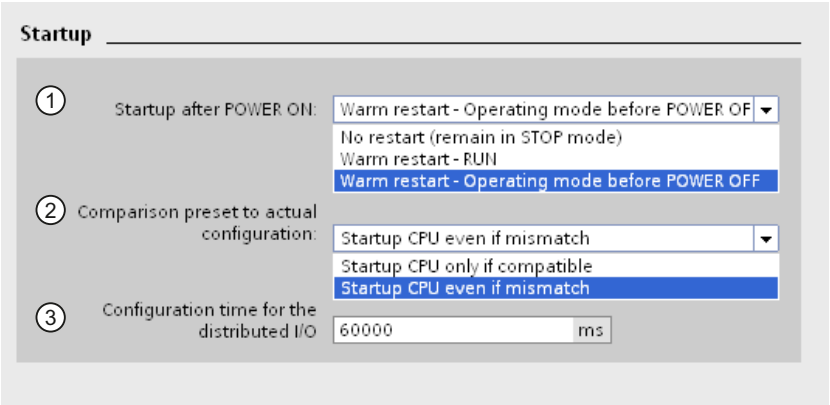


Figure 8-3 Setting the startup behavior

① Setting the startup type after POWER ON

② Defines the startup behavior for the case where a module in a slot does not correspond to the configured module. This parameter applies to the CPU and to all the modules for which no other setting was selected.

- Startup of the CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module.
- Startup of the CPU even if there are differences: At this setting the CPU starts up irrespective of the type of module plugged.

For locally used modules you can configure the hardware compatibility in the parameter "Comparison between preset module and actual module" individually for each slot. When you change the setting of the hardware compatibility for a module, the setting made at the CPU does not apply for this module.

③ Specifies a maximum period (default: 60000 ms) in which the central and distributed I/O must be ready for operation. The CMs and CPs are supplied with voltage and communication parameters during the CPU startup. This parameter assignment time grants a period, within which the I/O modules connected to a CM or CP must be operationally ready.
The CPU goes into RUN mode when the central and the distributed I/O is operationally ready within the parameter assignment time.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the hardware compatibility.

Hardware compatibility

Compatible means that the module matches the number of inputs and output and must match with respect to its electrical and functional properties. A compatible module must be fully able to replace a configured module; it may be more capable, but not less capable.

In case of the "Startup of the CPU only if compatible" setting the CPU only starts up if the configured module or a compatible module is inserted. The CPU does not start up if an incompatible module is inserted.

Example for the "Startup of the CPU only if compatible" setting:

The input module DI 32x24VDC HF with 32 digital inputs is a compatible replacement for the input module DI 16x24VDC HF with 16 digital inputs, because the pin assignment and all the electrical and functional properties agree.

Example for the "Startup of the CPU even if there are differences" setting:

Instead of a configured digital input module an analog output module is plugged or no module is present in this slot. Although the configured inputs cannot be accessed, the CPU starts up.

Note in this case that the user program cannot function correctly, so take the appropriate measures!

8.4.2 "STARTUP" mode

Function

Before the CPU starts to execute the cyclic user program, a startup program is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the startup program. That is, you can set up one or several startup OBs in your program, or none at all.

Special features during startup

Note the following points regarding the "STARTUP" mode:

- All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operating mode.
- The process image is initialized.
- The process image is not updated.
  In order to read the current state of inputs during STARTUP, you can access inputs by direct I/O access.
  In order to initialize outputs during STARTUP, values can be written via the process image or via direct I/O access. The values are output at the outputs during the transition to the RUN mode.
- The CPU always starts up in a warm restart.
  - The non-retentive bit memories, timers and counters are initialized.
  - The non-retentive tags in data blocks are initialized.
- During startup, no cycle time monitoring is running yet
- The startup OB are executed in the sequence of the startup OB numbers. All startup OBs that you have programmed are executed, regardless of the selected startup mode.
- The following OBs can be started during startup, if a corresponding event occurs:
  - OB 82: Diagnostic error interrupt
  - OB 83: Removal/insertion of modules
  - OB 86: Rack error
  - OB 121: Programming error (only for global error handling)
  - OB 122: I/O access error (only for global error handling)

  All other OBs cannot be started until the transition into the "RUN" operating mode.

Response when expected and actual configurations do not match

The expected configuration is represented by the configuration loaded into the CPU. The actual configuration is the actual configuration of the automation system. If the expected configuration and actual configuration deviate from one another, then the CPU's behavior is specified by the setting of the hardware compatibility. For additional information about the hardware compatibility, see the section Operating mode transition (Page 99).

Canceling a startup

If errors occur during startup, the startup is canceled and the CPU remains in "STOP" mode.

Under the following conditions, a startup will not be performed or will be canceled:

- If no SIMATIC memory card is inserted or an invalid one is inserted.
- If no hardware configuration has been downloaded.

Parameter assignment of startup behavior

You can assign parameters for the behavior of the CPU in the "Startup" group of the CPU properties. Additional information on configuring the startup behavior can be found in the Operating mode transitions (Page 99) section.

8.4.3 "STOP" mode

Function

In the "STOP" operating mode the user program is not executed.

All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and thus hold the controlled process in a safe operating mode.

8.4.4 "RUN" mode

Function

In "RUN" mode the cyclic, time-driven, and interrupt-driven program execution is performed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. See also the Process images and process image partitions (Page 89) section.

Execution of the user program

Once the CPU has read the inputs, the cyclic program is executed from the first instruction to the last instruction.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time is up even if the user program is completed sooner.

A maximum cycle time is set which you can adjust according to your requirements. This ensures that the cyclic program is completed within a specified time. If the cyclic program has not finished running within this time, the system responds with a time error.
Further events such as hardware interrupts and diagnostic interrupts can interrupt the cyclic program flow and prolong the cycle time.

Reference

Further information about cycle and response times is available in the Function Handbook Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

8.5 Memory reset

Basics of a memory reset

A memory reset on the CPU is possible only in the STOP operating mode.

When memory is reset, the CPU is changed to a so-called "initial status".

This means that:

- An existing online connection between your programming device/PC and the CPU is terminated.
- The content of the work memory and the retentive and non-retentive data are deleted.
- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). These data are copied from the load memory to the work memory. As a result, the DBs no longer have current values but their initial values.
- The diagnostics buffer, the time of day and the IP address are retained, in as far as they are not set in the project.

How can I tell if the CPU is performing a memory reset?

The RUN/STOP LED flashes yellow at 2 Hz. After completion the CPU goes into STOP mode, and the RUN/STOP LED is switched on (unchanging yellow).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Retained
Diagnostics buffer entries (retentive area)	Retained
Diagnostics buffer entries (non-retentive area)	Initialized
Operating hours counter	Retained
Time of day	Retained

8.5.1 Automatic memory reset

Possible cause of automatic memory reset

The CPU executes an automatic memory reset, if an error occurs that prevents normal further processing.

Causes for such errors can be:

- User program is too large, and can't be completely loaded into work memory.
- The project data on the SIMATIC memory card are damaged, for example because a file was deleted.
- If the SIMATIC memory card is removed during POWER OFF, and reinserted with a new user program.
- When a SIMATIC memory card is removed or inserted while the CPU is switched on.

8.5.2 Manual memory reset

Reason for manual memory reset

Memory reset is required to reset the CPU to its "original state".

Options for performing memory reset on a CPU

There are three options for performing a memory reset on the CPU:

- Using the operating mode switch
- Using the display
- Using STEP 7

Procedure using the operating mode switch

Note

Memory reset ↔ Reset to factory settings

The selector operation described below also reflects the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: Memory reset is executed
- Selector operation without inserted SIMATIC memory card: Reset to factory settings is executed

Proceed as follows to reset the CPU memory using the mode selector switch:

1. Set the operating mode switch to the STOP position.

   Result: The RUN/STOP LED lights up in yellow.
2. Set the operating mode switch to the MRES position. Hold the selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the selector.
3. Within the next three seconds, switch the operating mode switch back to MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

Procedure using the display

To navigate to the desired "Memory reset" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Memory reset

Result: The CPU executes memory reset.

Procedure using STEP 7

To perform a memory reset of the CPU using STEP 7, follow these steps:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU is set to STOP mode and performs memory reset.

8.6 Identification and maintenance data

8.6.1 Reading out and entering I&M data

Introduction

Identification and maintenance data (I&M data) is data saved on the module as read-only (I data) or read/write (M data) information.

Identification data (I&M0): Manufacturer information about the module, that can only be read, and is in part also printed on the housing of the module, e.g., order number and serial number.
Maintenance data (I&M1, 2, 3): system-specific information, e.g. the installation location. Maintenance data for the S7-1500 are created during configuration and loaded into the automation system.

All modules of the S7-1500 support identification data (I&M0 through I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a plant
- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

You can read out the identification data with STEP 7 (see online help for STEP 7).

Options for reading out I&M data

- via the user program
- via the CPU's display
- via the CPU's web server
- via STEP 7 or HMI devices

Procedure for reading I&M data via the user program

To read the modules' I&M data in the user program, use the RDREC instruction.

The record structure for centrally inserted modules, as well as for modules that are accessible distributed through PROFINET IO / PROFIBUS DP, is described in the Record structure for I&M data (Page 112) section.

Procedure for reading I&M data via the display

Proceed as follows to read the I&M data "higher level designation" or "location designation" of the CPU via the display:

1. Navigate to the "Overview" menu on the display of the CPU.
2. Select "higher level designation" or "location designation" and confirm with "OK".

Proceed as follows to read the I&M data "higher level designation" or "location designation" of a centrally used module:

1. Navigate to the "Modules" menu on the display of the CPU.
2. Select the menu command "Local modules" and confirm with "OK".
3. Select the slot of the module (for example Slot 3: DI 32 x 24VDC HF) and confirm with "OK".
4. Select the "Status" and confirm with OK.
5. Select "higher level designation" or "location designation" and confirm with "OK".

Proceed as follows to read the I&M data "higher level designation" or "location designation" of a distributed module:

1. Navigate to the "Modules" menu on the display of the CPU.
2. Select the corresponding distributed I/O system (for example PROFINET IO system) and confirm with "OK".
3. Select the corresponding device (for example ET 200SP-Station_1) and confirm with "OK".
4. Select the slot of the module (for example Slot 1: DI 16 x DC24V ST_1) and confirm with "OK".
5. Select the "Status" and confirm with OK.
6. Select "higher level designation" or "location designation" and confirm with "OK".

Procedure for reading I&M data via the web server

The procedure is extensively described in the Identification section of the Web Server Function Manual (http://support.automation.siemens.com/WW/view/en/59193560).

Procedure for reading I&M data via STEP 7

Requirements: There must be an online connection to the CPU.

1. In the project tree, select the CPU and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "General" area.

Procedure for entering maintenance data via STEP 7

The default module name is assigned by STEP 7. You can enter the following information:

- Plant designation (I&M 1)
- Location identifier (I&M 1)
- Installation date (I&M 2)
- Additional information (I&M 3)

1. In the device view of the STEP 7 device configuration, select the CPU or a module.
2. In the properties under "General" select the "Identification & Maintenance" area, and enter the data.

During the loading of the hardware configuration, the maintenance data (I&M 1, 2, 3) are also loaded.

Reference

The description of the instructions can be found in the STEP 7 online help.

8.6.2 Record structure for I&M data

Reading I&M records (centrally and distributed via PROFINET IO)

You can directly access specific identification data for a module using **Read record** ("RDREC" instruction). Under the associated record index you obtain the corresponding part of the identification data.

The records are structured as follows:

Table 8- 2 Basic record structure for I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/Index $AFF0_H$: 54 I&M1/Index $AFF1_H$: 54 I&M2/Index $AFF2_H$: 16 I&M3/Index $AFF3_H$: 54	- - - -

Table 8- 3 Record structure for I&M identification data

Identification data	Access	Example	Explanation
Identification data 0: (record index AFF0$_H$)			
VendorIDHigh	read (1 bytes)	0000$_H$	Vendor name (002A$_H$ = SIEMENS AG)
VendorIDLow	read (1 bytes)	002A$_H$	
Order_ID	read (20 bytes)	6ES7516-3AN00-0AB0	Order number of the module (e.g. CPU 1516-3 PN/DP)
IM_SERIAL_NUMBER	read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	read (2 bytes)	1	corresponds to hardware version (e.g. 1)
IM_SOFTWARE_REVISION	read	Firmware version	Provides information about the firmware version of the module (e.g. V1.0.0)
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_ Enhancement	(1 byte)	0000$_H$ - 00FF$_H$	
• IM_SWRevision_Bug_Fix	(1 byte)	0000$_H$ - 00FF$_H$	
• IM_SWRevision_Internal_ Change	(1 byte)	0000$_H$ - 00FF$_H$	
IM_REVISION_COUNTER	read (2 bytes)	0000$_H$	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	read (2 bytes)	0000 $_H$	Generic Device
IM_PROFILE_SPECIFIC_TYPE	read (2 bytes)	0001$_H$	CPU
		0003$_H$	I/O modules
IM_VERSION	read	0101$_H$	Provides information on the ID data version (0101$_H$ = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	read (2 bytes)	000E$_H$	provides information about the available identification and maintenance data (I&M1 to I&M3)
Maintenance data 1: (Record index AFF1$_H$)			
IM_TAG_FUNCTION	read/write (32 bytes)	-	Enter an identifier for the module here, that is unique plant-wide.
IM_TAG_LOCATION	read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (Record index AFF2$_H$)			
IM_DATE	read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (Record index AFF3$_H$)			
IM_DESCRIPTOR	read/write (54 bytes)	-	Enter a comment about the module here.

Reading I&M records with record 255 (decentrally via PROFINET IO)

The modules also support standardized access to the identification data via record 255 (index 65000 through 65003). Additional information on the data structure of record 255 can be found in the specifications of the PROFIBUS Guideline - order no. 3.502, version 1.1.1, from March 2005.

Maintenance 9

9.1 Removing and inserting I/O modules

Front connectors and I/O modules must only be inserted or removed when the voltage is switched off.

NOTICE
Physical damage can occur If you install or uninstall front connectors and/or I/O modules with switched-on voltage, this can lead to undefined conditions in your plant. Physical damage to the S7-1500 automation system may occur as a result. Therefore only install/uninstall front connectors and/or I/O modules with switched-off voltage. Therefore during the planning of a plant always make sure to comply with the necessary, pertinent standards and safety guidelines.

9.2 Replacement of I/O modules and front connectors

9.2.1 Coding element on the I/O module and on the front connector

Introduction

All front connectors for the I/O modules of the S7-1500 automation system are identical. The coding element prevents a front connector from being inserted on a module with a different electrical pin assignment.

In the delivery state, the coding element is located in the I/O module.

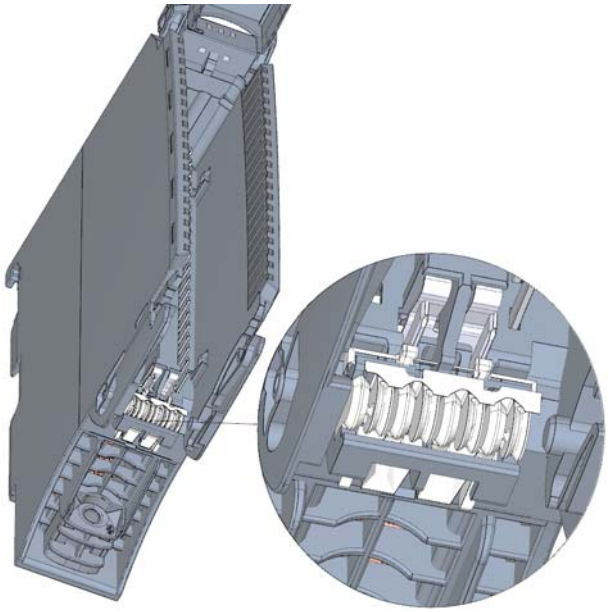
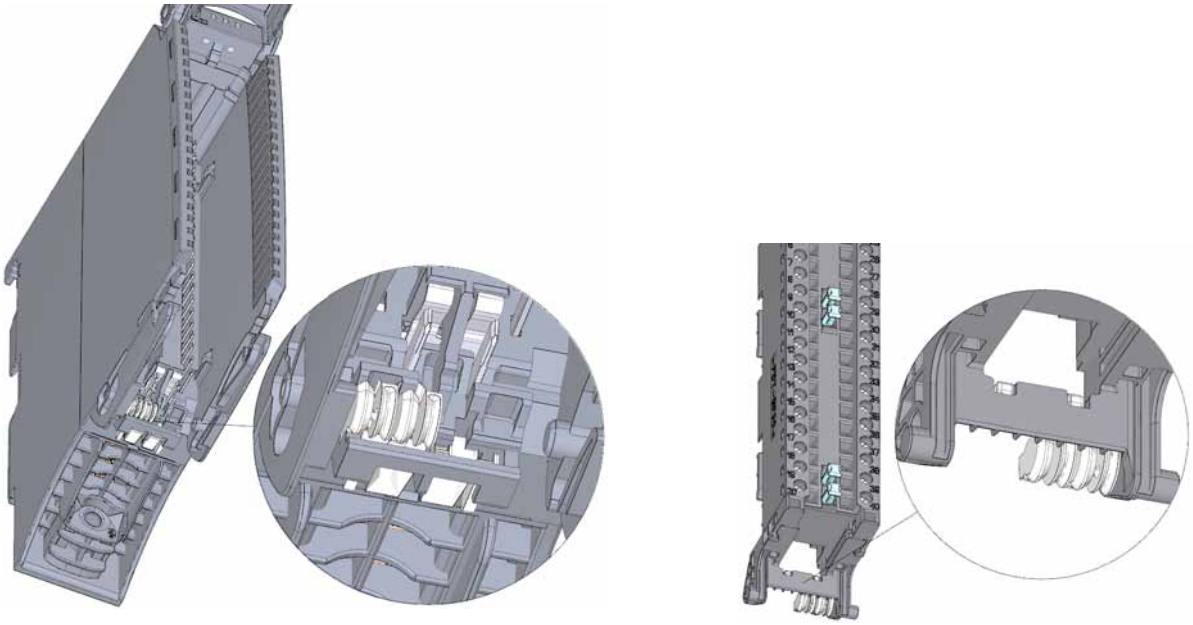


Figure 9-1 Coding element in the I/O module (delivery condition)

When the front connector is inserted into the I/O module for the first time, one half of the coding element latches into the front connector. When the front connector is removed from the I/O module, this half of the coding element remains in the front connector, while the other half remains in the I/O module.



I/O module with separated coding element

Front connector with separated coding element

Figure 9-2 Coding element in the I/O module/front connector

A coded front connector can be inserted on modules with the same electrical pin assignment.

Please note the Application Planning (Page 29) section.

NOTICE
Physical damage can occur If the coding element is changed or removed, it will be possible to insert the front connector on modules in which the electrical connection is not properly wired. This can destroy the module and/or the connected sensors and actuators. Even hazardous plant states are possible. Do not change the coding element unless you want to use the front connector on a different module and you change the process wiring accordingly.

Use cases for replacing the coding element

- Replacing an I/O module, for example due to a defect or to incorrect assembly
- Replacing a front connector

9.2.2 Replacing an I/O module

Introduction

When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When you replace an I/O module with the same type of module, the correct coding element is already present in the front connector.

Replacing an I/O module

You have already uninstalled the I/O module.

1. With a new I/O module, use a screwdriver to break out the half of the coding element that is designated for the front connector.

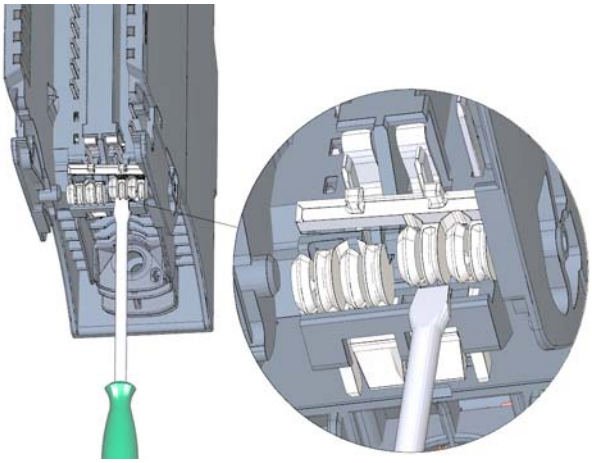


Figure 9-3 Breaking the coding element out of the I/O module

2. Insert the old front connector into the new I/O module (same module type) until your hear it click into place.

9.2.3 Replacing a front connector

Introduction

When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When you replace a defective front connector with a new front connector, then you must transfer the coding element into the new front connector.

Replacing a front connector

You have already removed the front connector from the module and loosened the wiring. If you are using the front connector for an analog module, you also need to remove the power supply element and shield element. Proceed as follows to replace the front connector:

1. Carefully remove the coding element from the front connector. Take care not to damage the coding element.

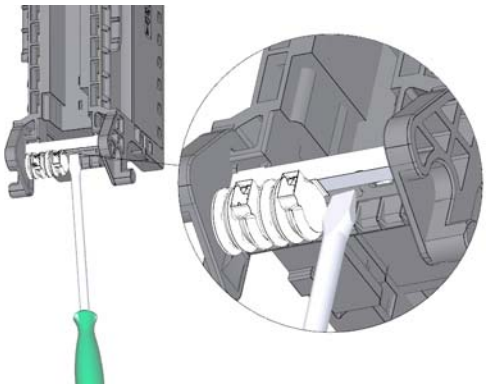


Figure 9-4 Removing the coding element from the front connector

2. Insert the removed coding element into the new front connector.

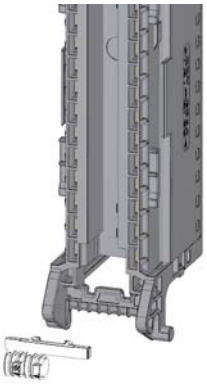


Figure 9-5 Inserting the coding element into the front connector

3. Insert the new front connector into the existing I/O module, until your hear it click into place.
4. Wire the new front connector.

9.3 Replacing the coding element at the power connector of the system power and load current supply

Introduction

The coding consists of a 2-part coding element.

Ex factory a part of the coding element is inserted into the back side of the power connector. The other part is firmly inserted in the system power supply or load current supply module.

This prevents the insertion of a power connector of a system power supply or load current supply module into a supply module of a different type.

⚠ DANGER

Do not manipulate the coding element, or leave it off

- If you undertake changes to the coding element or replace it, then this can lead to dangerous conditions in your plant.
- In order to prevent damage, you must not change or replace the coding.
- The coding element may not be left off.

Replacement parts scenario

Insertion of the coding element into a new power connector in the case of a replacement part.

⚠ DANGER

Dangerous voltage

When installing the coding element, you must take into account the supply voltage of the power supply module, 24 VDC, 24/48/60 VDC or 120/230 VAC/DC.

Only install the coding element with switched-off voltage.

You must insert the coding element in such a way that the power connector matches the power supply module in terms of voltage.

Procedure

1. Orient yourself to the labeling on the power cable connection.

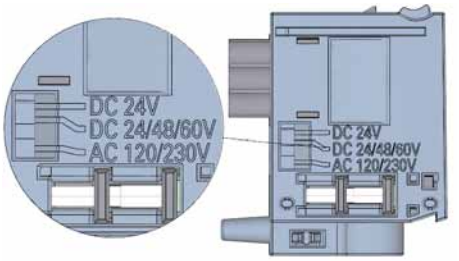


Figure 9-6 Labeling on the power connector

2. Orient yourself to the red marking on the coding element.
3. The coding element has 3 red markings. Turn the coding element in such a way that one of the 3 red markings corresponds to the voltage indicated on the connector.
4. Insert the coding element into the back side of the power cable connector, until you hear it click into place. The figure below shows you how to insert a coding element into a power cable connector for 24 VDC.

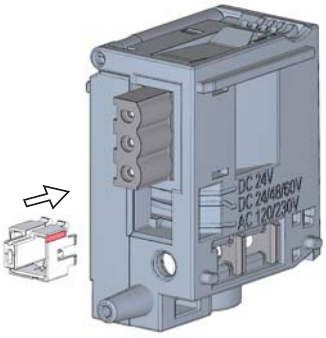


Figure 9-7 Inserting a coding element into a power connector

9.4 Firmware update

Introduction

During operation it may be necessary to update the firmware (for example due to functional enhancements).

Update the firmware of the CPU, display, and I/O modules using firmware files.

Requirements

- You have downloaded the file(s) for the firmware update from the Customer Support (http://www.siemens.com/automation/) web site.

  On this web site, select: Automation technology > Automation systems > SIMATIC industrial automation system > Controllers > SIMATIC S7 modular controllers > SIMATIC S7-1500.

  From there, navigate to the specific type of module that you want to update. To continue, click on the link for "Software downloads" under "Support". Save the desired firmware update files.
- Ensure before installing the firmware update, that the modules are not being used.

Options for the firmware update

There are two options for performing a firmware update.

- via STEP 7 (online)
- via SIMATIC memory card (possible for CPU, display, and all centrally inserted modules)

Installation of the firmware update

WARNING

Impermissible plant states possible

Due to the installation of the firmware update, the CPU enters the STOP mode, which can impact the operation of an online process or a machine.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.

Ensure before installing the firmware update, that the CPU is not executing any active process.

Procedure using STEP 7

Proceed as follows to perform an online firmware update via STEP 7:

1. Select the CPU or the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. In the "Functions" folder, select the "Firmware update" group.
   For a CPU, you can select whether you want to update the CPU or the CPU's display.
4. In the "Firmware update" area, click the "Browse" button to select the path to the firmware update files.
5. Select the matching firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Start update" button. If the selected file can be interpreted by the module, the file is downloaded to the module. If the operating mode of the CPU needs to be changed for this purpose, you will be prompted to do this by means of dialogs.

Updating the firmware

The "Run firmware after update" check box is always activated.

After a successful loading process the CPU includes imports the firmware and subsequently operates with the new firmware.

Insertion of the SIMATIC memory card

Proceed as follows perform a firmware update via the SIMATIC memory card:

Step 1: Load the firmware update onto the SIMATIC memory card

Step 2: Installation of the firmware update

Load the firmware update onto the SIMATIC memory card

1. Insert a SIMATIC memory card into an SD card reader of your programming device / computer.
2. In order to save the update file onto the SIMATIC memory card, select the SIMATIC memory card in the project tree under "Card reader/USB memory", and then in the "Project" menu select the command "Card reader/USB memory > Create firmware update memory card".

   Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether the content of the SIMATIC memory card is to be deleted or whether firmware update files are to be added to the SIMATIC memory card.

Special feature at a firmware update of analog modules

If you want to carry out a firmware update for analog modules, you have to supply 24 VDC load supply to the module through the power supply element.

Procedure

1. Remove any inserted SIMATIC memory card.
2. Insert the SIMATIC memory card with the firmware update files into the CPU.
3. The firmware update begins shortly after the SIMATIC memory card has been plugged.

   The display indicates that the CPU is in STOP mode, and that a firmware update is being executed (STOP [FW UPDATE]). It displays the progress of the firmware update. Possibly occurring errors during the firmware update will likewise be displayed on the display.
4. After a completed firmware update, the display indicates that you can remove the SIMATIC memory card.
   The RUN LED of the CPU lights up yellow, the MAINT LED flashes yellow.

Note

If your hardware configuration contains several modules, to which a firmware update from the SIMATIC memory card can be applied, then the CPU updates all affected module in the slot sequence, i.e. in increasing sequence of the module position in the STEP 7 device configuration.

Reference

Further information on the procedure can be found in the STEP 7 online help.

9.5 Resetting the CPU to factory settings

With "Reset to factory settings" the CPU is restored to the "as-delivered condition". This means that all data that were internally stored in the CPU have been deleted.

Recommendation:

If you want to remove a PROFINET CPU and use it elsewhere with a different program, or put it into storage, then the CPU should be restored to the as-delivered condition. When restoring factory settings, remember that the IP address parameters are also deleted.

Options for resetting a CPU to factory settings

There are three options for resetting the CPU to the as-delivered condition:

- Using the operating mode switch
- Using the display
- Using STEP 7

Procedure using the operating mode switch

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (RUN/STOP LED is lit up in yellow).

Note

Reset to factory settings ↔ Memory reset

The selector operation described below also reflects the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: Memory reset is executed
- Selector operation without inserted SIMATIC memory card: Reset to factory settings is executed

---

Perform a reset to factory settings, when there is no SIMATIC memory card inserted, as follows:

1. Set the operating mode switch to the STOP position.

   Result: The RUN/STOP LED lights up in yellow.

2. Set the operating mode switch to the MRES position. Hold the operating mode switch in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the selector.

3. Within the next three seconds, switch the operating mode switch back to the MRES position and then back to STOP again.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Note

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the mode selector.

Procedure using the display

Make sure that the CPU is in STOP mode (RUN/STOP LED lights up yellow).

To navigate to the desired "Factory settings" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Factory settings

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Note

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the display.

Procedure using STEP 7

Make sure there is an online connection to the CPU that is to be reset to the factory settings.

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button if you want to retain the IP address, or the "Reset IP address" option button if you want to delete the IP address.
4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 9- 1 Result after resetting to factory settings

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Initialized
Diagnostics buffer entries (retentive area)	Initialized
Diagnostics buffer entries (non-retentive area)	Initialized
Operating hours counter	Initialized
Time of day	Initialized

If a SIMATIC memory card was inserted prior to the reset to factory settings, the configuration contained on the SIMATIC memory card (hardware and software) is downloaded to the CPU. A configured IP address then becomes valid again.

Reference

Additional information on "Reset to factory settings" can be found in the Function Manual Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) in the section on memory areas and retentivity, and in the online help for STEP 7.

Test functions and fault resolution 10

10.1 Test functions

Introduction

You have the option of testing the operation of your user program on the CPU. You can then monitor signal states and values of tags and can assign values to tags to simulate specific situations in the running of the program.

Note

Using test functions

The use of test functions can influence the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirements

The following requirements must be met:

- There is an online connection to the relevant CPU.
- There must be an executable program in the CPU.

Test options

The following test options are available:

- Testing with program status
- Testing with a watch table
- Testing with a force table
- Testing with the LED flash test
- Testing with the trace and logic analyzer function

Testing with program status

The program status allows you to monitor the execution of the program. You can display the values of operands and the results of logic operations (RLO) allowing you to recognize and fix logical errors in your program.

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  This allows the current values of the individual tags of a user program or a CPU to be monitored on the programming device or PC.

  The following operand areas are possible:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs
  – Timers and counters

- Modifying tags

  You can use this function to assign fixed values to the individual tags of a user program or CPU. Modifying is also possible with Test with program status .

  The following operand areas are modifiable:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)
  – Timers and counters

- "Enable peripheral outputs" and "Modify now"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with the force table

The following functions are available in the force table.

- Monitoring of tags

  This allows the current values of the individual tags of a user program or a CPU to be displayed on the programming device or PC. Tags can be monitored with or without a trigger frequency.

  The following tags can be monitored:

  – Bit memory
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.

  – Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) is a "bypassing" of sensors / inputs by the specification of fixed values to the program. Instead of the actual input value (via process image or via direct access) the program receives the force value.
  – Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) is a "bypassing" of the complete program by the specification of fixed values to the actuators.

Difference between controlling and forcing

The fundamental difference between the controlling and forcing functions consists in the storage behavior:

- Controlling: Controlling of variables is an online function and is not stored in the CPU. You can end controlling of variables in the watch table or by disconnecting the online connection.
- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. An active force job is indicated in the display of the S7-1500 CPU through a corresponding icon. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This function is useful, for example, when you are not sure which device in the hardware configuration corresponds to the station currently selected in the software.

When you click the "Flash LED" button, an LED flashes at the currently selected station. On the CPU, the following LEDs flash: RUN/STOP LED, ERROR LED and MAINT LED. The LEDs continue to flash until you terminate the flash test.

Testing with the trace and logic analyzer function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, drive parameters or system and user tags of a CPU. The recorded data are saved on the CPU and, when required, can be displayed and read out with STEP 7.

The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

Further information on the test functions can be found in the STEP 7 online help.

Further information about testing with trace and logic analyzer functions is available in the Function Manual Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128).

10.2 Reading out/saving service data

Introduction

In addition to the contents of the diagnostics buffer, the service data contain numerous additional data points about the internal status of the CPU. If a problem with the CPU should occur, that cannot otherwise be resolved, please send the service data to our Service & Support. The service data allow Service & Support to analyze problems that have occurred rapidly.

Requirements

Service data can be read out via the Web server. For this reason the Web server has to be activated.

Procedure

1. Open a web browser that is suitable for communication with the CPU.
2. Enter the following address in the address bar of the web browser:
   https://<CPU IP address>/save_service_data.html,
   e.g., https://172.23.15.3/save_service_data.html
3. The service data page will appear on your screen, with a button for saving the service data.

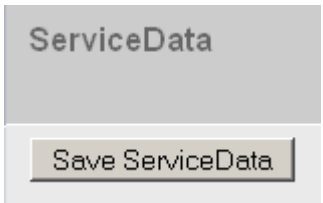


Figure 10-1 Reading out service data via the web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The data are saved in a .dmp file with the following naming convention: "<MLFB> <serial number> <time stamp>.dmp". The file name can be changed.

SIMATIC memory card 11

11.1 SIMATIC memory card - overview

Introduction

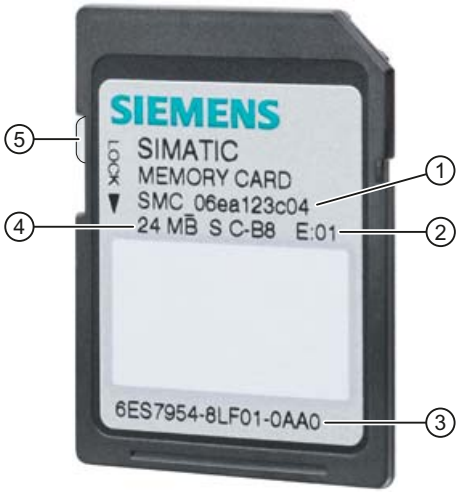
The S7-1500 automation system uses a so-called SIMATIC memory card as the program memory. The SIMATIC memory card is a preformatted memory card compatible with the Windows file system. The memory card is available in different memory sizes and can be used for the following purposes:

- Transportable data carrier
- Program card
- Firmware update card

A commercially available SD card reader is required to write / read the SIMATIC memory card with the programming device / PC. This allows, for example, files to be copied directly to the SIMATIC memory card using the Windows Explorer.

A SIMATIC memory card is absolutely required in order to operate the CPU.

Insertion of the SIMATIC memory card



① Serial number, e.g. SMC_06ea123c04
② Product version, e.g., E:01
③ Order number, e.g., 6ES7954-8LF01-0AA0
④ Memory size, e.g., 24 MB
⑤ Slider for enabling write protection:
- Slider up: not write-protected
- Slider down: write-protected

Figure 11-1 Insertion of the SIMATIC memory card

Folders and files on the SIMATIC memory card

The following folders and files can be found on the SIMATIC memory card:

Table 11- 1 Folder structure

Folder	Description
FWUPDATE.S7S	Firmware update files for CPU and I/O modules
SIMATIC.S7S	User program, i.e. all blocks (OBs, FCs, FBs, DBs) and system blocks, project data of the CPU
SIMATIC.HMI	HMI-relevant data
DataLogs	DataLog files
Recipes	Recipe files

Table 11- 2 File structure

File type	Description
S7_JOB.S7S	Job file
SIMATIC.HMI\Backup*.psb	Panel backup files
SIMATICHMI_Backups_DMS.bin	Protected files (required to use panel backup files in the TIA Portal)
__LOG__	Protected system file (required in order to use the card)
crdinfo.bin	Protected system file (required in order to use the card)
*.pdf, *.txt, *.csv, ...	Further files with different formats that you can also store in folders of the SIMATIC memory card

Use the serial number for copy protection

You can set up copy protection for CPUs, which binds execution of the block to a specific SIMATIC memory card. Configuration is carried out in STEP 7 in the properties of the block "Bind to serial number of the SIMATIC memory card".

The block can then only be executed if it is on the SIMATIC memory card with the specified serial number.

Removing the SIMATIC memory card

Only remove the SIMATIC memory card in the POWER OFF or STOP operating modes of the CPU. Ensure that no writing functions (e.g. loading/deleting a block) are active in STOP mode, or were active in POWER OFF mode. For this purpose, disconnect the communication connections.

If the SIMATIC memory card is removed during a write process, the following problems can occur:

- The data contents of a file are incomplete
- The file is no longer readable, or no longer exists
- The entire data contents are defective

If you remove the SIMATIC memory card from the CPU in the operating modes STOP, STARTUP or RUN, then the CPU performs a memory reset and then goes into STOP mode.

Removing the SIMATIC memory card from Windows computers

If you are using the card in a commercially available card reader under Windows, use the "Eject" function before you remove the card from the card reader. Otherwise data loss can arise.

Deleting the contents of the SIMATIC memory card

You have the following options for deleting the contents of the SIMATIC memory card:

- delete files using Windows Explorer
- format with STEP 7

Note

If you format the card with Windows utilities, you will render the SIMATIC memory card unusable as a storage medium for a CPU.

Deletion of files and folders is permitted, with the exception of the "__LOG__" and "crdinfo.bin" system files. These are required by the CPU. If you delete these files, then you will no longer be able to use the SIMATIC memory card with the CPU.

If the "__LOG__" and "crdinfo.bin" system files have been deleted, format the SIMATIC memory card as described in the following section.

Formatting a SIMATIC memory card

Note

Formatting of a SIMATIC memory card may only be carried out in a CPU. Otherwise the SIMATIC memory card cannot be used in the S7-1500 CPUs.

If you want to format the SIMATIC memory card using STEP 7, an online connection to the relevant CPU must exist. The relevant CPU is in the STOP mode.

Proceed as follows to format a SIMATIC memory card:

1. Open the Online and Diagnostics view of the CPU (either from the project context or via "Accessible devices").
2. In the "Functions" folder, select the "Format memory card" group.
3. Click the "Format" button.
4. Click "Yes" in response to the confirmation prompt.

Result:

- The SIMATIC memory card is formatted for use in S7-1500 CPUs
- The data on the CPU are deleted with the exception of the IP address

Service life of a SIMATIC memory card

The service life of a SIMATIC memory card depends essentially on the following factors:

- The number of delete or write processes
- External influences, e.g., ambient temperature

With an ambient temperature of up to 60 °C, at least 100,000 delete/write processes are possible on the SIMATIC memory card.

11.2 Setting the card type

Setting the card type

You can use the SIMATIC memory card as a program card or as a firmware update card.

To set the card type, insert the SIMATIC memory card in the programming device's card reader, and select the "SIMATIC Card Reader" folder in the project tree.

In the properties of the selected SIMATIC memory card, specify the card type:

- Program card

  You use a program card as an external load memory for the CPU. It contains the entire user program for the CPU. The user program is transferred from the load memory to the work memory and runs there. If the SIMATIC memory card with the user program is removed, the CPU goes into STOP mode.

  The following folder is created on the SIMATIC memory card: SIMATIC.S7

- Firmware update card

  Firmware for the CPU, for a display and for I/O modules can be stored on a SIMATIC memory card. It is thus possible to perform a firmware update with the help of a specifically prepared SIMATIC memory card.

  The following folder is created on the SIMATIC memory card: FWUPDATE.S7S

Reference

You can find additional information in the STEP 7 online help.

11.3 Data transfer with SIMATIC memory cards

Transferring objects from the project to a SIMATIC memory card

When the SIMATIC memory card is inserted into the programming device or into an external card reader, you can transfer objects as follows from the project tree (STEP 7) to the SIMATIC memory card:

- Individual blocks (multiple selection possible)

  In this case a consistent transfer is available, i.e. the dependencies between blocks due to block calls are taken into account.

- CPU folder

  In this case, all runtime-relevant objects including blocks and the hardware configuration are transferred onto the SIMATIC memory card - just as when downloading.

To perform a transfer, you can transfer the objects by dragging and dropping, or use the "Card Reader/USB memory > Write to memory card" command in the "Project" menu.

Firmware update via SIMATIC memory card

You can find information on how to perform a firmware update via SIMATIC memory card in the Firmware update (Page 122) section.

Reference

For additional information about the SIMATIC memory card, refer to the STEP 7 online help.

Display of the CPU

12

Introduction

The S7-1500 CPU has a front cover with a display and operating keys. Control data and status data can be displayed in various menus on the display, and numerous settings can be configured. You use the operating keys to navigate through the menus.

Benefits

The display of the CPU offers the following advantages:

- Reduced downtimes through diagnostic messages in plain text
- Changing of the interface settings on site without programming device
- Password assignment for display operation is possible through the TIA Portal

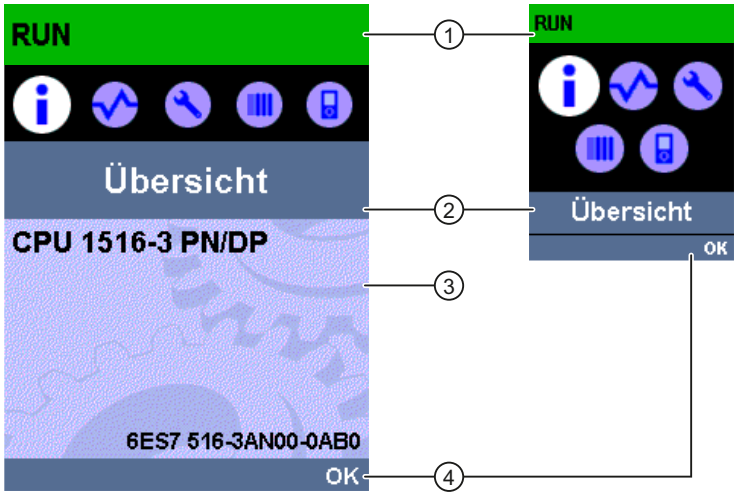
Operating temperature for the display

In order to increase the service life of the display, the display switches off before the permissible operating temperature is reached. When the display has cooled down again, it switches on automatically again. The status of the CPU continues to be indicated via the LEDs while the display is switched off.

Further information about the temperatures at which the display switches off and back on again is available in the technical data of the manuals of the CPUs.

Display

The following figures show an example view of the displays of a CPU 1516-3 PN/DP on the left and a CPU 1511-1 PN or CPU 1513-1 PN on the right.



① CPU status data
② Submenu names
③ Data display field
④ Navigation aid, e.g. OK/ESC or the page number

Figure 12-1 Example views of the displays

Regarding ①: CPU status data

The following table shows the CPU status data that can be retrieved via the display.

Table 12- 1 CPU status data

Color and icons for the status data	Meaning
green	• RUN • RUN with alarm
yellow	STOP
red	ERROR
white	• Connection establishment between CPU and display • Firmware update of the display
	Protection level configured
	Interrupt (at least one interrupt is active in the CPU)
	Fault (at least one fault is active in the CPU)
	Force table is active in the CPU

Regarding ②: Submenu names

The following table shows the available submenus of the display.

Table 12- 2 Submenu names

Main menu items	Meaning	Description
	Overview	The "Overview" menu contains information about the properties of the CPU.
	Diagnostics	The "Diagnostics" menu contains information about diagnostic messages, the diagnostic description, and the indication of interrupts. Additionally there is information about the network properties of each of the CPU's interfaces.
	Settings	In the "Settings" menu, IP addresses of the CPU are assigned, the date, time of day, time zones, operating modes (RUN/STOP) and protection levels are set, a memory reset and reset to factory settings can be performed on the CPU, and the status of firmware updates displayed.
	Modules	The "Modules" menu contains information about the modules that are used in your configuration. The modules can be centrally or peripherally deployed. Peripherally deployed modules are connected to the CPU via PROFINET and/or PROFIBUS. You can set the IP addresses for a CP here.
	Display	In the "Display" menu, settings with respect to the display can be configured, for example language setting, brightness and Energy-saving mode (the Energy-saving darkens the display. The Standby mode switches the display off).

Menu icons

The following table shows the icons that are displayed in the menus.

Table 12- 3 Menu icons

Icon	Meaning
	Editable menu item
	Select the desired language here.
	There is an alarm in the next lower level object.
	There is a fault in the next lower level object.
	Navigate to next sublevel, or alternatively: navigate using "OK" and "ESC"
	In edit mode you make the selection using two arrow keys: • down/up: jumps to a selection, or serves for selecting desired digits / options
	In edit mode you make the selection using four arrow keys: • down/up: jumps to a selection, or serves for selecting desired digits • left/right: jumps one spot forward or backward

Handling the front cover

The front cover is removable, and can be taken off or replaced during operation (RUN), during extensive work. Removing or replacing of the displays does not have any influence on the running CPU.

The front cover is removed from the CPU as follows:

1. Flip up the front cover until the front cover stands at a 90° angle to the front of the module.
2. In the upper area of the front cover simultaneously press on the anchor(s) and pull the front cover forward and away.

Note

The removal and insertion of the display is also possible during operation (RUN).

Control keys

The following keys are available on the CPU's display:

- Four arrow keys: "up", "down", "left", "right"
- An ESC key
- An OK key

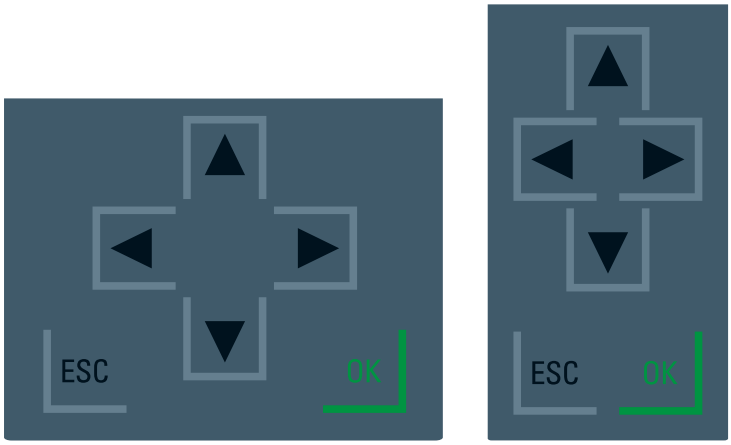


Figure 12-2 Control keys

Note

If the display is in Energy-saving mode or in Standby mode, this mode can be exited by pressing any key.

Functions of the "OK" and "ESC" keys

- At menu commands in which an entry can be made:
  - OK → valid access to the menu command, confirmation of input, and exit from the edit mode
  - ESC → set the original contents (i.e., changes are not saved) and exit from edit mode
- At menu commands in which no entry can be made:
  - OK → to next submenu item
  - ESC → back to previous menu item

Available language settings

You can set the following languages separately for menu and message texts:

- German
- English
- French
- Spanish
- Italian
- Chinese

The settings are carried out directly at the display in the "Display" menu or in STEP 7 in the hardware configuration of the CPU under User interface languages".

To display message texts on the display these have to be loaded into the CPU as a software component. To do so, select "Consistent download" under "Text libraries" in the "Load preview" dialog.

Basics of program processing 13

13.1 Events and OBs

OB start events

The occurrence of an OB start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. This means that the event is positioned in a queue that corresponds to its priority.
- If the event comes from an event source to which you have not assigned an OB, the default system reaction is executed.

Note

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

The following table provides an overview of the OB start events, including the possible values for OB priority, possible OB numbers, default system reaction and number of OBs. The table is sorted in ascending order by OB numbers.

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system reaction	Number of OBs
Startup*	1	100, ≥ 123	Ignore	0 to 100
Cyclic program*	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt*	2 to 24 (2)	10 to 17, ≥ 123	not applicable	0 to 20
time-delay interrupt*	2 to 24 (3)	20 to 23, ≥ 123	not applicable	0 to 20
Cyclic interrupt*	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	not applicable	0 to 20
Hardware interrupt*	2 to 26 (18)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Isochronous mode interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error	22	80	Ignore	0 or 1
Maximum cycle time exceeded once			STOP	
Diagnostic error interrupt	2 to 26 (5)	82	Ignore	0 or 1
Removal/insertion of modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1
MC servo interrupt	17 to 26 (25)	91	not applicable	0 or 1
MC interpolator interrupt	16 to 26 (24)	92	not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

* To these event sources, besides the permanently assigned OB numbers (see column: possible OB numbers), you can also assign OB numbers from the range ≥ 123 via the TIA Portal.

Assignment between event source and OBs

The type of OB determines where you make the assignment between OB and event source:

- With hardware interrupts and isochronous mode interrupts, the assignment is made during the configuration of the hardware or when the OB is created.
- STEP 7 automatically assigns OBs 91/92 to the MC-Servo interrupt and MC-Interpolator interrupt, as soon as an "S7-1500 Motion Control" technology object is added.
- For all other types of OB, the assignment is made when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment is changed, not the configured assignment. The configured assignment takes effect after loading, and upon each startup.

Hardware interrupts are ignored if no OB was assigned by their configuration or if they occur after the DETACH instruction. The check as to whether an OB is assigned to an event does not take place when the associated event occurs, but only when the hardware interrupt actually has to be executed.

OB priority and runtime behavior

S7-1500 CPUs support the priority classes 1 (lowest) to 26 (highest). Start events are executed with a defined priority. The processing of a start event includes in particular the updating of the process image partition of each assigned OB, and the processing of its user code.

The OBs are executed exclusively on a priority basis. This means that the OB with the highest priority will be executed first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. Events of the same priority are processed in order of occurrence.

Note

Communication

Communication always has Priority 15. This makes it possible to assign a priority greater than 15 to OBs, so that these OBs are not interrupted by the communication.

Reference

Further information on organization blocks is available in the STEP 7 online help.

13.2 CPU overload behavior

Principle of CPU overload behavior

For the event scenarios considered in the following section, it is assumed that you have assigned an OB to each event source and that these OBs have the same priority. The second condition, in particular, is only for the sake of a simplified representation.

When an event occurs, the execution of the associated OB is triggered. Depending on the OB priority and the current processor load, in most cases there is a time delay before the OB is executed. The same event can therefore occur once or several times before the OB belonging to the preceding event is processed. Such a situation is handled by the CPU as follows: In the order of their occurrence, the operating system positions the events into the queue associated with their priority.

To control temporary overload situations, you can limit the number of pending events that are linked from the same source. The next event is discarded as soon as the maximum number of pending start events of a specific cyclic interrupt OB, for example, is reached.

An overload occurs when events which originate from the same source occur faster than they can be processed.

More detailed information is provided in the following sections.

Discarding similar events or fetching them later

Below, the term "similar events" refers to events from a single source, such as start events for a specific cyclic interrupt OB.

The OB parameter "Events to be queued" is used to specify how many similar events the operating system places in the associated queue and therefore post-processes. If this parameter has the value 1, for example, exactly one event is stored temporarily.

Note

Post-processing of cyclic events is often not desirable, as this can lead to an overload with OBs of the same or lower priority. Therefore, it is generally advantageous to discard similar events and to react to the overload situation during the next scheduled OB processing. If the value of the "Events to be queued" parameter is low, this ensures that an overload situation is mitigated rather than aggravated.

If, for example, the maximum number of start events is reached in the queue for a cyclic interrupt OB, each additional start event is only counted and subsequently discarded. During the next scheduled execution of the OB, the number of discarded start events is made available (in the start information) in the "Event_Count" input parameter. You can then react appropriately to the overload situation. The CPU then sets the counter for lost events to zero.

If the CPU, for example, first discards a start event for a cyclic interrupt OB, its further behavior depends on the OB parameter "Report event overrun into diagnostic buffer": If the check box is selected, the CPU enters the event DW#16#0002:3507 once in the diagnostics buffer for the overload situation at this event source. Additional diagnostic buffer entries of the event DW#16#0002:3507 that refer to this event source are suppressed until all events from this source have been post-processed.

Threshold mechanism for time error OB request

The OB parameter "Enable time error" is used to specify whether the time error interrupt should be called when a specific overload level is reached for similar events.

If yes (check box selected), you use the OB parameter "Event threshold for time error" to specify the number of similar events in the queue at which the time error interrupt should be called. If this parameter has the value 1, for example, the event DW#16#0002:3502 is entered once in the diagnostics buffer and the time error interrupt is requested when the second event occurs. Additional diagnostic buffer entries of the event DW#16#0002:3502 that refer to this event source are suppressed until all events from this source have been post-processed.

In the event of an overload, you therefore have the option of programming a reaction well before the limit is reached for similar events and thus before the events are discarded.

The following value range applies to the "Event threshold for time error" parameter: 1 ≤ "Event threshold for time error" ≤ "Events to be queued".

Protection 14

14.1 Overview of the protective functions of the CPU

Introduction

This chapter describes the following functions for protecting the S7-1500 automation system against unauthorized access:

- Access protection
- Know-how protection
- Copy protection
- Protection by locking the CPU

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized accesses to functions and data of the S7-1500 CPU from external sources and via the network:

- Deactivation of the Web server
- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication

When the Web server is used, you protect your S7-1500 automation system against unauthorized access by setting password-protected access rights for specific users in the user management.

14.2 Configuring access protection for the CPU

Introduction

The CPU offers four access levels, in order to limit access to specific functions.

By setting up the access levels and the passwords for a CPU, you limit the functions and memory areas that are accessible without entering a password. The individual access levels as well as the entry of their associated passwords are specified in the object properties of the CPU.

Access levels of the CPU

Table 14- 1 Access levels of the CPU

Access levels	Access restrictions
Complete access (no protection)	The hardware configuration and the blocks can be read and changed by all users.
Read access	With this access level, read-only access to the hardware configuration and the blocks is possible without entering a password, which means you can download hardware configuration and blocks to the programming device. HMI access and access to diagnostics data is also possible. Without entering the password, you cannot load any blocks or hardware configuration into the CPU. Additionally, the following are **not** possible without the password: Test functions which write, changing the operating mode (RUN/STOP), and firmware update (online).
HMI access	With this access level only HMI access and access to diagnostics data is possible without entering the password. Without entering the password, you can neither load blocks and hardware configuration into the CPU, nor load blocks and hardware configuration from the CPU into the programming device. Additionally, the following are **not** possible without the password: Test functions which write, changing the operating mode (RUN/STOP), and firmware update (online).
No access (complete protection)	When the CPU is completely protected, no read or write access to the hardware configuration and the blocks is possible. HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

Each access level allows unrestricted access to certain functions without entering a password, e.g. identification using the "Accessible devices" function.

The CPU's default setting is "No restriction" and "No password protection". In order to protect access to a CPU, you must edit the properties of the CPU and set up a password.

Communication between the CPUs (via the communication functions in the blocks) is not restricted by the protection level of the CPU, unless PUT/GET communication is deactivated.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

Note

Configuring an access level does not replace know-how protection

Configuring access levels prevents unauthorized changes to the CPU, by restricting download privileges. However, blocks on the SIMATIC memory card are not write- or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC memory card.

Parameterizing the procedure at access levels

To configure the access levels of an S7-1500 CPU, follow these steps:

1. Open the properties of the S7-1500 CPU in the Inspector window.
2. Open the "Protection" entry in the area navigation.

   A table with the possible access levels appears in the Inspector window.

Protection level	Access			Access permission	
Protection	HMI	Read	Write	Password	Confirmation
Full access (no protection)	✓	✓	✓		
Read access	✓	✓			
HMI access	✓				
No access (complete protection)					

Figure 14-1 Possible access levels

3. Activate the desired protection level in the first column of the table. The green checkmarks in the columns to the right of the respective access level show you which operations are still available without entering the password.
4. In the "Password" column, specify a password for the selected access level. In the "Confirmation" column, enter the selected password again to protect against incorrect entries.

   Ensure that the password is sufficiently secure, in other words, that is does not follow a pattern that can be recognized by a machine!

   You must enter a password in the first row ("Full access" access level). This enables unrestricted access to the CPU for those who know the password, regardless of the selected protection level.
5. Assign additional passwords as needed to other access levels if the selected access level allows you to do so.
6. Download the hardware configuration to the CPU, so that the access level will take effect.

Behavior of a password-protected CPU during operation

The CPU protection takes effect after the settings are downloaded in the CPU.

Before an online function is executed, the necessary permission is checked and, if necessary, the user is prompted to enter a password. The functions protected by a password can only be executed by one programming device/PC at any one time. Another programming device/PC cannot log on.

Access authorization to the protected data is in effect for the duration of the online connection, or until the access authorization is manually rescinded with "Online > Delete access rights".

Access to a password-protected CPU in the RUN mode can be limited locally in the display so that access with a password is also not possible.

14.3 Using the display to configure additional access protection

Introduction

On the display of an S7-1500, you can block access to a password-protected CPU (local lock). The access lock is only in effect, when the operating mode switch is in the RUN position.
The access lock applies independently of password protection, i.e. if someone accesses the CPU via a connected programming device and has entered the correct password, access to the CPU is still blocked.
The access block can be set separately for each access level on the display, so that, for example, read access is allowed locally, but write access is not allowed locally.

Procedure

If an access level with a password is configured in STEP 7, access can be blocked using the display.

Proceed as follows to set the local access protection for an S7-1500 CPU on the display:

1. On the display, select Settings > Protection menu.
2. Confirm the selection using "OK", and configure for each access level, whether access at the RUN mode selector is allowed or not:

   Allow: Access to the CPU is possible, provided the corresponding password in STEP 7 is entered.

   Deactivated in RUN: When the operating mode switch is in the RUN position, no more users with privileges for this access level can log in to the CPU, even if they know the password. In STOP mode, access is possible with password entry.

Access protection for the display

A password can be configured for the display in STEP 7 in the properties of the CPU so that the local access protection is protected by a local password.

14.4 Know-how protection

You can use know-how protection to protect one or more blocks of the OB, FB, FC type and global data blocks in your program from unauthorized access. You can enter a password in order to restrict access to a block. The password protection prevents the block from being read or changed without authorization.

Without the password only the following data concerning the block can be read:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling in a program
- Online/offline comparison
- Load

Setting up block know-how protection

1. Open the properties of the respective block.
2. Select the "Protection" option under "General".

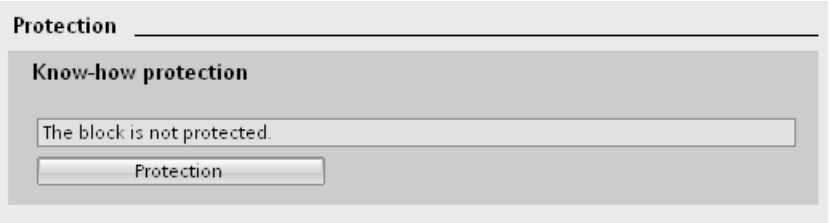


Figure 14-2 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Know-how protection" dialog.

Figure 14-3 Setting up block know-how protection (2)

4. Click the "Define" button to open the "Define password" dialog.

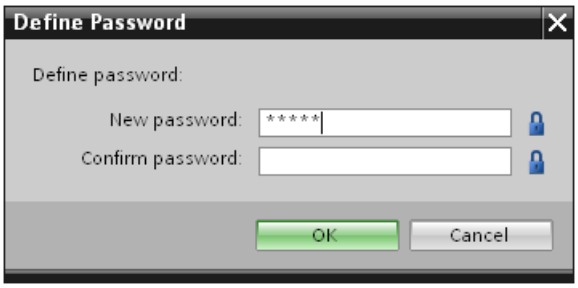


Figure 14-4 Setting up block know-how protection (3)

5. Enter the new password in the "New password" field. Enter the same password in the "Confirm password" field.
6. Click "OK" to confirm your entry.
7. Close the "Know-how protection" dialog by clicking "OK".

Result: The blocks selected will be know-how-protected. Know-how protected blocks are marked with a lock in the project tree. The password entered applies to all blocks selected.

Opening know-how protected blocks

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected block will open.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or TIA Portal is open. The password must be entered again the next time the block is opened. If you close the "Access protection" dialog with "Cancel", the block will open but the block code will not be displayed and you will not be able to edit the block.

The know-how protection of the block is not removed if, for example, you copy the block or add it to a library. The copies will also be know-how-protected.

Removing block know-how protection

1. Select the block from which you want to remove know-how protection.
2. In the "Edit" menu, select the "Know-how protection" command to open the "Know-how protection" dialog.
3. Deactivate the "Hide code (Know-how protection)" check box.

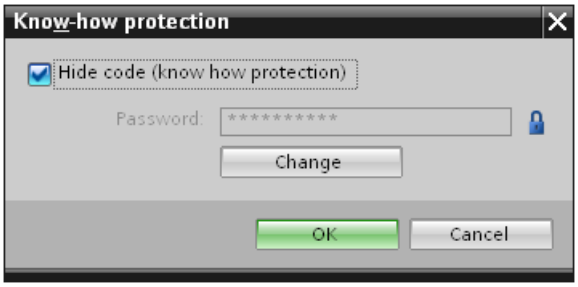


Figure 14-5 Removing block know-how protection (1)

4. Enter the password.

Figure 14-6 Removing block know-how protection (2)

5. Click "OK" to confirm your entry.

Result: Know-how protection will be removed from the block selected.

14.5 Copy protection

Copy protection allows you to bind the program or the blocks to a specific SIMATIC memory card or CPU. Through the linking of the serial number of a SIMATIC memory card or of a CPU the use of this program or of this block is only possible in combination with a specific SIMATIC memory card or CPU. With this function a program or block can be sent electronically (e.g. by e-mail) or by shipping a memory module.

When you set up such a copy protection for a block, also assign know-how-protection to this block. Without know-how protection, anyone can reset the copy protection. You must, however, set up copy protection first as the copy protection settings are read-only if the block is already know-how-protected.

Setting up copy protection

1. Open the properties of the respective block.
2. Select the "Protection" option under "General".

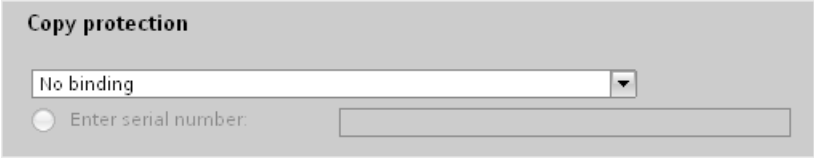


Figure 14-7 Setting up copy protection (1)

3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.

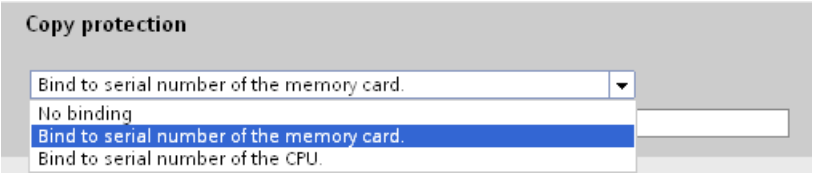


Figure 14-8 Setting up copy protection (2)

4. Enter the serial number of the CPU or the SIMATIC memory card.

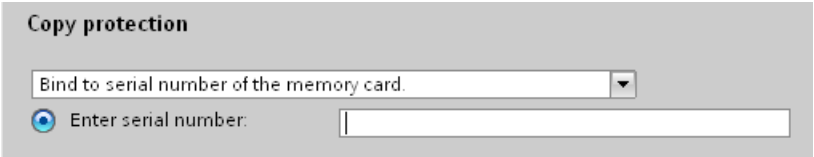


Figure 14-9 Entering the serial number

5. You can now set up the know-how protection for the block in the "Know-how protection" area.

Note

If you download a copy protected block to a device that does not match the specified serial number, the entire download operation will be rejected. This means that blocks without copy protection will also not be downloaded.

Removing copy protection

1. Remove any existing know-how protection (Page 157).
2. Open the properties of the respective block.
3. Select the "Protection" option under "General".
4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.

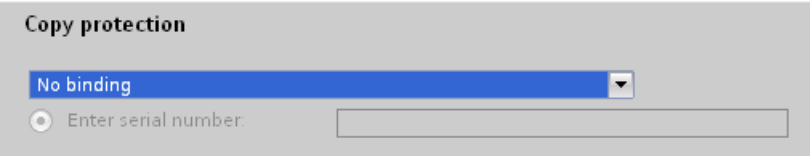


Figure 14-10 Removing copy protection

14.6 Protection by locking the CPU

Protect your CPU from unauthorized access using a sufficiently secured front cover.

You have e.g. the following options:

- affix a seal
- secure the front cover with a lock (shackle diameter: 3 mm)

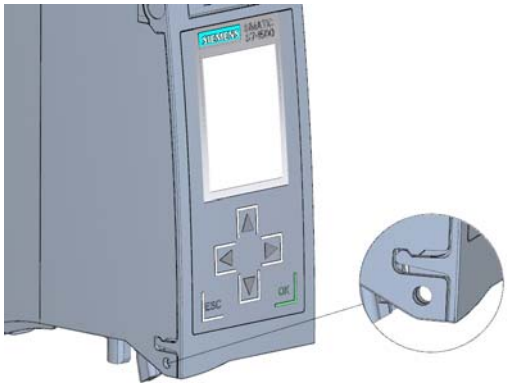


Figure 14-11 Locking latch on the CPU

Technical specifications 15

15.1 Standards and Approvals

Introduction

Contents of general technical specifications:

- The standards and test values that the modules of the S7-1500 automation system comply with and fulfill.
- The test criteria according to which the S7-1500 automation system was tested.

Note

Information on the components of the S7-1500 automation system

The current valid markings and approvals are printed on the components of the S7-1500 automation system.

Technical specifications for the modules

The technical specifications of the individual modules can be found in the manuals of respective modules. In the event of deviations between the statements in this document and the manuals, the statements in the product manuals take priority.

Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://www.siemens.com/automation/service&support).

Safety information

WARNING

Personal injury and damage to property may occur

In hazardous areas, injury to persons and material damage may occur if you disconnect plug-in connections during operation of an S7-1500 automation system.

Always switch off the power to the S7-1500 automation system when disconnecting plug-in connections in potentially explosive atmospheres.

WARNING

Explosion hazard

If you replace components, compliance with Class I, DIV. 2 could be compromised.

WARNING

Deployment requirements

This device is only appropriate for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

CE mark

The S7-1500 automation system meets the requirements and protection targets of the following EC guidelines and complies with the harmonized European standards (EN) for programmable logic controllers published in the official gazettes of the European Community:

- 2006/95/EC "Electrical Equipment Designed for Use within Certain Voltage Limits" (LowVoltage Directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC on "equipment and protective systems for use in hazardous areas" (explosion protection directive)

The EC declaration of conformity is held on file available to competent authorities at:

Siemens Aktiengesellschaft
Industry Sector
I IA AS FA WF AMB
Postfach 1963
D-92209 Amberg, Germany

These files are also available for download on the Customer Support Internet pages, under the keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment)
- C22.2 No. 142 (Process Control Equipment)

OR

cuLus HAZ LOC approval

Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.
- These products need to be connected by means of the front connector Cat. No. 6ES7592-1AM00-0XB0

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

FM approval

Factory Mutual Research (FM) according to

- Approval Standard Class Number 3611, 3600, 3810
- ANSI/ISA 82.02.01 (IEC 61010-1)
- CSA C22.2 No. 213
- CSA 22.2 No. 1010.1

APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

ATEX approval

In accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC T4 Gc

Tick mark for Australia and New Zealand

The S7-1500 automation system meets the requirements of the standard AS/NZS CISPR 16.

Korea Certification

KC registration number: KCC-REM-S49-S71500

Please note that this device corresponds to limit value class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

IEC 61131

The S7-1500 automation system meets the requirements and criteria of the standard IEC 61131-2 (programmable logic controllers, Part 2: Equipment requirements and tests).

Industrial use

SIMATIC products are designed for industrial applications.

Table 15- 1 Industrial use

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4: 2007	EN 61000-6-2: 2005

Use in residential areas

Note

The S7-1500 automation system is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you want to use the S7-1500 automation system in residential areas, you must ensure that its radio interference emission complies with limit value class B in accordance with EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the S7-1500 automation system in grounded switchboards/control cabinets
- Use of noise filters in the supply lines

15.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Among other things, the S7-1500 automation system also meets the requirements of the EMC legislation for the European single market. The prerequisite for this is that the S7-1500 system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The S7-1500 automation system meets the EMC specifications of the NAMUR guideline NE21.

Pulse-shaped disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to pulse-shaped disturbances.

Table 15- 2 Pulse-shaped disturbances

Pulse-shaped disturbance	Test voltage	corresponds with degree of severity
Electrostatic discharge in accordance with IEC 61000-4-2.	Air discharge: ±8 kV Contact discharge: ±6 kV	3 3
Burst pulses (high-speed transient disturbances) in accordance with IEC 61000-4-4.	±2 kV (power supply lines) ±2 kV (signal lines > 30 m) ±1 kV (signal lines < 30 m)	3 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 External protective circuit required (not for 230 V modules) (see the Defining interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual)		3
• asymmetric coupling	±2 kV (power supply lines) DC with protective elements ±2 kV (signal/data line only > 30 m), with protective elements	
• symmetric coupling	±1 kV (power supply lines) DC with protective elements ±1 kV (signal/data line only > 30 m), with protective elements	

Sinusoidal disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to sinusoidal disturbances (RF radiation).

Table 15- 3 Sinusoidal disturbances with RF radiation

RF radiation in accordance with IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		corresponds with degree of severity
80 to 1000 MHz; 1.4 to 2 GHz	2.0 GHz to 2.7 GHz	3
10 V/m	1 V/m	
80 % AM (1 kHz)		

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to sinusoidal disturbances (RF coupling).

Table 15- 4 Sinusoidal disturbances with RF coupling

RF coupling in accordance with IEC 61000-4-6	corresponds with degree of severity
from 10 kHz	3
10 V_{rms}	
80 % AM (1 kHz)	
150 Ω source impedance	

Emission of radio interference

Interference emission of electromagnetic fields in accordance with EN 55016: Limit value class A, group 1 (measured at a distance of 10 m).

Table 15- 5 Interference emission of electromagnetic fields

Frequency	Interference emission
30 MHz to 230 MHz	< 40 dB (µV/m) QP
230 MHz to 1000 MHz	< 47 dB (µV/m) QP

Table 15- 6 Interference emission via the AC power supply

Frequency	Interference emission
0.15 MHz to 0.5 MHz	< 79 dB (µV/m)Q < 66 dB (µV/m) M
0.5 MHz to 30 MHz	< 73 dB (µV/m)Q < 60 dB (µV/m) M

Interference emission via the AC power supply in accordance with EN 55016: Limit value class A, Group 1.

15.3 Shipping and storage conditions

Introduction

With respect to transportation and storage conditions, the S7-1500 automation system fulfills the requirements in accordance with IEC 61131-2. The following statements apply to modules that are transported and stored in the original packaging.

Shipping and storage conditions for modules

Table 15- 7 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤ 1 m
Temperature	from -40 °C to +70 °C
Barometric pressure	1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations in accordance with IEC 60068-2-6	5 - 9 Hz: 3.5 mm 9 - 500 Hz: 9.8 m/s^2
Shock in accordance with IEC 60068-2-27	250 m/s^2, 6 ms, 1000 shocks

15.4 Mechanical and climatic ambient conditions

Operating conditions

The S7-1500 automation system is suitable for use in weather-proof, fixed locations. The operating conditions exceed requirements according to DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 15- 8 Test of mechanical ambient conditions

Condition tested	Test Standard	Remark
Vibration	Vibration test according to IEC 60068-2-6 (Sinus)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. 5 Hz ≤ f ≤ 8.4 Hz, constant amplitude 7 mm 8.4 Hz ≤ f ≤ 150 Hz, constant acceleration 2 g Duration of oscillation: 10 frequency sweeps per axis, along each of the 3 mutually perpendicular axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 15 g max., duration 11 ms Direction of shock: 3 shocks each in (+/-) direction, along each of the 3 mutually perpendicular axes
Continuous shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 250 m/s^2 peak value, 6 ms duration Direction of shock: 1000 shocks each in (+/-) direction, along each of the 3 mutually perpendicular axes

Reduction of vibrations

If your S7-1500 automation system is exposed to severe shock or vibration, take appropriate measures to reduce the acceleration or the amplitude.

We recommend the installation of the S7-1500 automation system on damping materials (for example, rubber-bonded-to-metal mounting).

Climatic ambient conditions

The S7-1500 automation system may be used in the following climatic ambient conditions:

Table 15- 9 Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: horizontal mounting position: vertical mounting position:	0 °C to 60 °C 0 °C to 40 °C	In order to increase the service life of the display, the display switches off before the permissible operating temperature is reached. Further information about the temperatures at which the display switches off and back on again is available in the technical data of the manuals of the CPUs.
Temperature variation	10 K/h	-
Relative humidity	from 10 % to 95 %	Without condensation, corresponds to relative humidity (RH) class 2 in accordance with IEC 61131 part 2
Barometric pressure	from 1080 hPa to 795 hPa	corresponds to an altitude of -1000 m to 2000 m
Concentration of pollutants	SO_2: <0.5 ppm; RH <60%, no condensation H_2S: < 0.1 ppm; RH < 60 %, no condensation	-
	ISA-S71.04 severity level G1; G2; G3	-

15.5 Information on insulation tests, protection class, degree of protection and rated voltage

Insulation

The insulation is designed in accordance with the requirements of EN 61131-2: 2007.

Note

For modules with 24 VDC supply voltage, the electrical isolation is designed for max. 60 VAC / 75 VDC and basic insulation is designed according to EN 61131-2: 2007.

Contamination level/overvoltage category according to IEC 61131-2: 2007

- Pollution degree 2
- Overvoltage category: II

Protection class in accordance with IEC 61131-2: 2007

Protection class I or III, depending on module type

Degree of protection IP20

Degree of protection IP20 in accordance with IEC 60529 for all modules of the S7-1500 automation system, i.e.:

- Protection against contact with standard test finger
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The S7-1500 automation system works with the rated voltages and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 15- 10 Rated voltage of all modules of the S7-1500 automation system, for operation

rated voltage	Tolerance range
24 VDC	19.2 VDC to 28.8 VDC [1]
48 VDC	40.8 to 57.6 VDC
60 VDC	51.0 to 72.0 VDC
120 VAC	93 VAC to 132 VAC
230 VAC	187 VAC to 264 VAC

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation in accordance with IEC 60364-4-41.

15.6 Use of the S7-1500 in Zone 2 potentially explosive atmospheres

See product information Deployment of the modules in zone 2 potentially explosive atmospheres (http://support.automation.siemens.com/WW/view/en/19692172).

Dimension drawings

A

A.1 Dimension drawings of the mounting rails

In this appendix you will find the dimension drawings of the mounting rails.

Mounting rail 160 mm

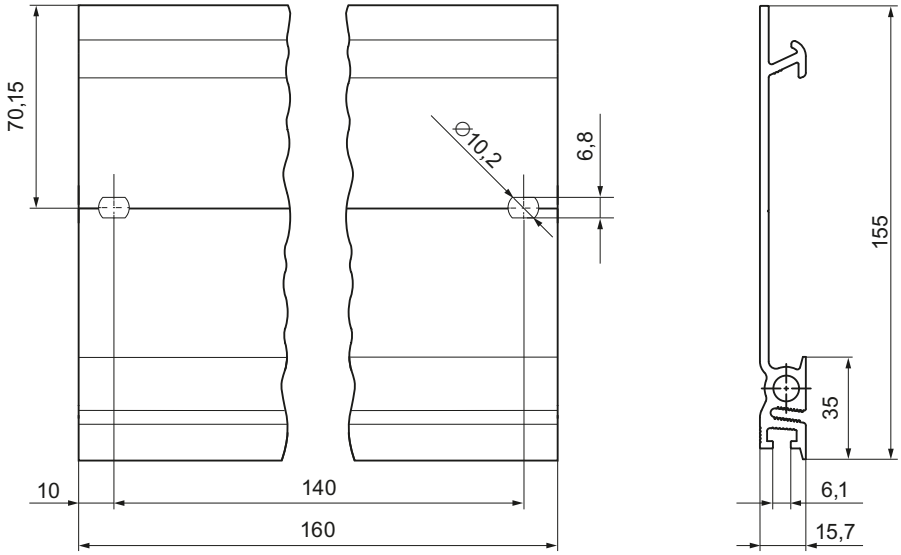


Figure A-1 Mounting rail 160 mm

Mounting rail 482.6 mm

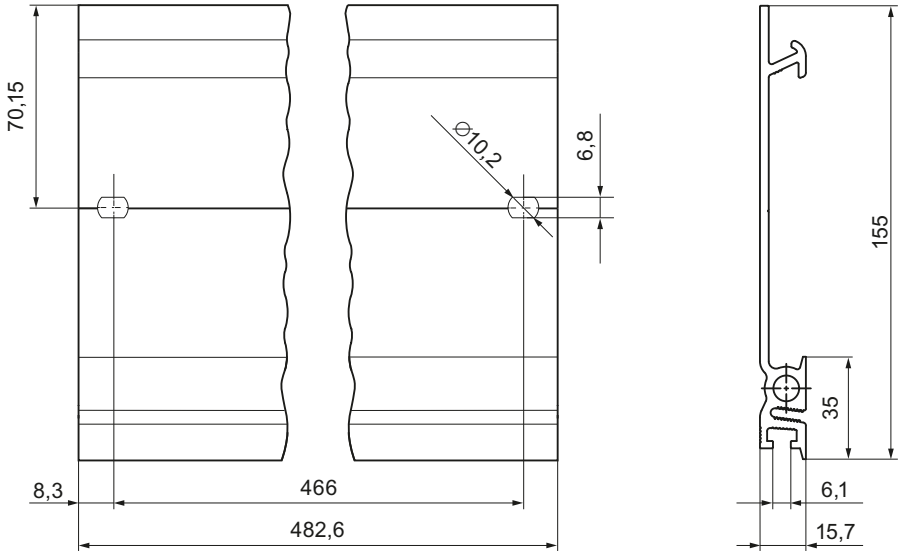


Figure A-2 Mounting rail 482.6 mm

Mounting rail 530 mm

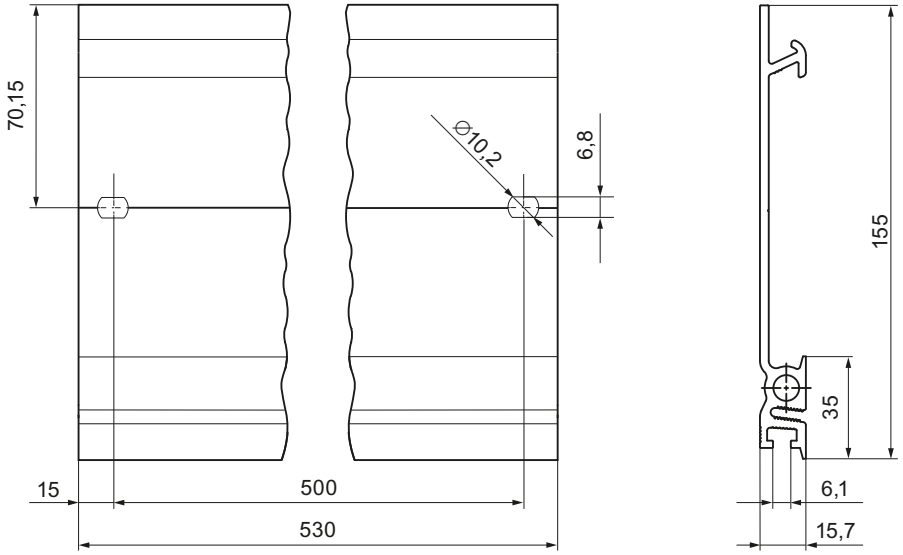


Figure A-3 Mounting rail 530 mm

Mounting rail 830 mm

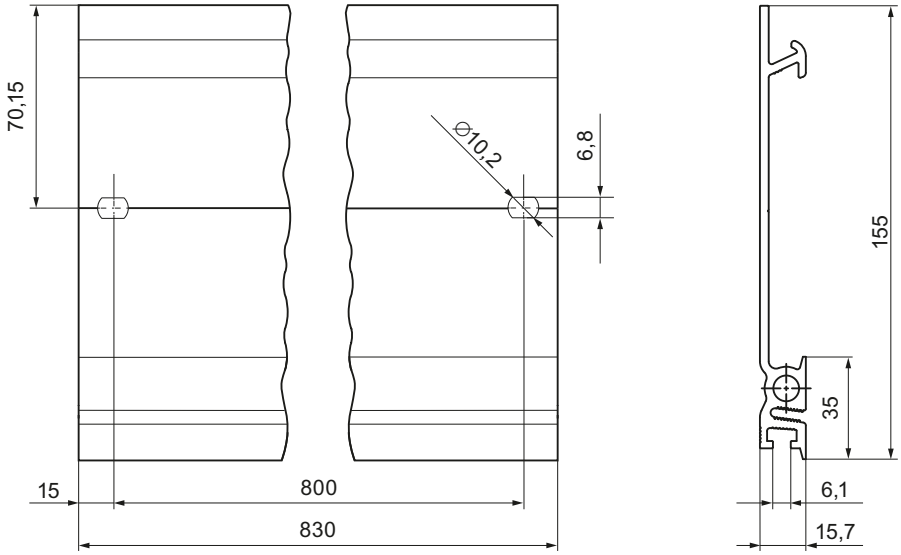


Figure A-4 Mounting rail 830 mm

Mounting rail 2000 mm

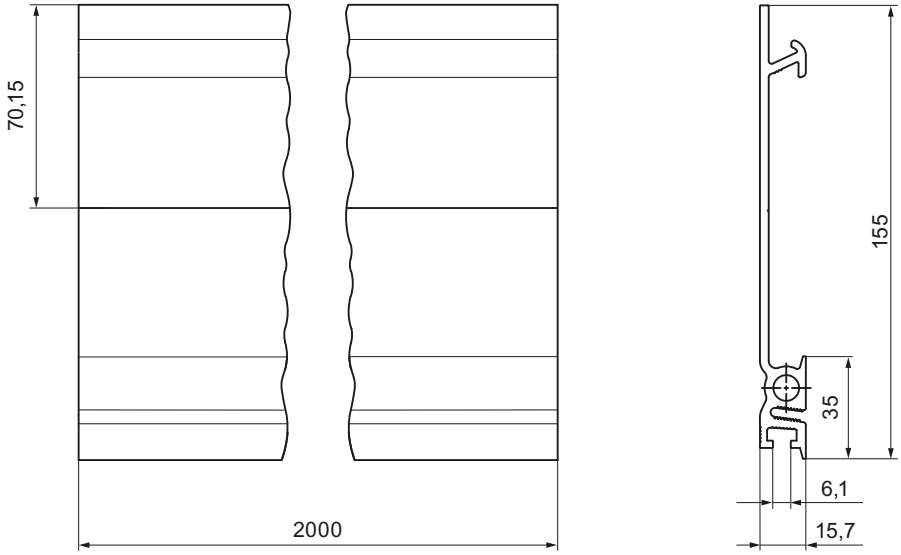


Figure A-5 Mounting rail 2000 mm

A.2 Dimension drawing of CPU, 35 mm wide

In this appendix you will find the dimension drawing of the CPU installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

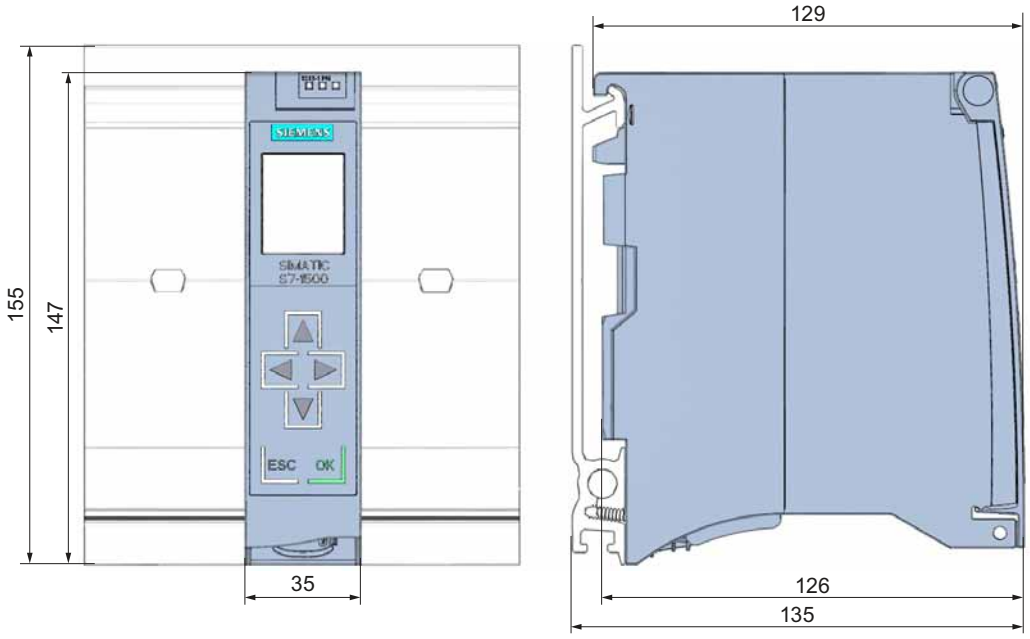


Figure A-6 Dimension drawing of CPU (35 mm wide), front and side views

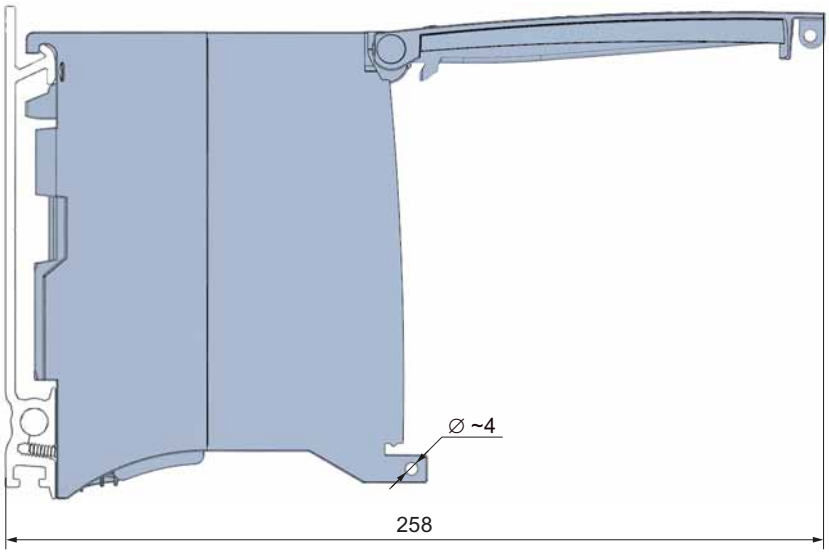


Figure A-7 Dimension drawing of CPU (35 mm wide), side view with open front cover

Note
Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.3 Dimension drawing of CPU, 70 mm wide

In this appendix you will find the dimension drawing of the CPU installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

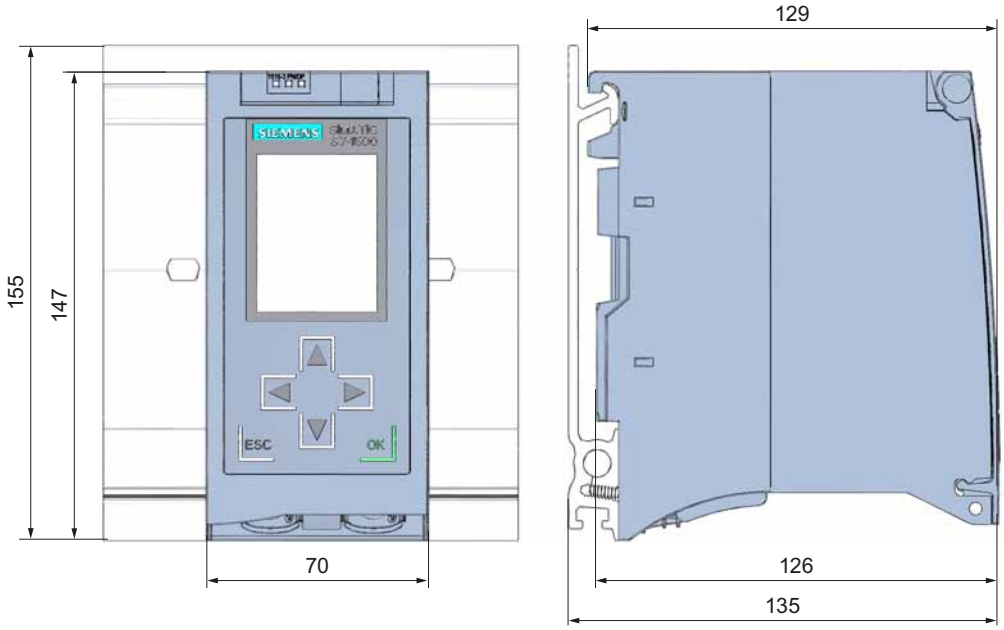


Figure A-8 Dimension drawing of CPU (70 mm wide), front and side views

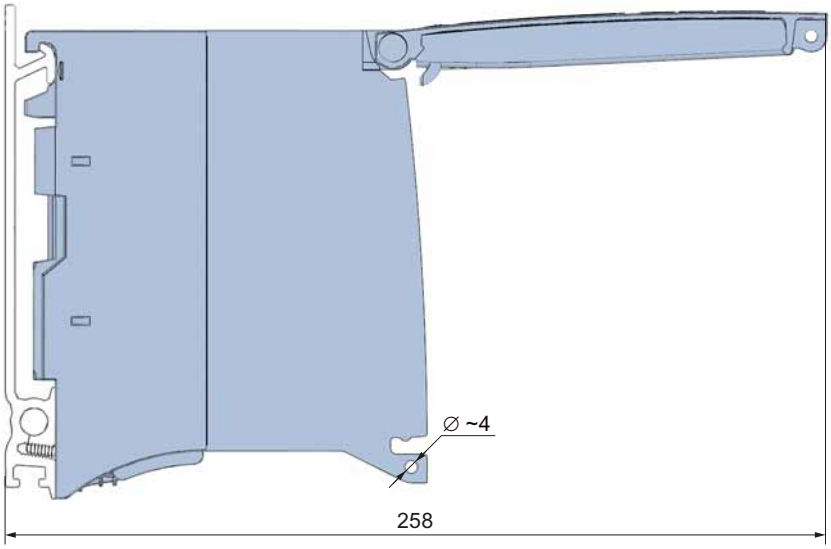


Figure A-9 Dimension drawing of CPU (70 mm wide), side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.4 Dimension drawing of I/O module

In this appendix you will find the dimension drawing of the module installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

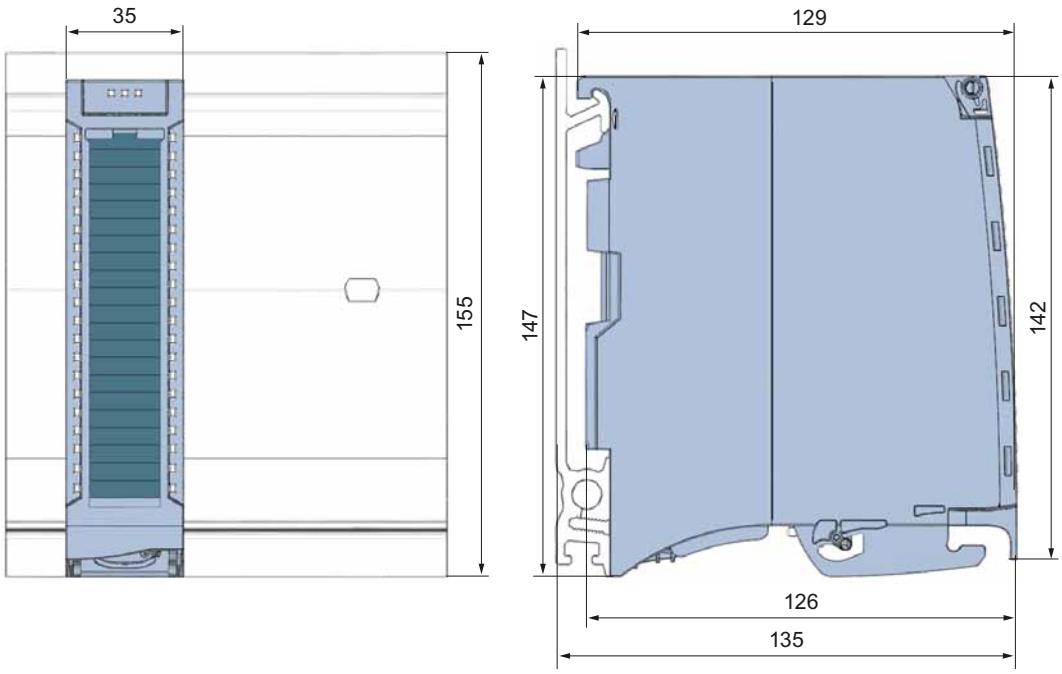


Figure A-10 Dimension drawing of I/O module, front and side views

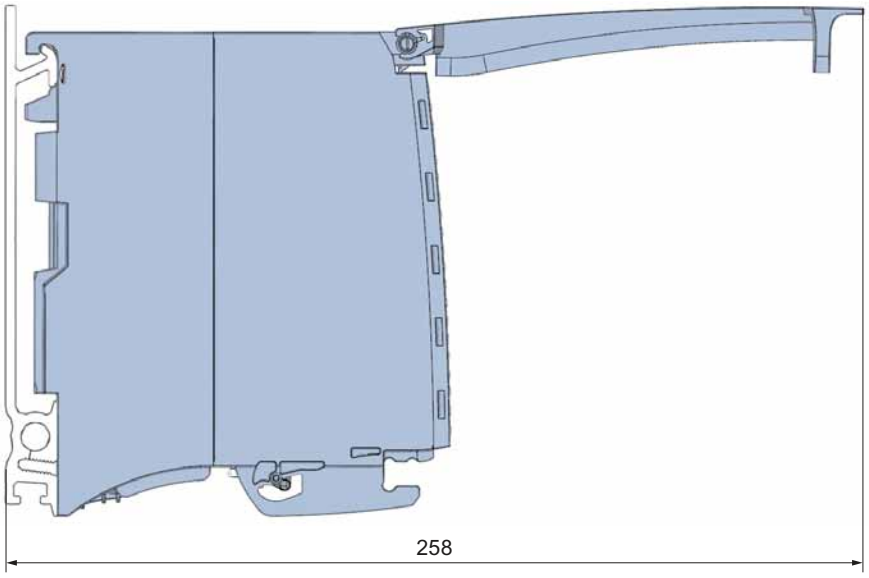


Figure A-11 Dimension drawing of I/O module, side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.5 Dimension drawing of I/O module with shield contact element

Dimension drawing of I/O module with shield contact element

The following figures show an I/O module with shield contact element, in front and side view.

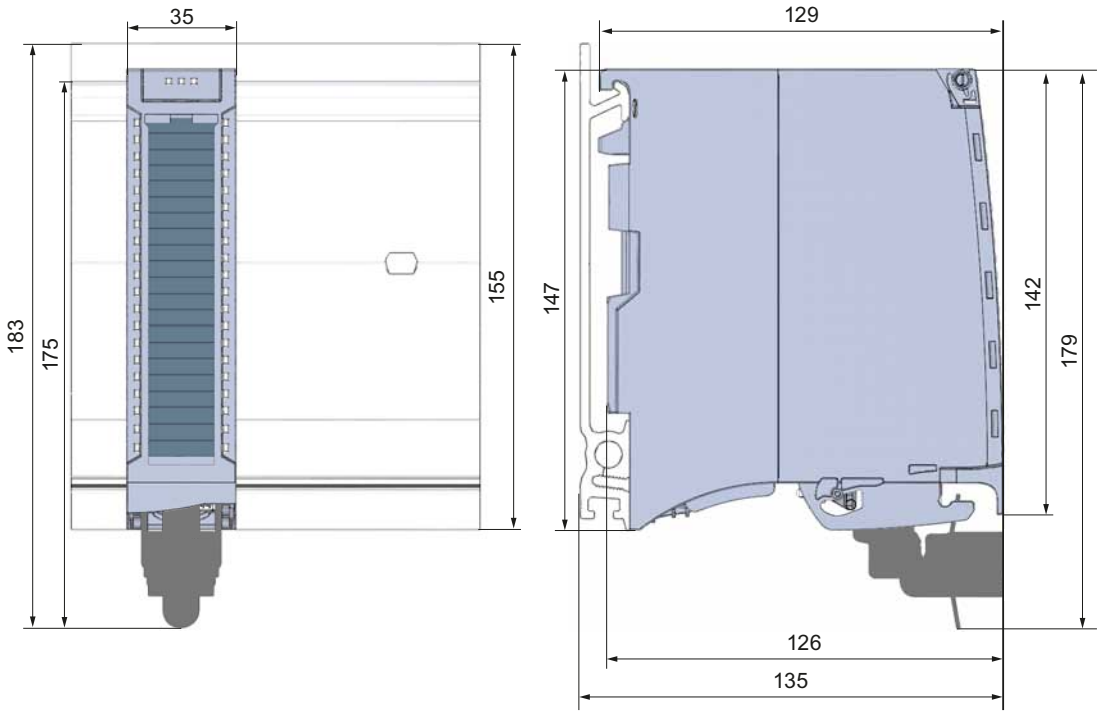


Figure A-12 Dimension drawing of I/O module with shield connection element, front and side views

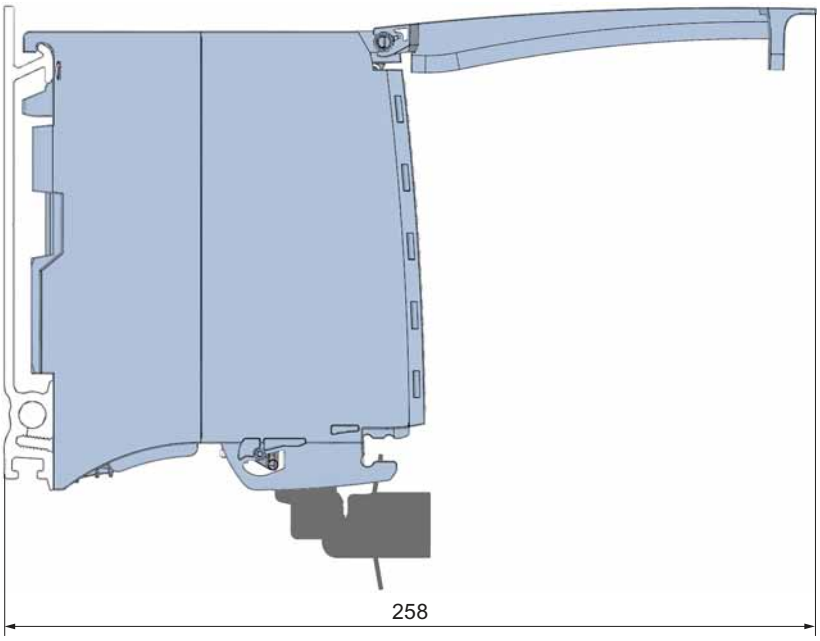


Figure A-13 Dimension drawing of I/O module with shield connection element, side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.6 Dimension drawing of system power supply, 35 mm wide

In this appendix you will find the dimension drawing of the system power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

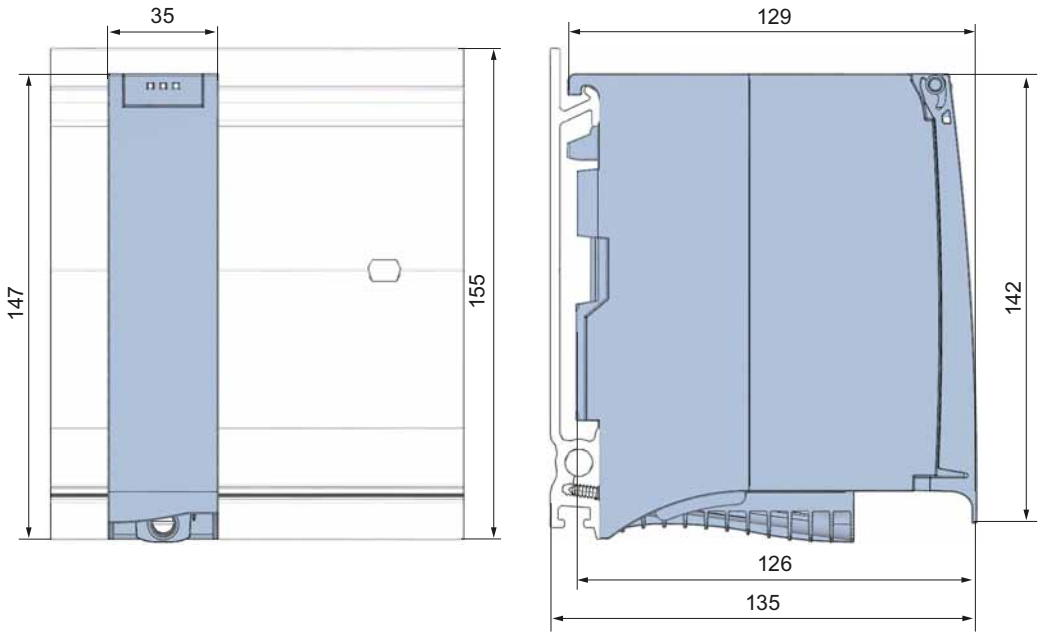


Figure A-14 Dimension drawing of system power supply (35 mm wide), front and side views

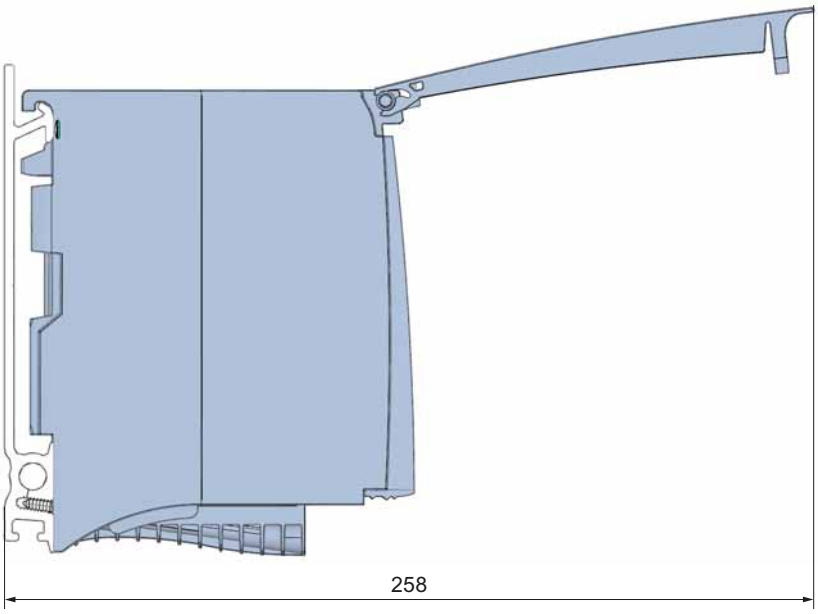


Figure A-15 Dimension drawing of system power supply (35 mm wide), side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.7 Dimension drawing of system power supply, 70 mm wide

In this appendix you will find the dimension drawing of the system power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

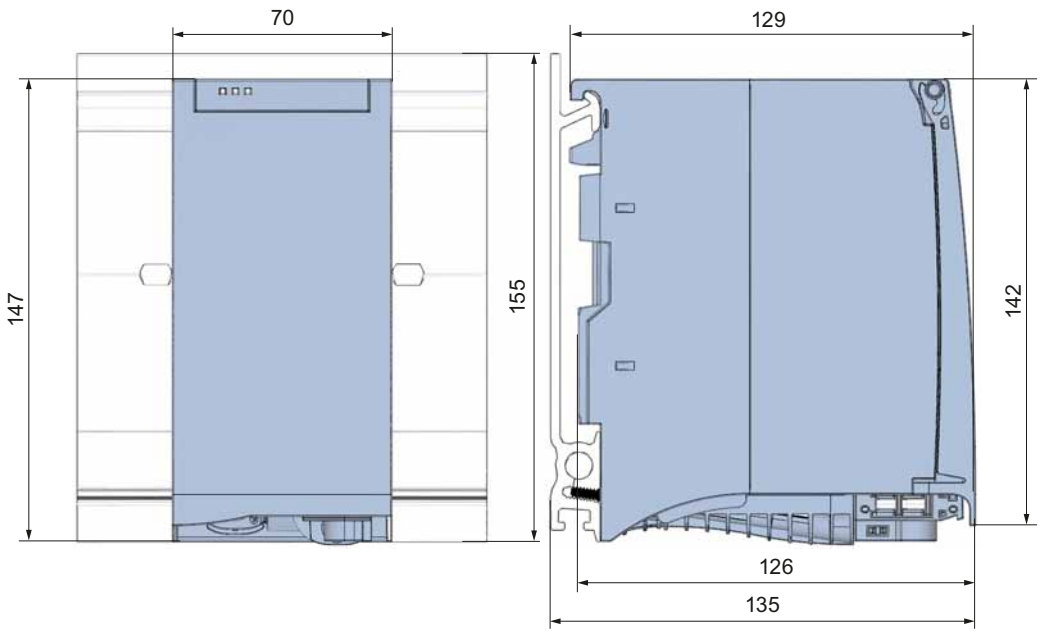


Figure A-16 Dimension drawing of system power supply (70 mm wide), front and side views

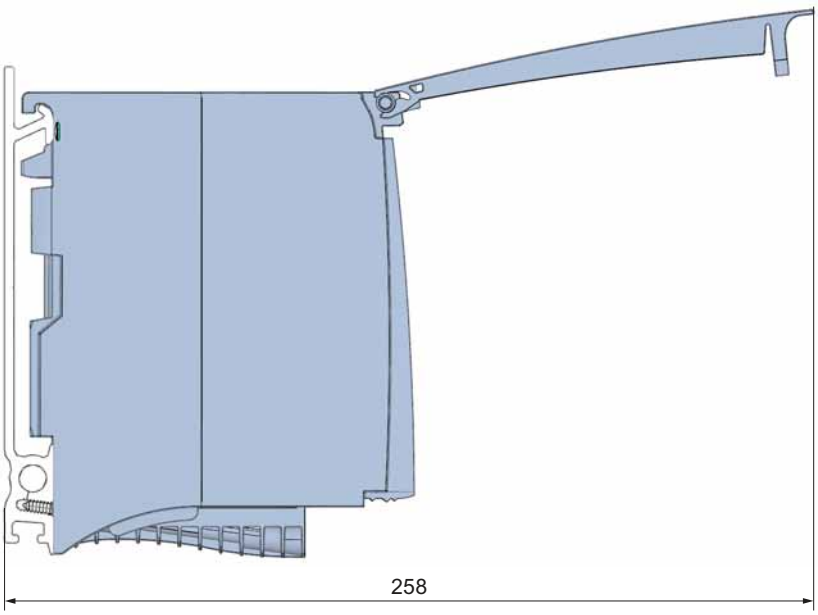


Figure A-17 Dimension drawing of system power supply (70 mm wide), side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.8 Dimension drawing of load power supply, 50 mm wide

In this appendix you will find the dimension drawing of the load power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

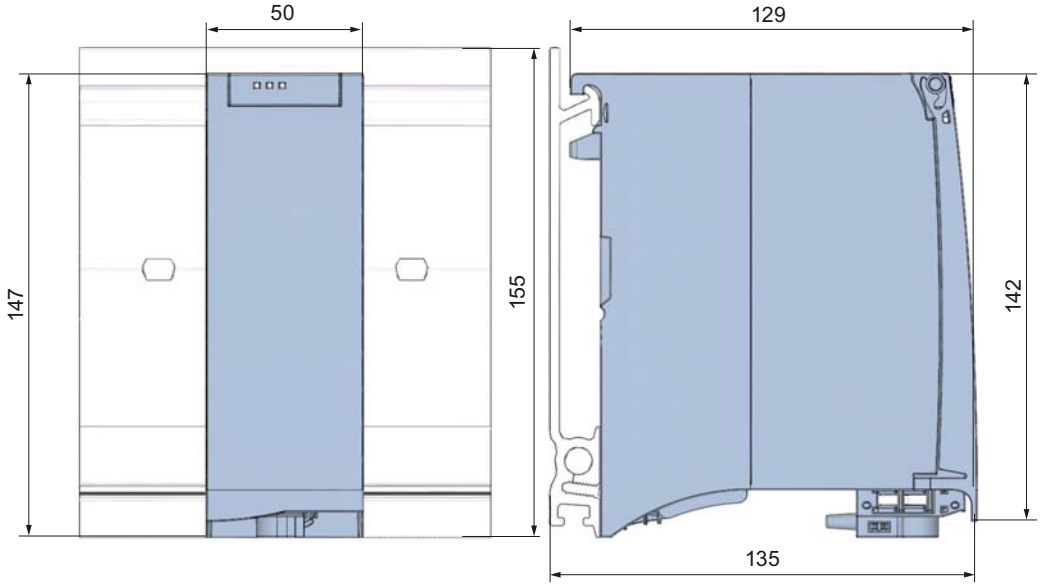


Figure A-18 Dimension drawing of load current supply (50 mm wide), front and side views

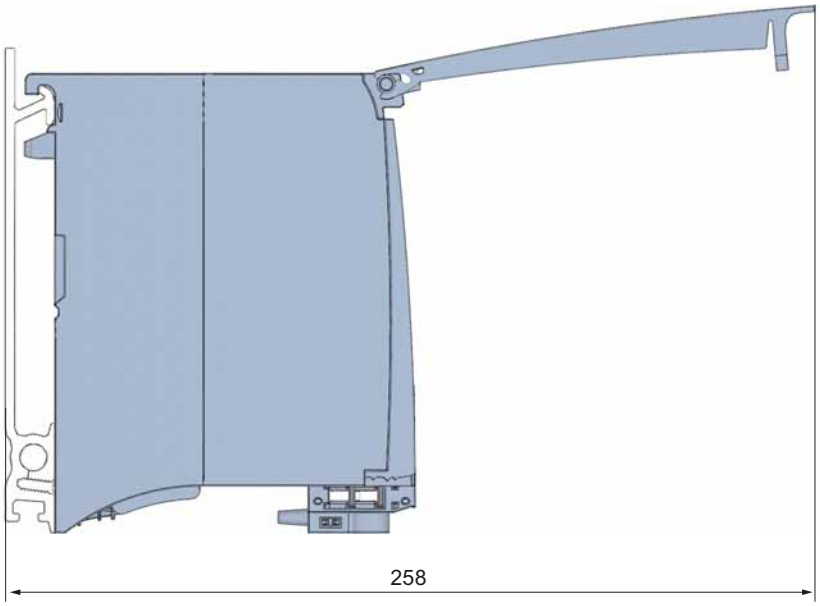


Figure A-19 Dimension drawing of load current supply (50 mm wide), side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.9 Dimension drawing of load power supply, 75 mm wide

In this appendix you will find the dimension drawing of the load power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

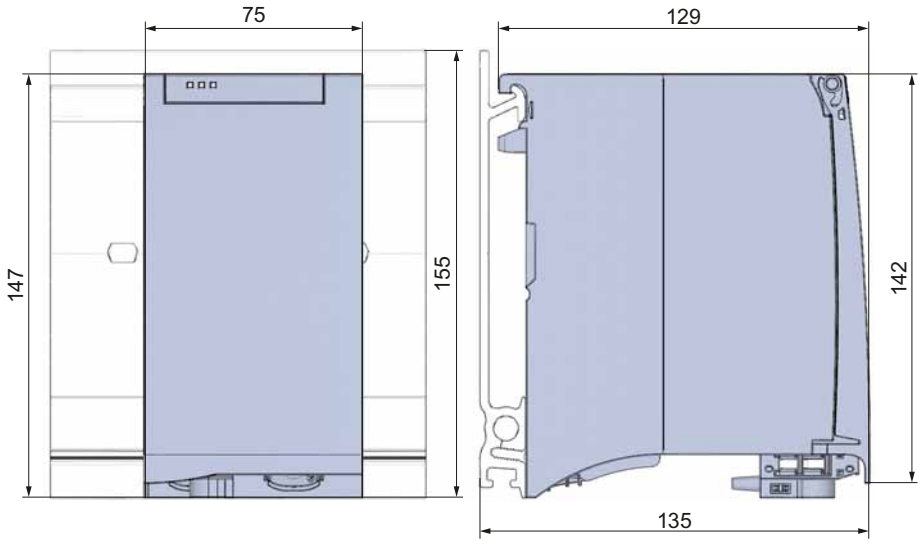


Figure A-20 Dimension drawing of load current supply (75 mm wide), front and side views

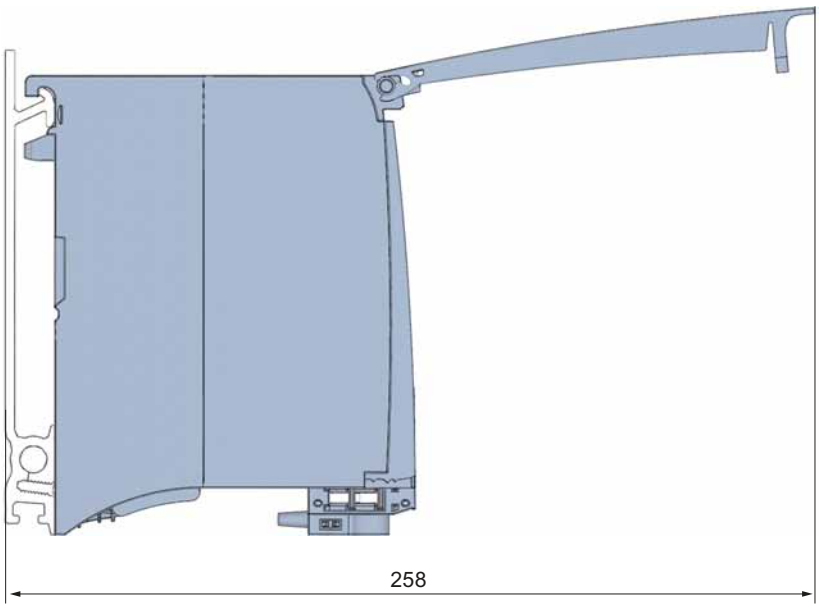


Figure A-21 Dimension drawing of load current supply (75 mm wide), side view with open front cover

Note

Minimum clearances

Observe the minimum clearances of 25 mm, above and below the mounting rail, as described in the chapterMounting (Page 39).

A.10 Dimension drawing of the shielding bracket

In this appendix you will find the dimension drawing of the shielding bracket in front and side view.

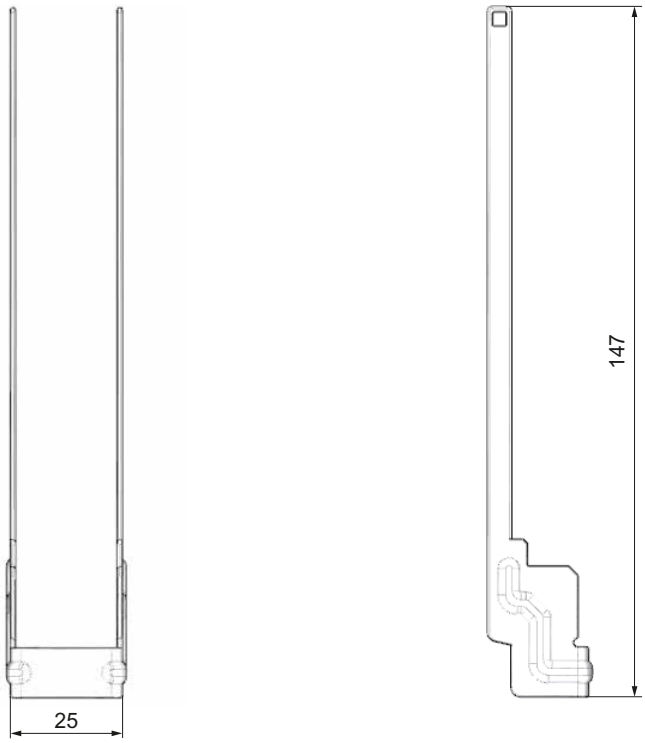


Figure A-22 Dimension drawing of the shielding bracket

A.11 Dimension drawing of the shield clamp

In this appendix you will find the dimension drawing of the shield clamp in front and side view.

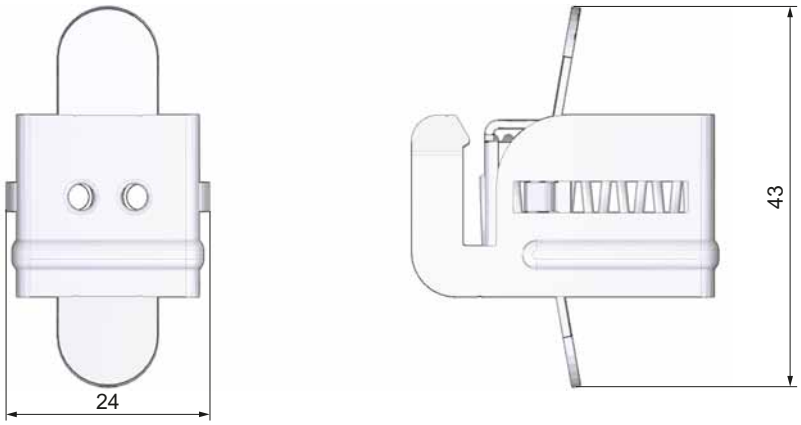


Figure A-23 Dimension drawing of the shield clamp

A.12 Dimension drawing of the power supply element

In this appendix you will find the dimension drawing of the power supply element in front and side view.

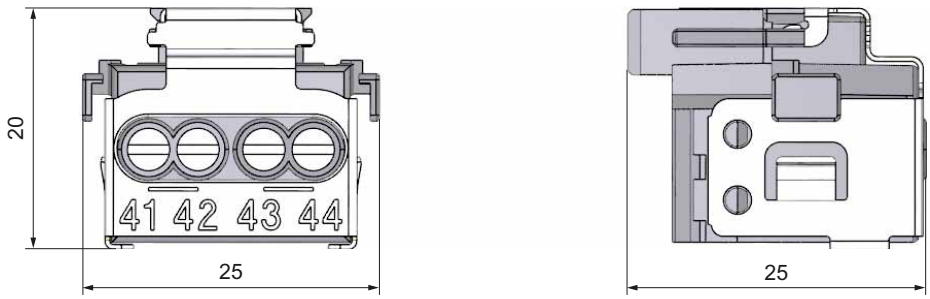


Figure A-24 Dimension drawing of the power supply element

A.13 Dimension drawing of the labeling strip

In this appendix you will find the dimension drawing of the labeling strip.

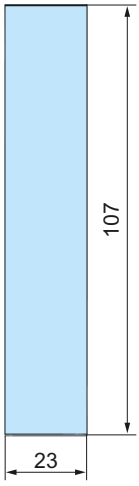


Figure A-25 Dimension drawing of the labeling strip

A.14 Dimensional drawing of communication module

This appendix contains the dimensional drawing of the communication module installed on a mounting rail and with a shield bracket. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

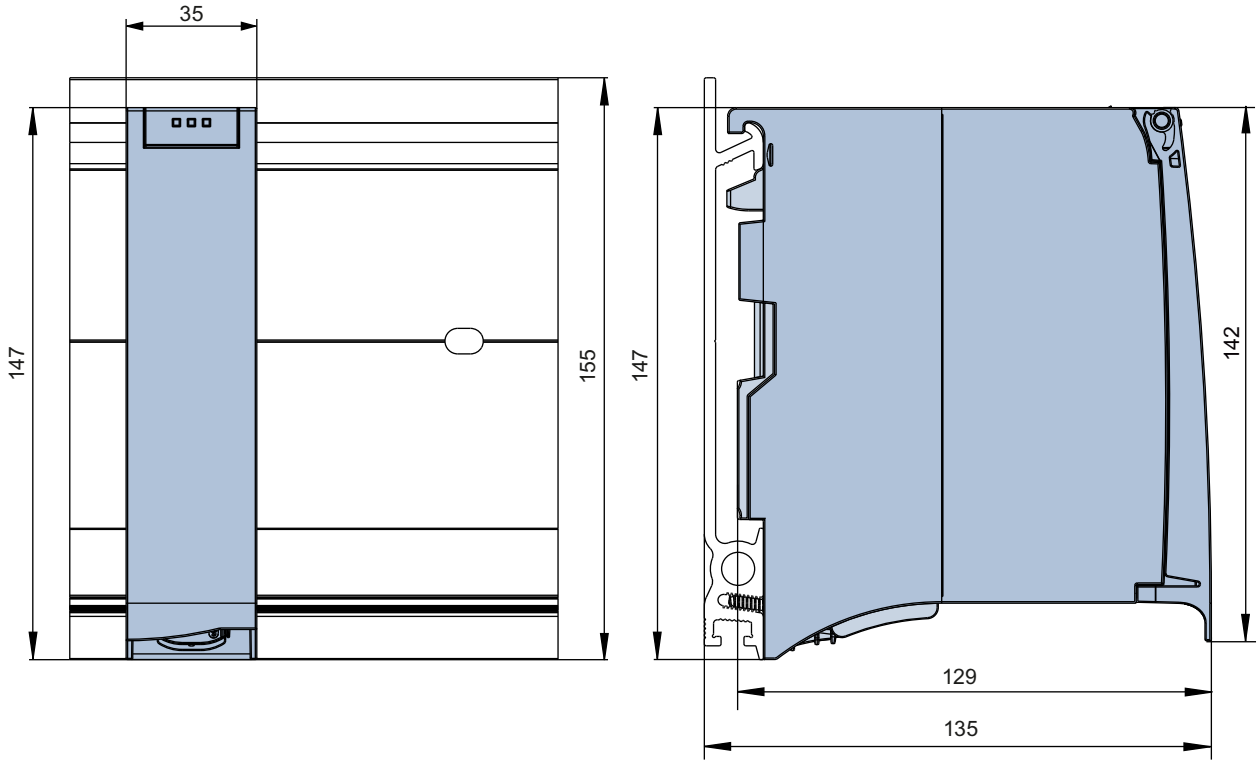


Figure A-26 Dimension drawing of communication module, front and side views

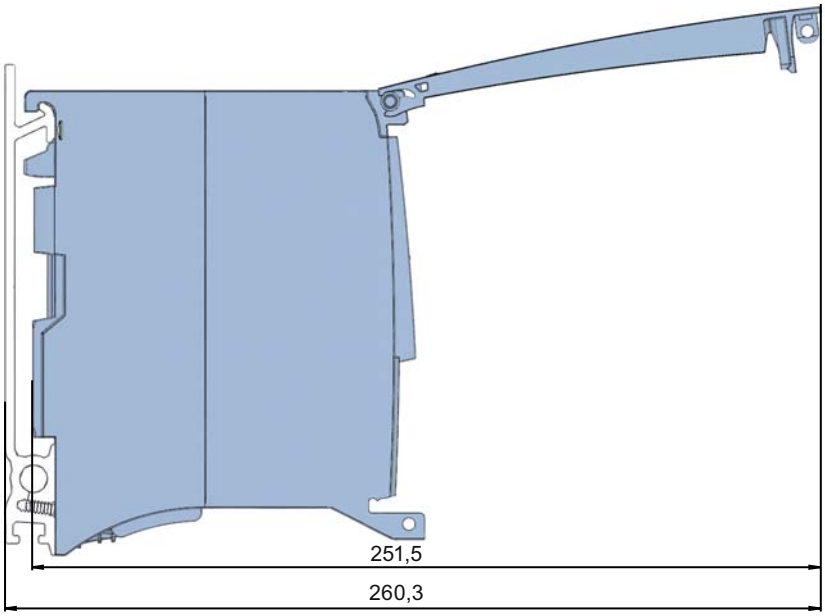


Figure A-27 Dimension drawing of communication module, side view with open front cover

Accessories/spare parts

B

Accessories for the S7-1500 automation system

Table B- 1 Accessories for the S7-1500 automation system

Description	Order number
Mounting rail	
• Mounting rail, 160 mm (with drill holes)	6ES7590-1AB60-0AA0
• Mounting rail, 482 mm (with drill holes)	6ES7590-1AE80-0AA0
• Mounting rail, 530 mm (with drill holes)	6ES7590-1AF30-0AA0
• Mounting rail, 830 mm (with drill holes)	6ES7590-1AJ30-0AA0
• Mounting rail, 2000 mm (without drill holes)	6ES7590-1BC00-0AA0
PE connection element for mounting rail, 2000 mm (spare part), 20 units	6ES7590-5AA00-0AA0
Front connector (incl. four potential bridges, cable tie, and a single labeling strip)	
• Screw-type terminals, 40-pin	6ES7592-1AM00-0XB0
4-pole connection plug for supply voltage (spare part), 10 units	6ES7193-4JB00-0AA0
DIN A4 labeling sheet (10 x for labeling the I/O modules)	
• pre-perforated, AI gray	6ES7592-2AX00-0AA0
U connector (spare part), 5 units	6ES7590-0AA00-0AA0
I/O shielding set (consists of: power supply element, shielding bracket, and shield clamp), (spare part), 5 units	6ES7590-5CA00-0AA0
U connector (spare part), 10 units	6ES7590-5BA00-0AA0
70 mm display for CPU (spare part)	6ES7591-1BA00-0AA0
35 mm display for CPU (spare part)	6ES7591-1AA00-0AA0
Power cable connector with coding element for power supply module (spare part), 10 units	6ES7590-8AA00-0AA0
Potential bridge for front connector (spare part), 20 units	6ES7592-3AA00-0AA0
Universal front cover for I/O modules (spare part), 5 units	6ES7528-0AA00-7AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module order number) • 5 x wiring plan (per module order number)
Industrial Ethernet FastConnect RJ45 plug 180, 1 unit	6GK1901-1BB10-2AA0
Industrial Ethernet FastConnect RJ45 plug 180, 10 units	6GK1901-1BB10-2AB0

Description	Order number
PROFIBUS-FastConnect bus connector without programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BA70-0XA0
PROFIBUS-FastConnect bus connector with programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BB70-0XA0

SIMATIC Memory Card

Table B- 2 SIMATIC Memory Card

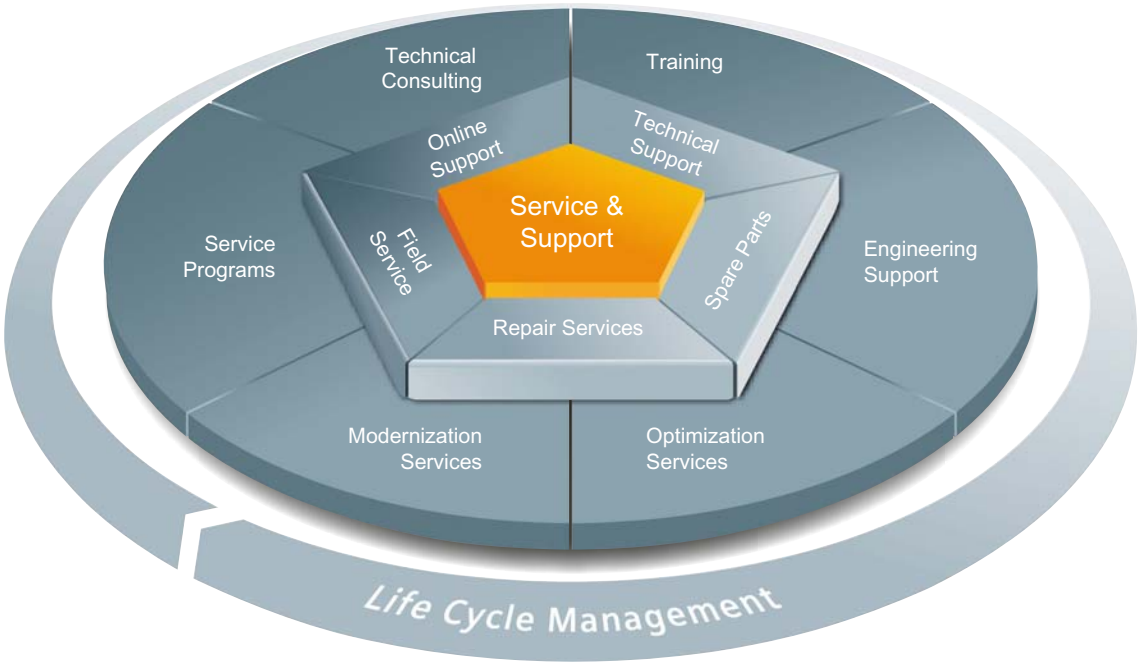
Order number	Capacity
6ES7954-8LCxx-0AA0	4 MB
6ES7954-8LExx-0AA0	12 MB
6ES7954-8LFxx-0AA0	24 MB

Online catalog

Additional order numbers for the S7-1500 automation system can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

Service & Support

C



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Training

Extend your competitive edge – through practical know-how directly from the manufacturer.

You can find the training courses we offer on the Internet at the following address: Internet (http://www.siemens.com/sitrain).

Engineering Support

Support during project engineering and development with services fine-tuned to your requirements, from configuration through to implementation of an automation project.

Field Service

Our Field Service offers you services for commissioning and maintenance – to ensure that your machines and plants are always available.

Spare parts

In every sector worldwide, plants and systems are required to operate with constantly increasing reliability. We will provide you with the support you need to prevent a standstill from occurring in the first place: with a worldwide network and optimum logistics chains.

Repairs

Downtimes cause problems in the plant as well as unnecessary costs. We can help you to reduce both to a minimum – with our worldwide repair facilities.

Optimization

During the service life of machines and plants, there is often a great potential for increasing productivity or reducing costs.

To help you achieve this potential, we are offering a complete range of optimization services.

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- Plant IT Security Services
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- SIMATIC PCS 7 Life Cycle Services
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- Optimized maintenance costs due to a tailored scope of services
- Costs that can be calculated and therefore planned
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You can find your personal contact in our contacts database at: Internet (http://www.siemens.com/automation/partner).

Glossary

Automation system

Programmable logic controller for the closed-loop and open-loop control of process chains in the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Baud rate

Data transmission rate indicates the number of bits transmitted per second (baud rate = bit rate).

Bus

A common transfer route to which all nodes of a field bus system are connected; it has two defined ends.

Bus cable connector

Physical connection between the bus node and the bus cable.

Configuration

Systematic arrangement of the individual modules (configuration).

Crimping

Procedure whereby two components that are joined together, e.g. end sleeve and cable are connected by means of plastic forming.

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. This approach was chosen for PROFINET because names are easier to administer than complex IP addresses.

An IO device has no device name upon delivery. An IO device can only be addressed by an IO controller - e.g., for transferring configuration data (including the IP address) during startup, or for user data exchange during cyclic operation - after it has been assigned a device name with the programming device/PC.

Diagnostics

Monitoring functions for the detection, localization, classification, display, and further evaluation of errors, faults, and alarms. They run automatically while the system is in operation. This increases the availability of systems by reducing commissioning times and downtimes.

Distributed I/O system

System with input and output modules that are configured on a distributed basis, far away from the CPU controlling them.

Equipotential bonding

Electrical connection (potential equalization conductor) that brings the bodies of electrical equipment and other conductive bodies to the same or almost the same potential, in order to prevent disruptive or dangerous voltages between these bodies.

Firmware update

Upgrade of firmware for modules, e.g. after functional enhancements, to the newest firmware version (update).

Functional ground

The functional ground is a low-impedance current path between electric circuits and ground. It is not designed as a safety measure but instead, for example, as a measure to improve noise immunity.

Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

Grounding

Grounding means connecting an electrically conductive part to a grounding electrode by means of a grounding system.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET device that are necessary for its configuration in XML format.

I/O modules

All modules that can be operated with a CPU or an interface module.

Identification data

Information that is saved in modules, and that supports the user in reviewing the system configuration and locating hardware changes.

Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system to the CPU (IO controller) via a fieldbus, and prepares the data for and from I/O modules.

Isolated modules

In the case of isolated input/output modules, the reference potentials of the control and load circuits are galvanically isolated, e.g. by means of optical isolators, relays or transformers. Input/output circuits can be connected to common potential.

Load current supply

Supply of the input/output circuits of the modules, sensors and actuators.

MAC address

globally unique device identifier, which is assigned to each PROFINET device in the factory. The 6 bytes of the address consist of a 3-byte manufacturer ID and a 3-byte device ID (serial number). The MAC address is usually clearly legible on the device.

Nodes

Device that can send, receive or amplify data via the bus, e.g., I/O device via PROFINET IO.

Non-isolated modules

In the case of non-isolated input and output modules, the reference potentials of the control and load circuits are electrically connected.

Parameter assignment

Parameter assignment is the transfer of parameters from the IO controller / DP master to the IO device / DP slave.

PELV

Protective **E**xtra **L**ow **V**oltage = grounded extra low voltage with safe isolation

Pre-wiring

Wiring of the electrical system on the front connector before the front connector is used on the I/O module.

Process image (I/O)

The CPU transfers the values from the input and output modules in this memory area. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. At the end of the cyclic program the process image of the outputs is transmitted as signal state to the output modules.

PROFIBUS

PROcess FIeld BUS, German process and field bus standard that is defined in IEC 61784-1:2002 Ed1 CP 3/1. It specifies functional, electrical and mechanical characteristics for a bit-serial field bus system.

PROFIBUS supports the protocols DP (= Distributed I/O), FMS (= Fieldbus Message Specification), PA (= Process Automation), or TF (= Technological Functions).

PROFIBUS master

When masters are in possession of the token, they can send data to other devices and request data from them (= active device).

PROFINET

PROcess FIeld NETwork, open industrial Ethernet standard which further develops PROFIBUS and industrial Ethernet. A cross-manufacturer communication, automation, and engineering model defined by PROFIBUS International e.V. as an automation standard.

PROFINET component

A PROFINET component includes the entire data of the hardware configuration, the parameters of the modules, and the corresponding user program. The PROFINET component consists of:

- Technological function

  The (optional) technological (software) function comprises the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical automation device or field device including the I/O, sensors and actuators, mechanics, and device firmware.

PROFINET IO

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO controller

Device used to address connected I/O devices. This means that: The IO controller exchanges input and output signals with assigned field devices. The IO controller often corresponds to the controller in which the automation program is running.

PROFINET IO device

A distributed field device that is assigned to an IO controllers (e.g., remote IO, valve terminals, frequency converters, switches).

Provider-Consumer principle

Principle of data communication on the PROFINET IO: in contrast to PROFIBUS, both parties are independent providers when sending data.

Reference potential

Potential from which the voltages of the circuits involved are observed and/or measured.

SELV

Safety **E**xtra **L**ow **V**oltage = Safety Extra Low Voltage

Slave station

A slave may only exchange data with a master after being requested to by the master.

SNMP

SNMP (Simple Network Management Protocol) is the standardized protocol for performing diagnostics on and assigning parameters to the Ethernet network infrastructure.

In the office setting and in automation engineering, devices from many different vendors support SNMP on the Ethernet.

SNMP-based applications can be operated on the same network in parallel to applications with PROFINET.

The scope of supported functions varies depending on the device type. For example a switch has more functions than a CP 1616.

Switch

PROFIBUS is a linear network. The communication nodes are linked by means of a passive cable - the bus.

By contrast, Industrial Ethernet consists of point-to-point connections: each communication node is interconnected directly with precisely one other communication node.

If a communication node is linked to several communication nodes, this communication node is connected to the port of an active network component - the switch. Additional communication nodes (including switches) can now be connected to the other ports of the switch. The connection between a communication node and the switch remains a point-to-point connection.

A switch thus has the task of regenerating and distributing received signals. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those signals that are intended for the connected PROFINET device or switch.

A switch has a specific number of connections (ports). You connect at most one PROFINET device or additional switch to each port.

System power supply

Supply of the I/O modules via the backplane bus.

Value status

The value status is a binary additional information of a digital input signal. The value status is entered simultaneously with the process signal in the process image input and provides information about the validity of the signal.

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S7-1500, ET 200MP, ET 200SP System diagnostics

Function Manual

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Service & Support A

01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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Preface

Purpose of the documentation

This function manual provides an overview of the diagnostic options for the automation systems S7-1500, ET 200MP and ET 200SP.

The documentation covers the following:

- Illustration of the uniformity and consistency of system diagnostics
- Overview of the options for establishing system diagnostics information

Basic knowledge required

The following knowledge is required in order to understand the "System Diagnostics" function manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of working with STEP 7 and WinCC
- Knowledge about the use of Microsoft Windows operating systems

Scope of the documentation

This documentation is the basic documentation for all products of the S7-1500, ET 200MP and ET 200SP systems. The product documentation is based on this documentation.

Conventions

STEP 7: We refer to the configuration and programming software as "STEP 7" in this documentation synonymously for "STEP 7 V12 (TIA Portal)" and subsequent versions.

This documentation contains figures of the devices described. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contains important information on the product, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Additional support

- Information about Technical Support is available in the appendix Service & Support (Page 67).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide 1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP und ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Overview of the documentation on the topic "System diagnostics"

The following table lists additional documentation which supplements this description on the topic "System diagnostics".

Table 1- 1 Documentation on the topic "System diagnostics"

Topic	Documentation	Most important contents
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	Configuring and programming with the engineering software
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
System description	ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
System description	ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning

Topic	Documentation	Most important contents
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925) function manual	For S7-1500, ET 200MP, ET 200SP: • Interfaces for communication • Communication services • Diagnostics of communication connections
	PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579)	• PROFIBUS basics • PROFIBUS functions • PROFIBUS diagnostics
	PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)	• PROFINET basics • PROFINET functions • PROFINET diagnostics
Web server	Web Server (http://support.automation.siemens.com/WW/view/en/59193560) function manual	• Basics • Function • Operation • Diagnostics via web server
Modules of the S7-1500 automation system	Manuals for the S7-1500 product family (http://support.automation.siemens.com/WW/view/en/56926743)	• Interrupt, error and system alarms • Technical specifications (incl. diagnostic functions)

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Overview of system diagnostics 2

2.1 Properties of system diagnostics

Introduction

In the SIMATIC environment, diagnostics of devices and modules is collectively referred to as system diagnostics. The monitoring functions are automatically derived from the hardware configuration.

All SIMATIC products have integrated diagnostic functions that they can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information. Unscheduled standstill times can be minimized with plant-wide diagnostics.

The following states are monitored by the system in the running plant:

- Device failure
- Remove/insert fault
- Module fault
- I/O access error
- Channel fault
- Parameter assignment error
- Failure of the external auxiliary voltage

Properties ofSIMATIC system diagnostics

The SIMATIC system diagnostics has the following properties:

- Integrated as standard in the hardware
- System-wide across bus limits
- Automatic localization of the error source
- Automatic output of the cause of the error in plain text
- Plant-wide diagnostics of all components
- Archiving and logging of alarms
- Configurability of alarms

Consistent diagnostics from the field level all the way to the management level

The different diagnostics media give you a uniform view of maintenance-related information of all automation components in a plant:

- System status (module and network status, alarms for system errors) are available plant-wide in a uniform display.

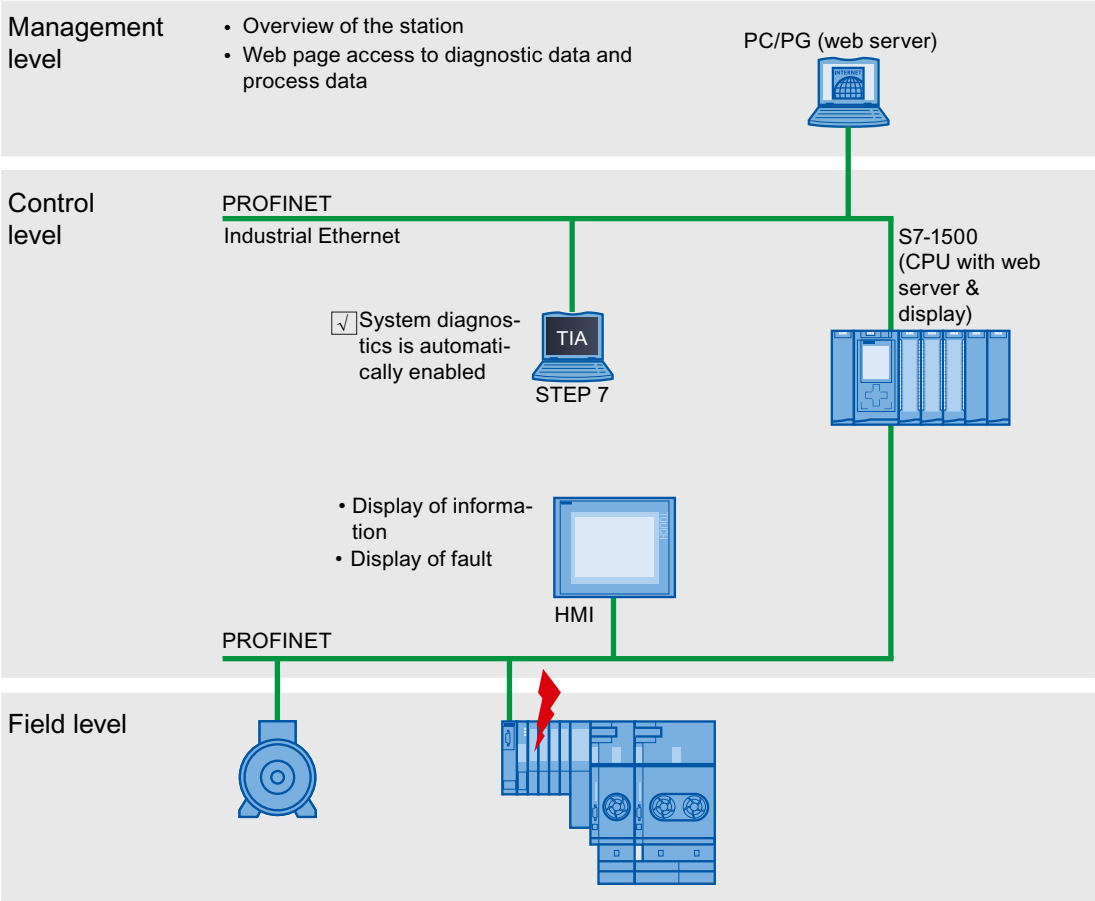


Figure 2-1 Overview of system diagnostics in a plant

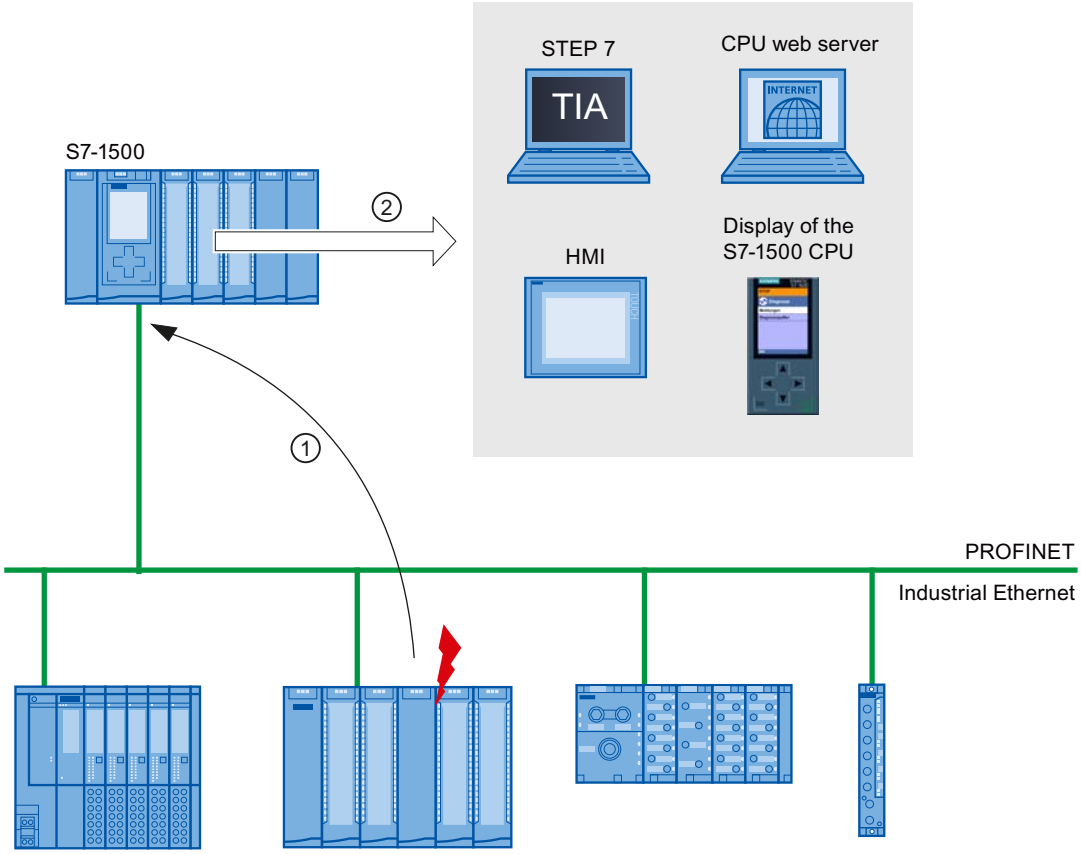
2.2 Benefits of innovative system diagnostics

System diagnostics is also possible in STOP.

The system diagnostics is integrated in the firmware of the S7-1500 CPU and works independently of the cyclic user program. This means it is also available in the STOP CPU operating mode. Faults are detected immediately and signaled to the higher-level HMI devices, the web server and the display of the S7-1500 CPU, even in STOP mode. This makes system diagnostics consistent with the actual plant state at all times.

Uniform display concept

All clients of a system are provided with diagnostic information by a uniform mechanism. The same system diagnostics information is used regardless of the display medium.



Step	Description
1	The device detects an error and sends diagnostic data to the assigned CPU.
2	The CPU informs the connected display media. The display of the system diagnostics is updated.

Figure 2-2 Sequence of the system diagnostics

Quick start

3

Introduction

The following chapters of this documentation describe the different options for establishing system diagnostics. All described options can be used independently of one another.

This chapter gives you an overview of the basic procedure to get initial diagnostic information fast.

Note

System diagnostics is generally available for the devices of the S7-1500 automation system.

3.1 Using the display of the CPU

The display of the S7-1500 CPU offers a fast and direct option to get diagnostic information. You can call up status information in different menus on the display.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.

Determining diagnostic information using the display of the S7-1500 CPU

To determine diagnostic information using the display, follow these steps:

1. Select the "Diagnostics" menu on the display.

Figure 3-1 Display of the S7-1500 CPU

2. Select the "Alarms" entry from the "Diagnostics" menu.

Result

The "Alarms" entry displays the latest error information.

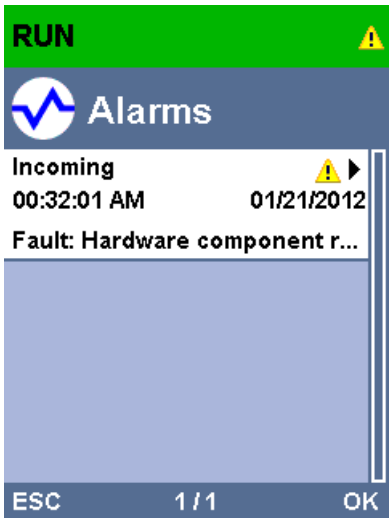


Figure 3-2 Display of the error message in the display of the S7-1500 CPU

Additional information

For additional information on configuring alarms, please refer to Configuring alarms for system diagnostics (Page 21).

3.2 Using STEP 7

The start using STEP 7 gives you fast access to detailed diagnostic information.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.
- An error has occurred.

Determining diagnostic information using STEP 7

To determine diagnostic information using STEP 7, follow these steps:

1. Open the respective project in STEP 7.
2. Open the portal view of STEP 7.
3. Select the "Online & Diagnostics" portal.
4. Select the "Online status" action.

   The "Select device" dialog opens. The dialog is an image of the configured devices in the project.

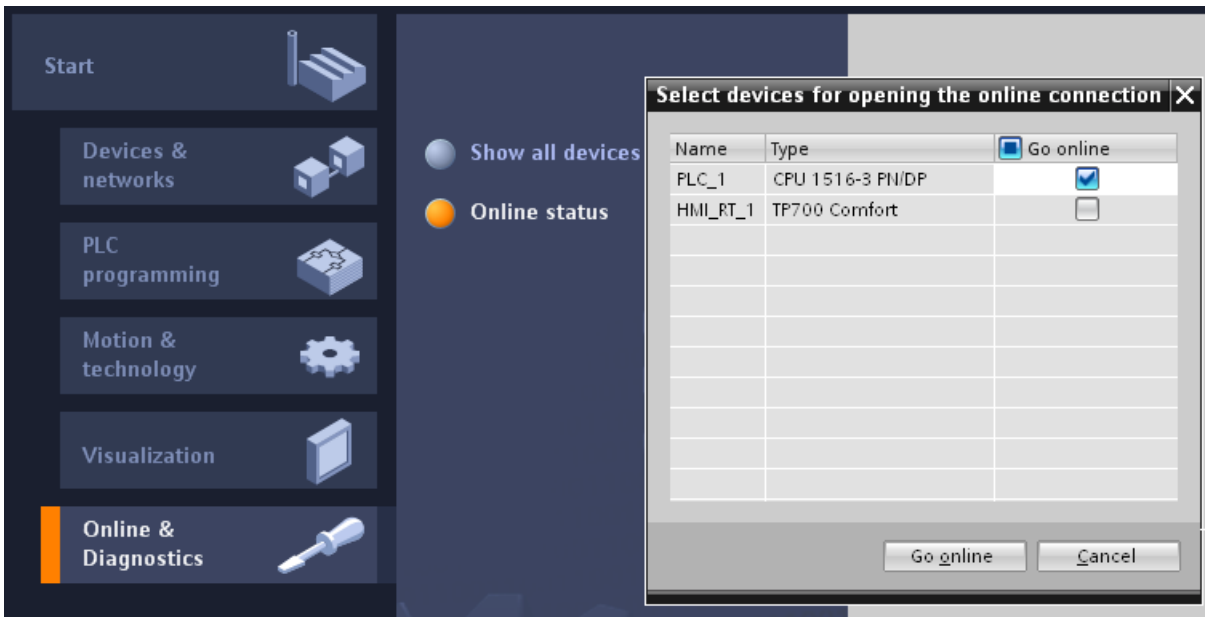


Figure 3-3 Device selection for online connection in the portal view

5. Activate the "Go online" option button for the device that you want to use to establish an online connection.
6. Click on the "Connect" button.

7. The "Go online" dialog opens.

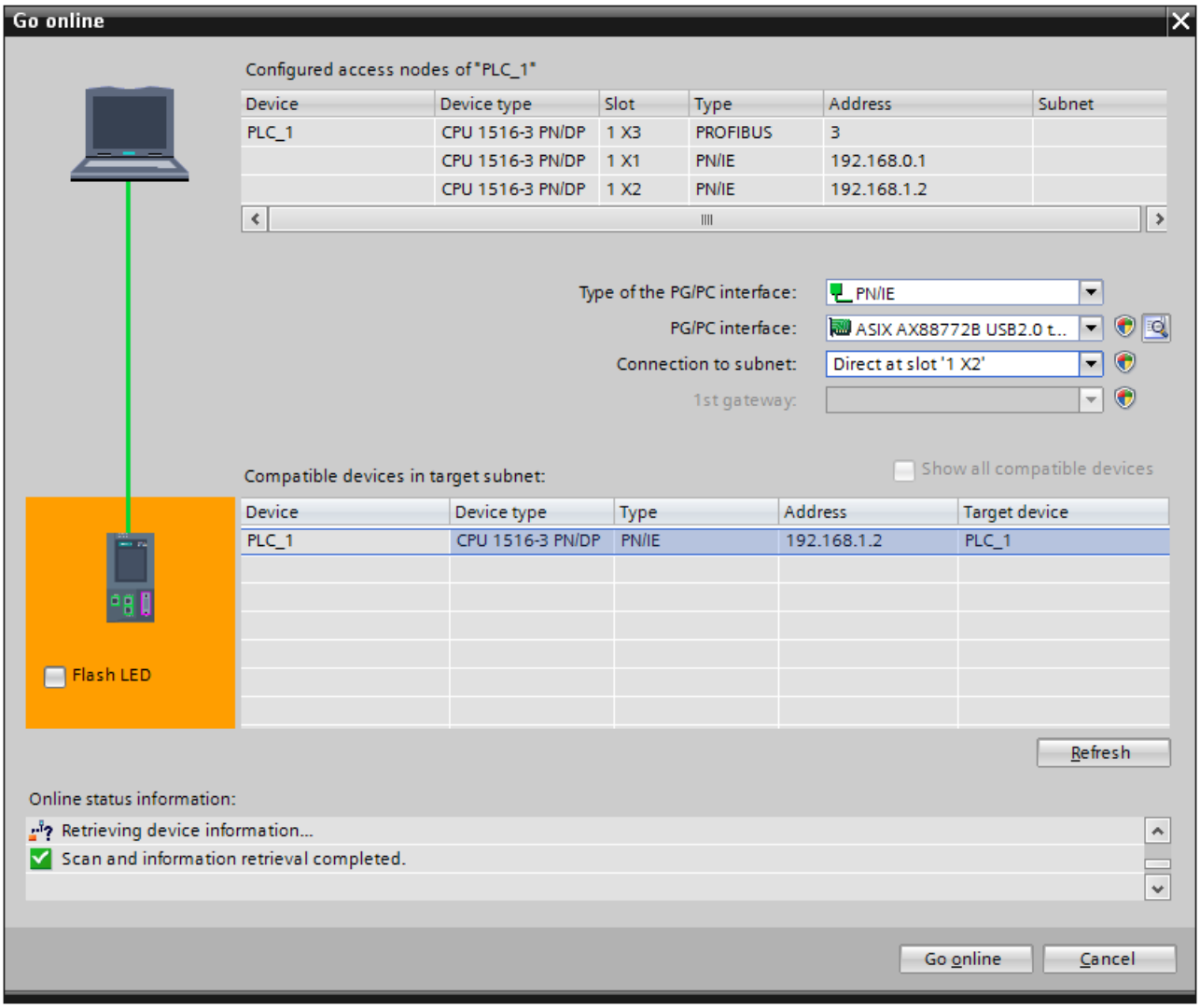


Figure 3-4 Establishing an online connection

8. Make the settings for the interface.

9. Click on the "Connect" button.

   The project view of STEP 7 opens. The network view is opened in the working area.

   The symbols in the project tree provide initial information about the faulty modules.

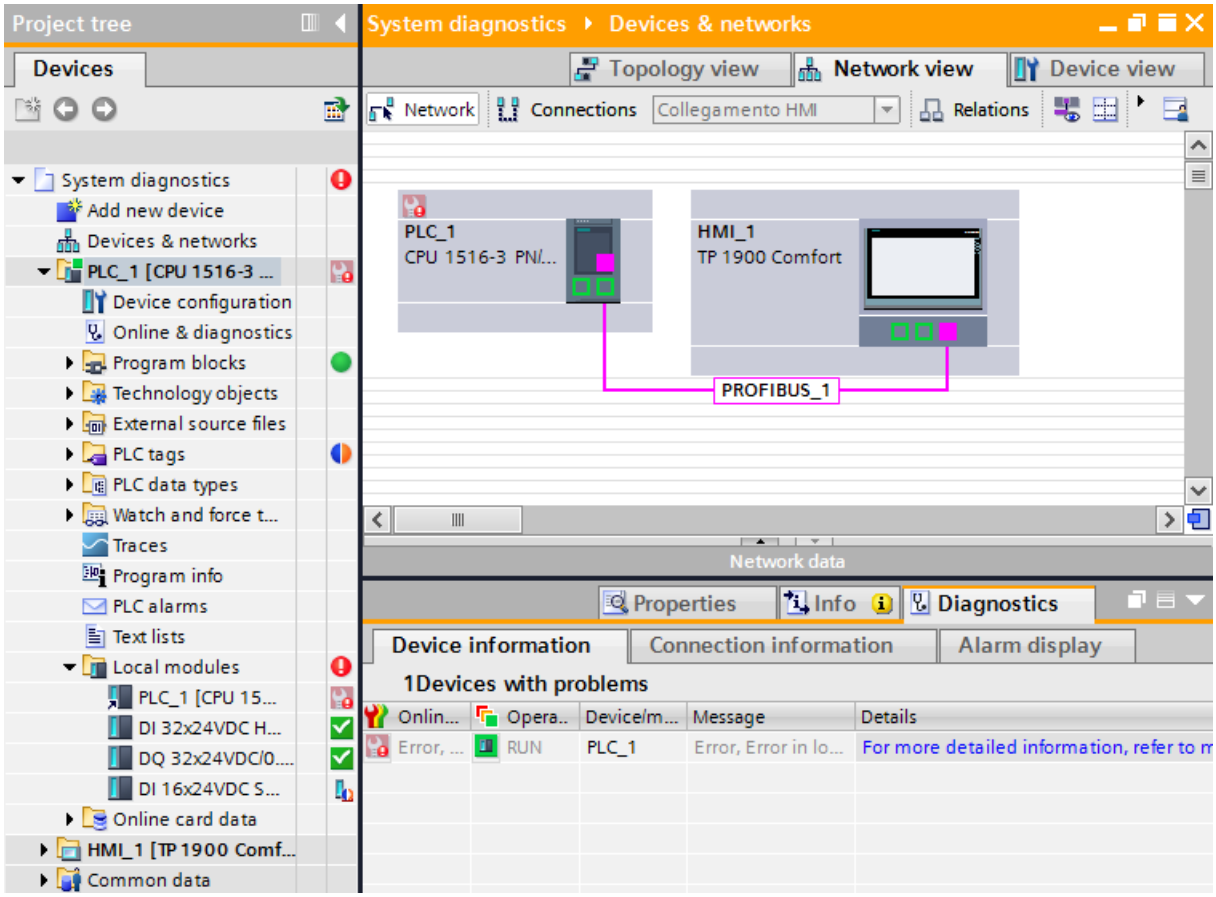


Figure 3-5 Display of the fault in network view

10. Double-click the device which displays an alarm message to access the faulty module directly. This is the CPU in the example.

    The device view of the CPU is opened in the working area. In this view you can see directly in which module the error has occurred.

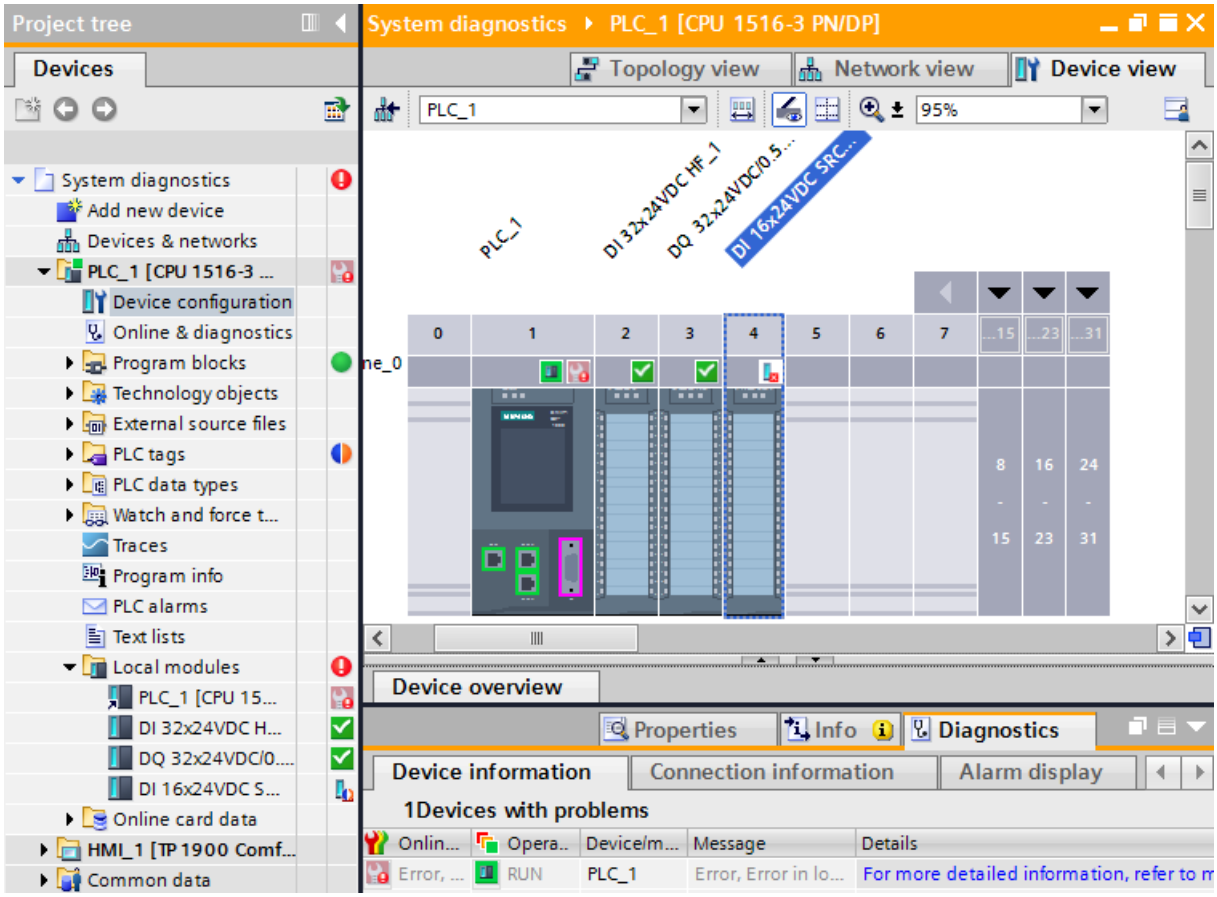


Figure 3-6 Display of the faulty module in the device view

11. Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Result

The link in the "Details" table column takes you to the online and diagnostics view of the device and to the diagnostics buffer there, for example. It includes more information on all diagnostic events in the order in which they occurred.

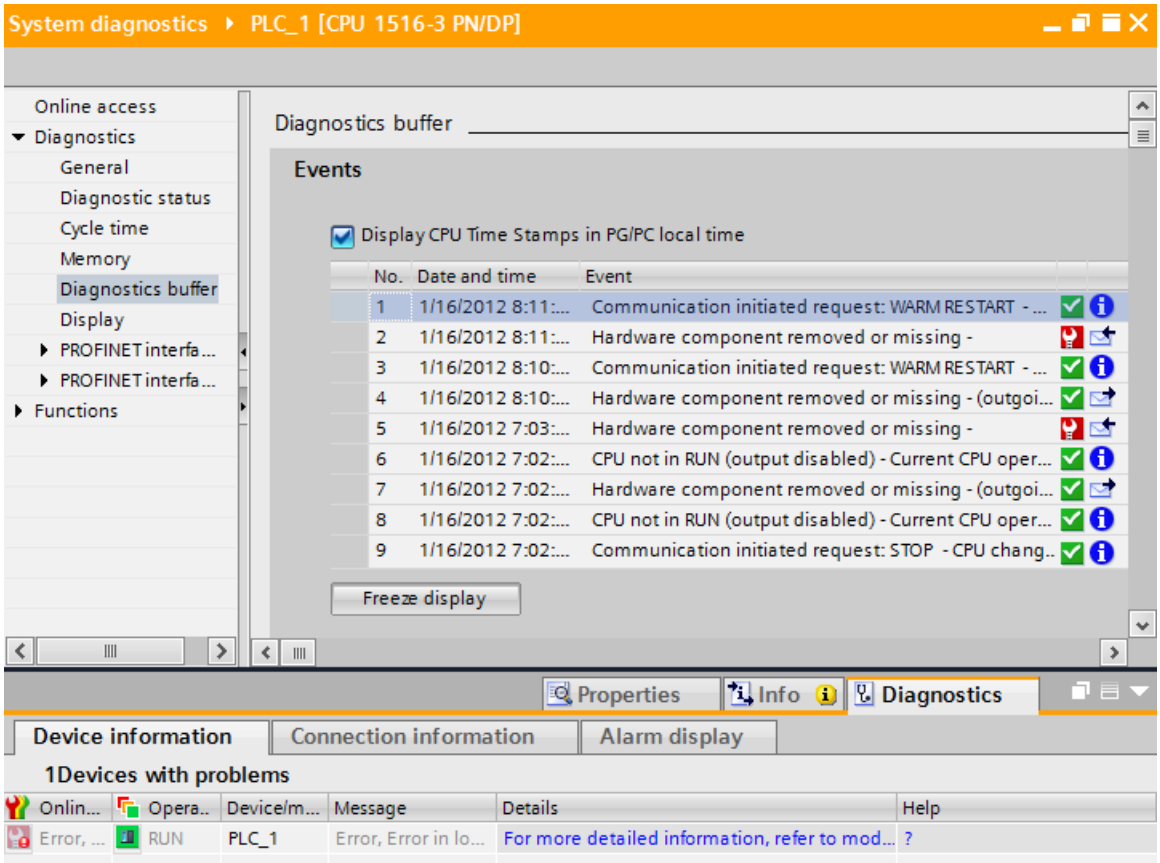


Figure 3-7 Diagnostics buffer with detailed error description

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Note

Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics icons (Page 27) and in the online help for STEP 7.

Setting and determining system diagnostics 4

Introduction

System diagnostics is generally available for the devices of the S7-1500 automation system.

In the properties of each individual CPU, you can specify if you want to receive alarms for system diagnostics on your display device. Alarms are provided on the display of the S7-1500 CPU, the CPU web server and the HMI device. Alarms are enabled by default. If you do not want to receive alarms for system diagnostics on your display device, you can disable the sending of alarms.

4.1 Configuring alarms for system diagnostics

Predefined message texts are available for establishing the system diagnostics.

Requirements

- STEP 7 is open.
- A S7-1500 CPU has been added to the project.

Procedure

To make alarm settings for system diagnostics of the CPU in STEP 7, follow these steps:

1. Open the project view.
2. Select the CPU.
3. Open the device view.
4. Open the "Properties" tab in the Inspector window.

5. Select the "System diagnostics" entry in the "General" area navigation.

   You now have access to the alarm settings. System diagnostics is enabled by default. System diagnostics cannot be disabled for the use of a CPU from the S7-1500 automation system.

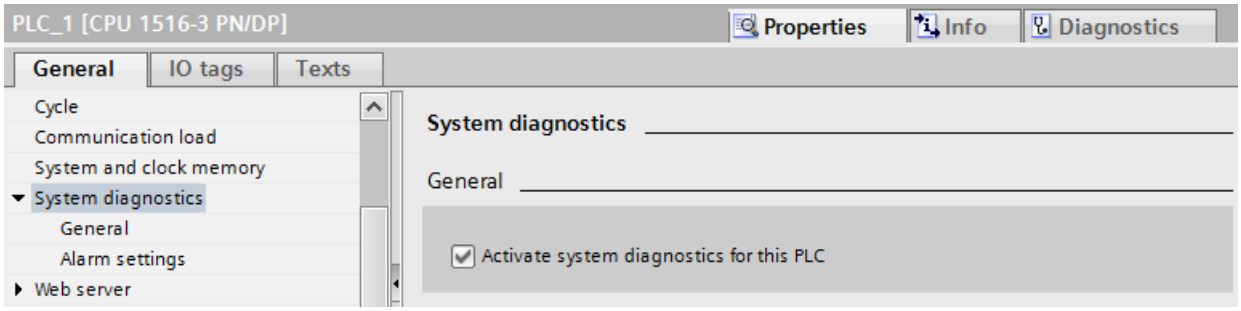


Figure 4-1 Properties of system diagnostics in STEP 7

6. In the settings, specify the alarm category that is to be displayed and if it needs to be acknowledged.

   The check boxes in the "Alarm" column are enabled by default. When you disable all check boxes, the status of the HMI system diagnostics view is still updated with the "Info Report" functionality.

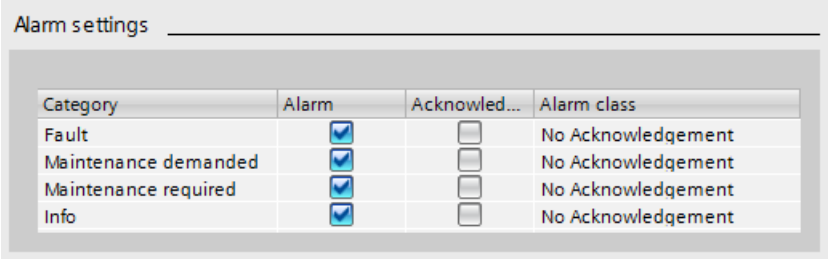


Figure 4-2 Alarm settings in STEP 7

7. Download the configuration to the CPU.

Result

You have configured the alarms for system diagnostics of the CPU in STEP 7.

The settings are saved with the project and become effective after the compiling and downloading of the hardware configuration to the involved components.

Maintenance events (maintenance demanded, maintenance required) are entered in the alarm buffer of the CPU just like any other event.

4.2 Options for displaying system diagnostics

Example

This chapter includes a diagnostics example to show how system diagnostics is established with the help of different display options. The example includes a S7-1500 CPU that is connected to an ET 200S distributed I/O system and an HMI Comfort Panel by means of PROFINET.

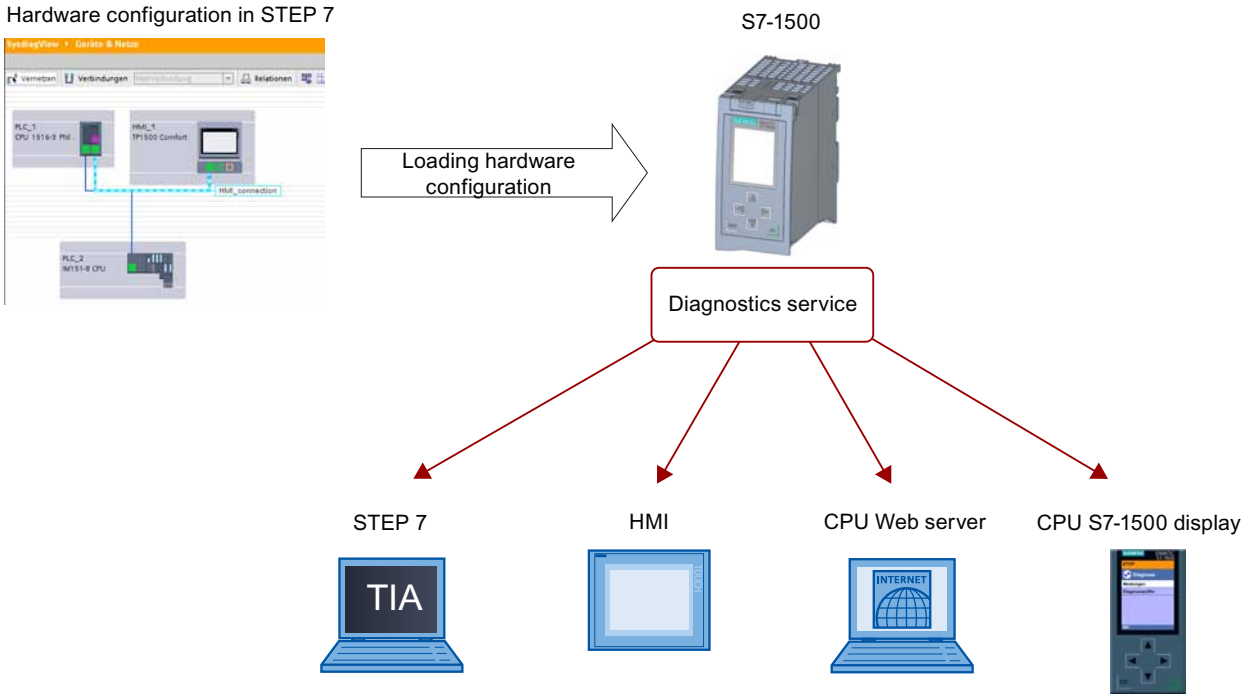


Figure 4-3 System diagnostics display options

The following chapters include figures that illustrate how diagnostic information is displayed with the help of different display options.

- Using the LEDs on the hardware (Page 24)
- local error analysis using the display of the CPU S7-1500 (Page 25)
- Using STEP 7 V12 (Page 27)
- Remote diagnostics by means of the web server (Page 44)
- Stationary system diagnostics using the HMI diagnostics view (Page 51)

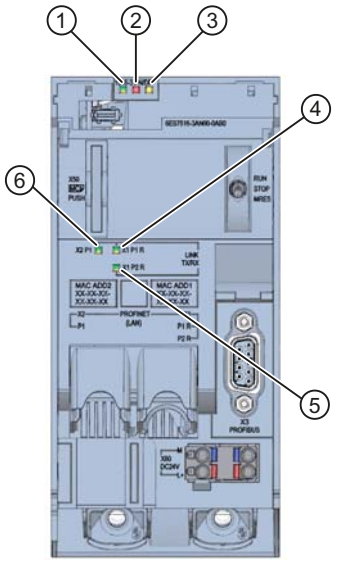
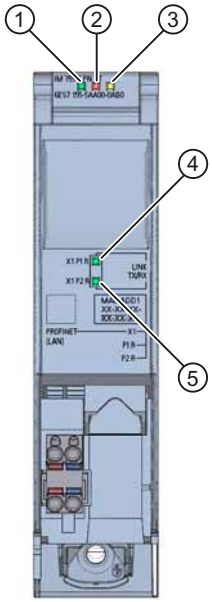
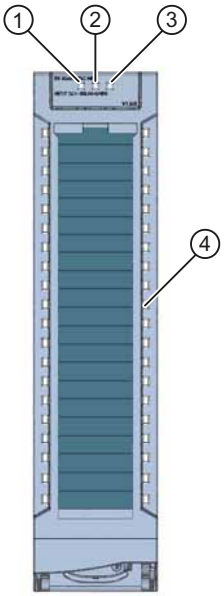
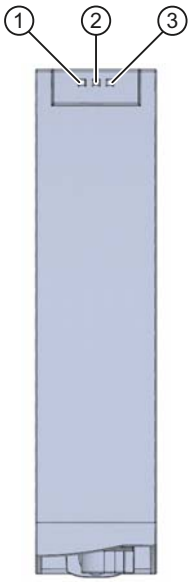
4.2.1 Diagnostic information at the devices

4.2.1.1 LEDs

Overview

All hardware components, such as CPUs, interface modules and modules, provide information about their operating mode as well as internal and external errors through their LEDs. Diagnostics by means of LEDs is an initial tool for error localization.

The graphics below include examples for the arrangement of LEDs on some modules.

	CPU 1516-3 PN/DP	IM 155-5 PN ST	DI 32x24VDC HF	PS 25W 24VDC
				
①	RUN/STOP LED (two-colored LED: green/yellow)	RUN LED (two-colored LED: green/yellow)	RUN LED (single-colored LED: green)	RUN LED (single-colored LED: green)
②	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)
③	MAINT LED (single-colored LED: yellow)	MAINT LED (single-colored LED: yellow)	without function	MAINT LED (single-colored LED: yellow)
④	X1 P1 (two-colored LED: green/yellow)	X1 P1 (single-colored LED: green)	LED CHx (two-colored LED: green/red)	
⑤	X1 P2 (two-colored LED: green/yellow)	X1 P2 (single-colored LED: green)		
⑥	X2 P1 (two-colored LED: green/yellow)			

Additional information

The meaning of the individual LED displays, their different combinations and the remedial measures resulting from them in case of errors are device-specific. You will find an explanation in the **manual of the respective module**.

4.2.1.2 Display of the CPU

Introduction

Each CPU in the S7-1500 automation system has a front cover with a display and operating keys. You can display status information in different menus on the display of the S7-1500 CPU. You use the operating keys to navigate through the menus.

Figure 4-4 Display - diagnostics screen

Display options

The display of the S7-1500 CPU displays the following information:

- Information entered in the diagnostics buffer
- Alarms
- Information about network diagnostics
- Detailed device view with diagnostic symbols
- Error and alarm texts (system diagnostic alarms)
- CPU information: order number, version
- CPU operating mode
- Module status for central and distributed modules
- Information about the currently installed firmware

Input options on the display of the S7-1500 CPU

You can enter the following configurations of the CPU directly on the display:

- Specify commissioning parameters (e.g., IP address, station name)
- Set up access protection
- Specify date and time

Additional information

For additional information on the topic "Functions and operation of the display of the S7-1500 CPU" see the documentation for the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

4.2.2 Diagnostic information in STEP 7

4.2.2.1 Explanation of diagnostics icons

Diagnostics icons for modules and devices

When the online connection to a device in STEP 7 is established, the diagnostics status of the device and its lower-level components and, if applicable, the device operating mode are also determined.

The following table shows the available icons and their meaning.

Icon	Meaning
	The connection with a CPU is currently being established.
	The CPU is not reachable at the set address.
	The configured CPU and the CPU actually present are of incompatible types.
	On establishment of the online connection to a protected CPU, the password dialog was terminated without specification of the correct password.
	No fault
	Maintenance required
	Maintenance demanded
	Error
	The module or device is deactivated.
	The module or the device cannot be reached from the CPU (valid for modules and devices below a CPU).
	Diagnostics data are not available because the current online configuration data differ from the offline configuration data.
	The configured module or device and the module or device actually present are incompatible (valid for modules or devices under a CPU).
	The configured module does not support display of the diagnostics status (valid for modules under a CPU).
	The connection is established, but the module status has not yet been determined or is unknown.
	Hardware error in lower-level component: A hardware error is present in at least one lower-level hardware component. (occurs as a separate icon only in the project tree)

Icons for the comparison status

The diagnostics icons can be combined at the bottom right with additional smaller icons that indicate the result of the online/offline comparison. The following table shows the available comparison icons and their meaning.

Icon	Meaning
	Hardware error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level hardware component.
	Software error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level software component.
	Online and offline versions of the object are different
	Object only exists online
	Object only exists offline
	Online and offline versions of the object are the same

Operating mode icons for CPUs and CPs

The following table shows the available icons and their respective operating states.

Icon	Operating mode
	RUN
	STOP
	STARTUP
	HOLD
	DEFECTIVE
	Unknown operating mode
	The configured module does not support display of the operating mode.

Event table

The following information is displayed in the table for each diagnostics event:

- Sequential number of the entry

  The first entry contains the latest event.
- Date and time of the diagnostics event

  If no date and time are shown, the module has no integral clock.
- Short designation of the event and, if applicable, the reaction of the CPU
- Icon for information on incoming/outgoing status

  The following table shows the available icons and their meaning.

Icon	Meaning
	Incoming event
	Outgoing event
	Incoming event for which there is no independent outgoing event
	User-defined diagnostics event

Additional information

For additional information on the individual icons, please refer to the online help for STEP 7.

4.2.2.2 Accessible devices (without project)

Accessible devices

Accessible devices are all devices that are connected to a PG/PC either directly by an interface or by means of a subnet and that are switched on. These devices can display diagnostic information even without an offline project.

Requirements

- STEP 7 is open.
- The project view is open.

Procedure

To display diagnostic information for specific devices even without an offline project, follow these steps:

1. Establish a connection to the respective CPU.
2. Select the command "Accessible devices" from the "Online" menu.

   The "Accessible devices" dialog opens.

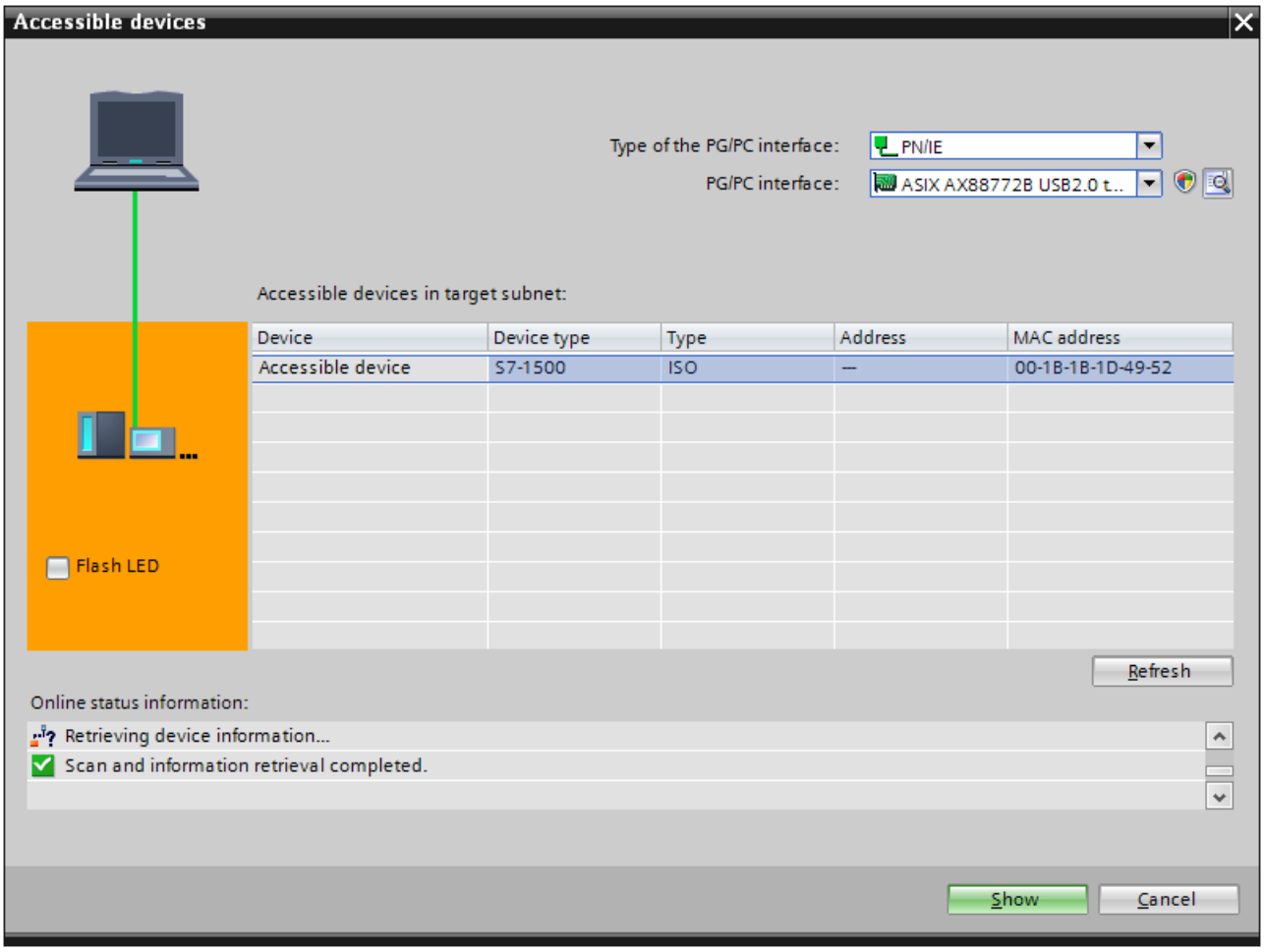


Figure 4-5 "Accessible devices" dialog

3. Make the settings for the interface.
4. Select the respective device under "Accessible devices in the target subnet".
5. Confirm the dialog with the "Display" button.

Result

The device is displayed in the project tree. You open the diagnostic information in the working area with a double-click on "Online & Diagnostics".

Information is available on the diagnostic status, cycle times, memory usage and the diagnostics buffer.

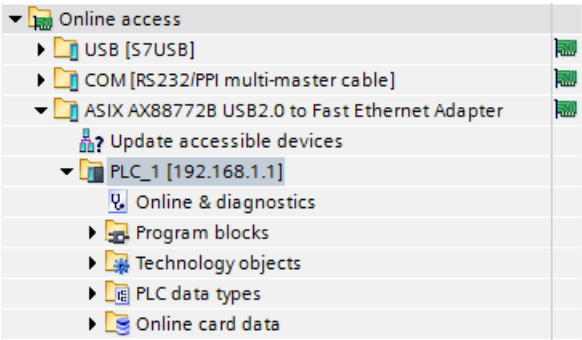


Figure 4-6 Device in the project tree

4.2.2.3 Devices & networks

Devices & networks - Go online

You can get an overview of the current state of your automation system in the device view or network view.

You implement the following tasks in the device view:

- Device configuration and parameter assignment
- Module configuration and parameter assignment

You implement the following tasks in the network view:

- Device configuration and parameter assignment
- Networking devices

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To get an overview of the current state of your automation system, follow these steps:

1. Open the "Network view" in the working area.
2. Select the CPU.
3. Click the "Go online" Go online button in the toolbar.

   The "Go online" dialog opens.

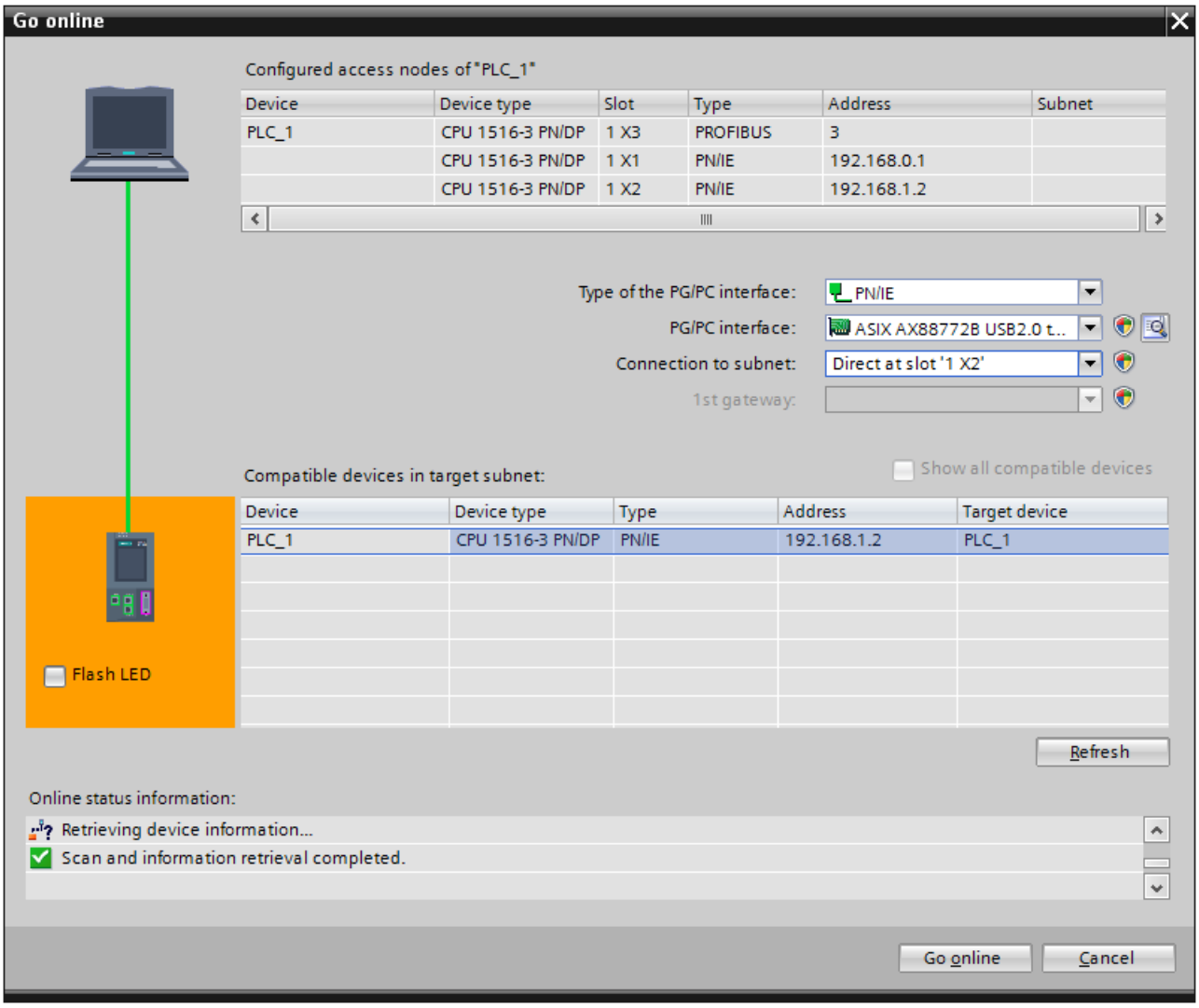


Figure 4-7 Go online

4. Make the settings for the interface.
5. Select the respective device under "Compatible devices in the target subnet".
6. Confirm the dialog with the "Connect" button.

   The online mode is started.

Result

The connected devices are now displayed with diagnostic information in the network view in the working area. Here you get an overview of the current state of your automation device.

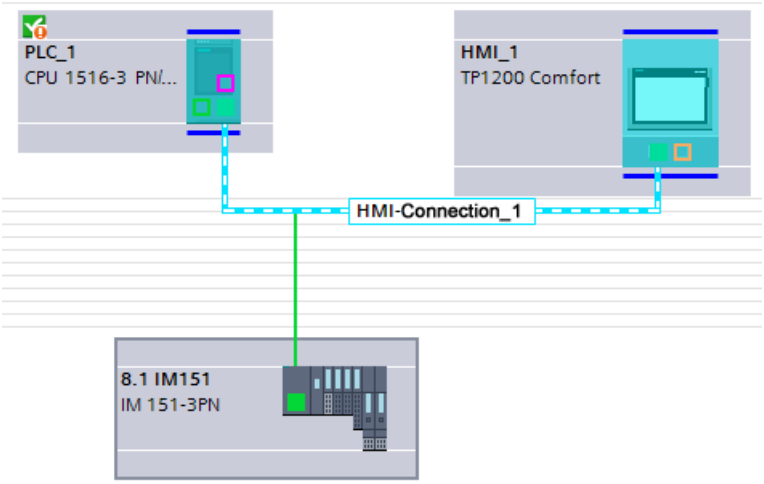


Figure 4-8 CPU with diagnostic information

You get to the "Device view" with a double-click on the device. The diagnostic information for the individual modules is displayed in this view.

Note

Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics icons (Page 27) and in the online help for STEP 7.

4.2.2.4 Online & diagnostics

Online mode

In online mode there is an online connection between your PG/PC and one or several devices. An online connection between PG/PC and device is required for the following information and activities:

- Information
  - General module information
  - Diagnostics status
  - Diagnostics buffer
  - Cycle time
  - Memory
  - Communication resources
- Activities
  - Assigning an IP address
  - Setting time and date of the CPU
  - Firmware update
  - Assigning device name
  - Reset to factory settings

To establish an online connection at least one PG/PC interface must be installed that is physically connected with a device, for example, with an Ethernet cable. The current online status of a device is indicated by a symbol to the right of the device in the project tree.

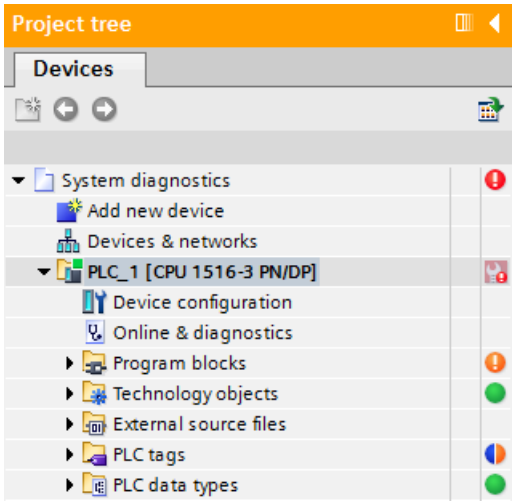


Figure 4-9 Partial view network view

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To display an overview of the faulty devices, follow these steps:

1. Select the affected device folder in the project tree.
2. Select the shortcut menu command "Online & Diagnostics".

   The online and diagnostics view of the module to be diagnosed is started.

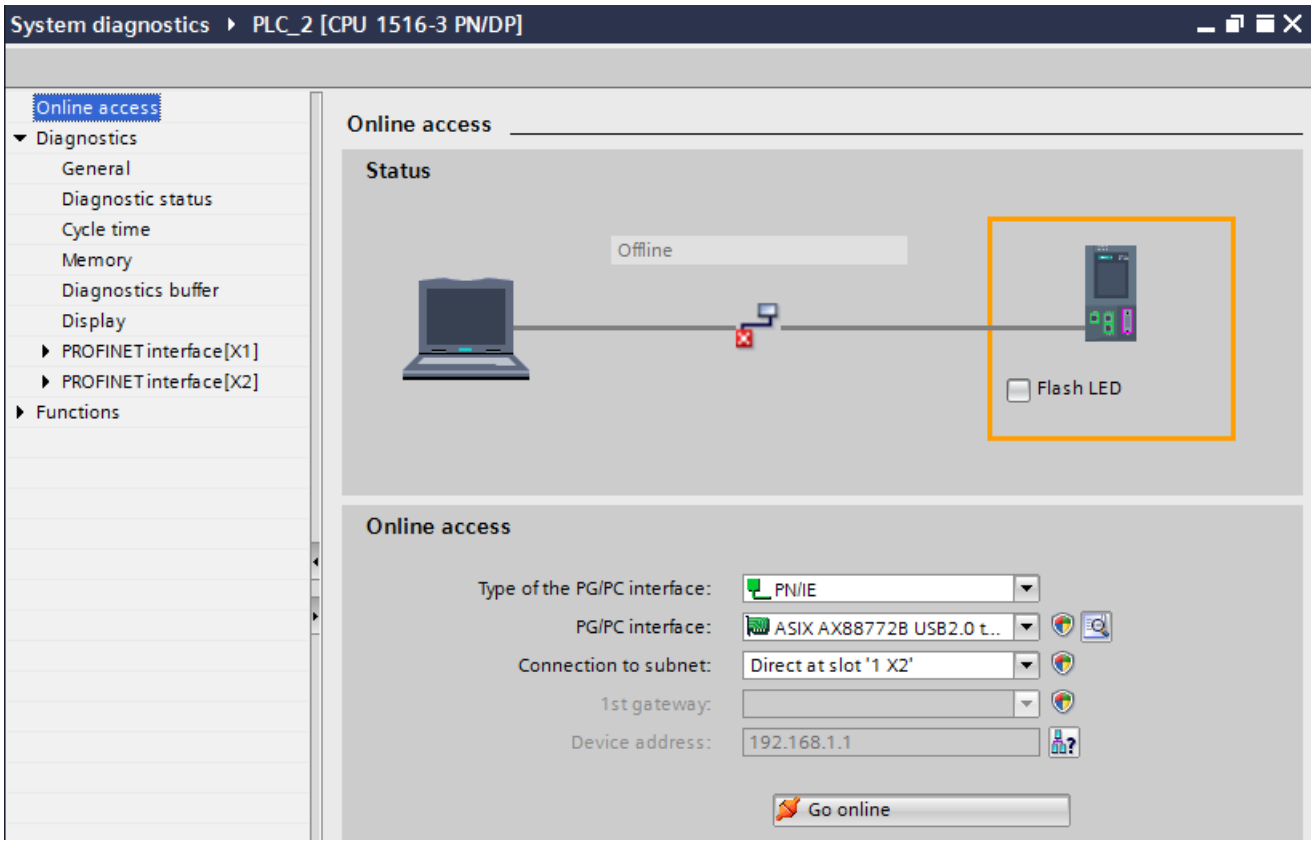


Figure 4-10 Setting online access

3. Make the settings for the interface.

   Here you can change an interface access that has already been set for an online connection that was successfully established previously.
4. Click on the "Go online" button.

   The online connection is established.

Result

You can find detailed diagnostic information on each device in the Inspector window, in the "Diagnostics" section of the area navigation on the "Properties" tab.

4.2.2.5 "Diagnostics" tab in the Inspector window

"Diagnostics" tab in the Inspector window

The "Diagnostics" tab of the Inspector window includes information on diagnostic events and configured alarm events.

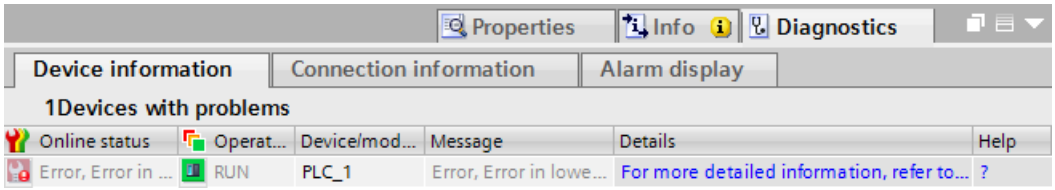


Figure 4-11 Diagnostics in the Inspector window, "Device information" tab

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Note

Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics icons (Page 27) and in the online help for STEP 7.

Subordinate "Device information" tab

This tab gives you an overview of faulty devices to which an online connection exists or has existed. The table provides the following diagnostic information on the faulty devices:

- Online status: includes the online status as diagnostic symbol and in words
- Operating mode: includes the operating mode as symbol and in words
- Device/module: Name of the affected device or the affected module
- Alarm: explains the entry in the previous column and displays an alarm, if necessary
- Details: The link opens the online and diagnostics view for the device or moves it to the foreground.
- Help: The link provides additional information on the fault.

Note

Communication and access errors

Errors in connection with the user program (e.g., communication errors, access errors) are not flagged in the "Diagnostics" tab of the device information. You must read out the diagnostics buffer of the CPU in the online and diagnostics view to get this information. The link in the "Details" column opens the diagnostics buffer.

Subordinate "Connection information" tab

The "Connection information" tab displays detailed diagnostics information for connections.

There will only be information on the "Connection information" tab if there is an active online connection to at least one end point of the relevant connection.

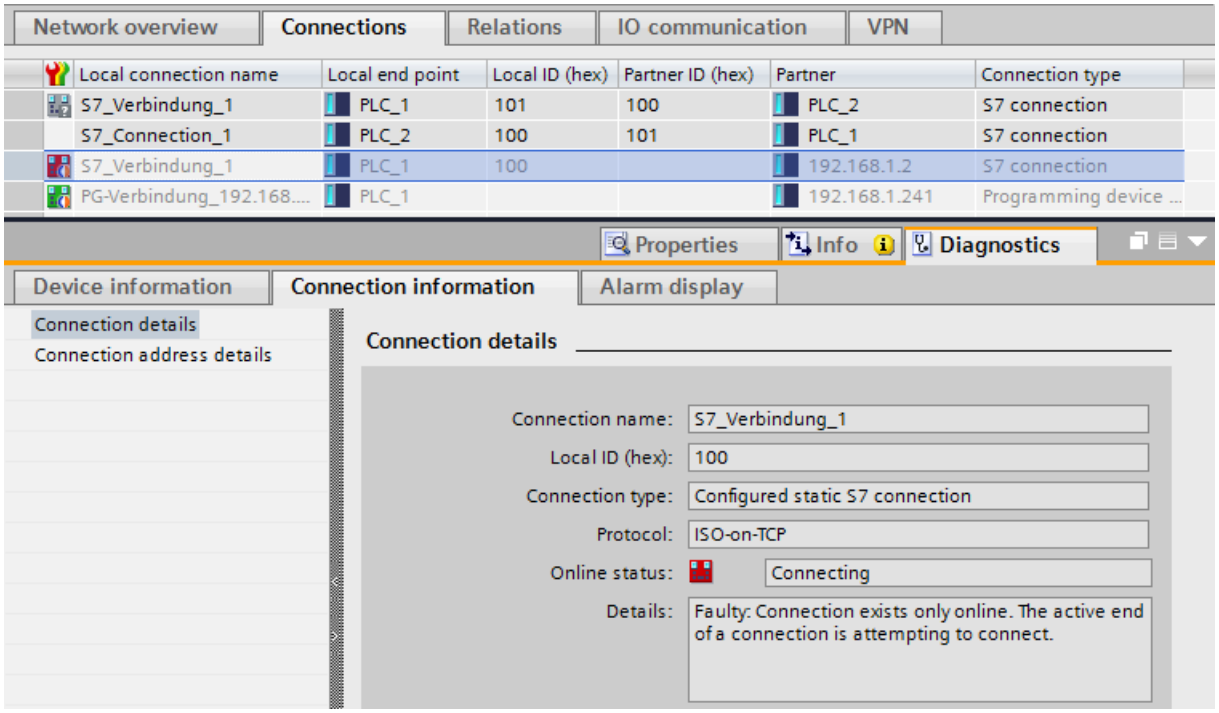


Figure 4-12 "Connection information" tab and open connection overview

If a module has been selected (network view), the tab contains the following group:

- Connection resources

If a connection has been selected (connection table), it contains the following groups:

- Connection details
- Address details of the connection

Subordinate "Alarm display" tab

System diagnostic alarms are output in the "Alarm display" tab.

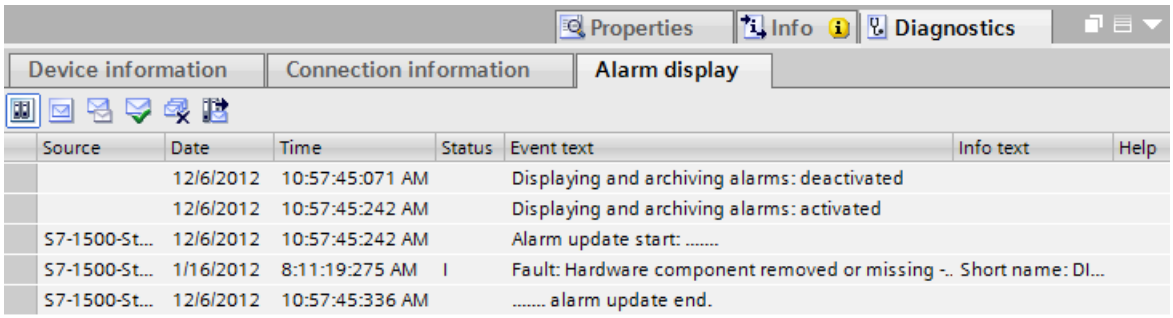


Figure 4-13 "Alarm display" tab

To receive alarms in STEP 7, follow these steps:

1. Open the project view.
2. Select the required CPU in the project tree.
3. Select the shortcut menu command "Go online" to connect online with the respective CPU.
4. Select the required CPU once again in the project tree and select the shortcut menu command "Receive alarms".

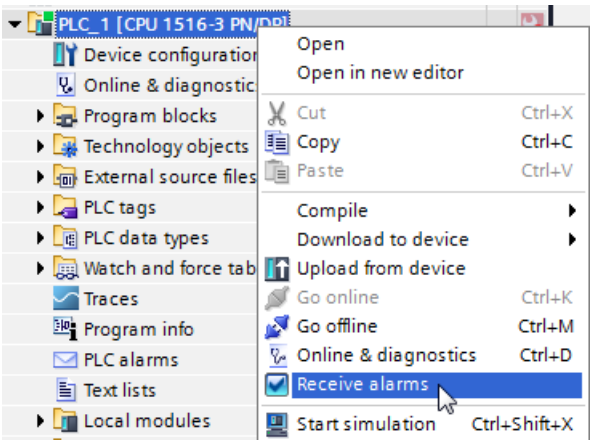


Figure 4-14 Receive alarms

5. Alarms are now displayed in the alarm display. "Archive view" is enabled by default.
6. To display the latest alarms, click the symbol "Active alarms" .

4.2.2.6 CPU diagnostics buffer

Definition

Each CPU and some other modules have their own diagnostics buffer, in which detailed information on all diagnostic events is entered in the order in which they occurred.

The CPU diagnostics buffer can be displayed on all display media (STEP 7, HMI, CPU web server and display of the CPU).

Diagnostic events

The entries available in the diagnostics buffer include:

- Internal and external errors on a module
- System errors in the CPU
- Operating mode transitions (e.g., from RUN to STOP)
- Errors in the user program
- Removal/insertion of modules

The contents of the diagnostics buffer is stored in the retentive memory in case of a memory reset of the CPU. Errors or events can be evaluated even after a longer period of time thanks to the diagnostics buffer to determine the cause of a STOP or to trace the occurrence of a single diagnostic event and to be able to assign it.

Procedure

To display the diagnostics buffer of a CPU, follow these steps:

1. Select the respective CPU.
2. Select the shortcut menu command "Online & Diagnostics".

   The "Online access" view is opened in the working area.

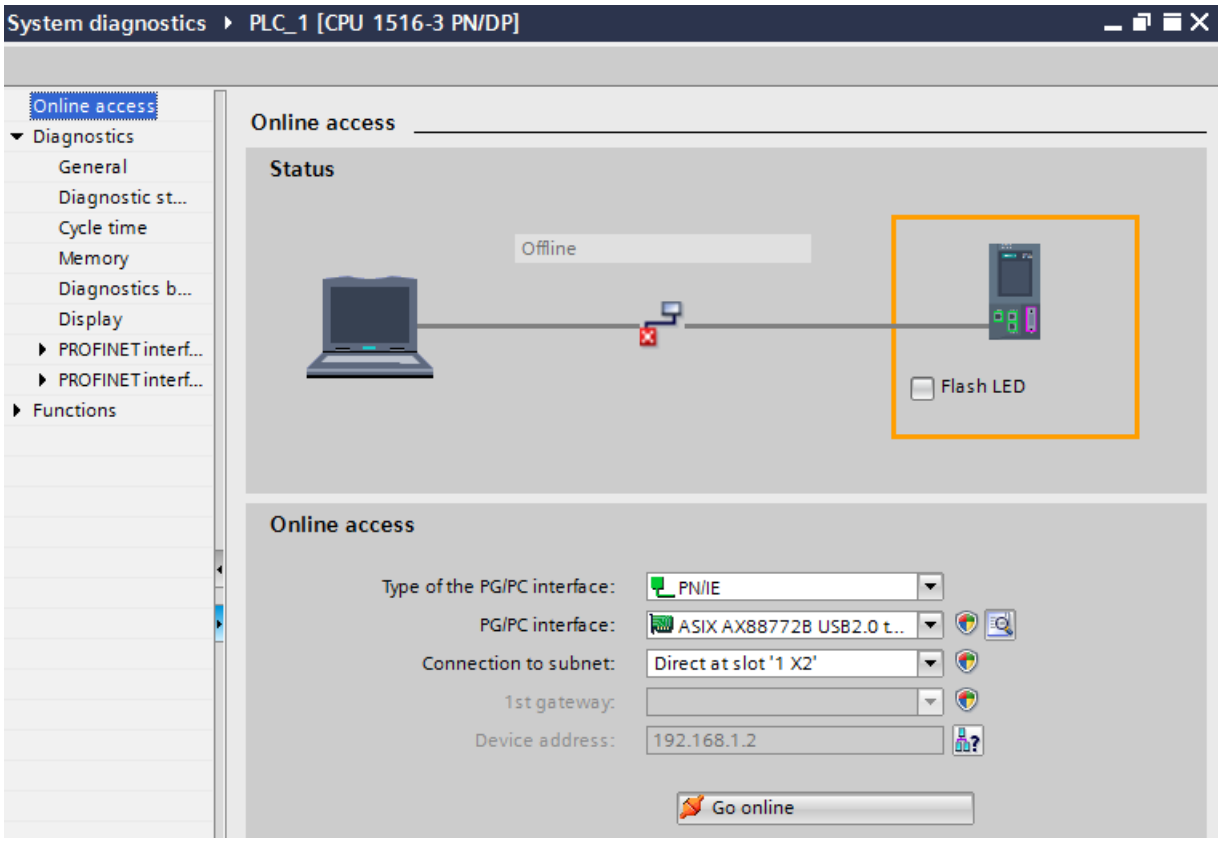


Figure 4-15 Setting up online access

3. Set the interface.
4. Click on the Go online button.

5. Select the area "Diagnostics buffer".

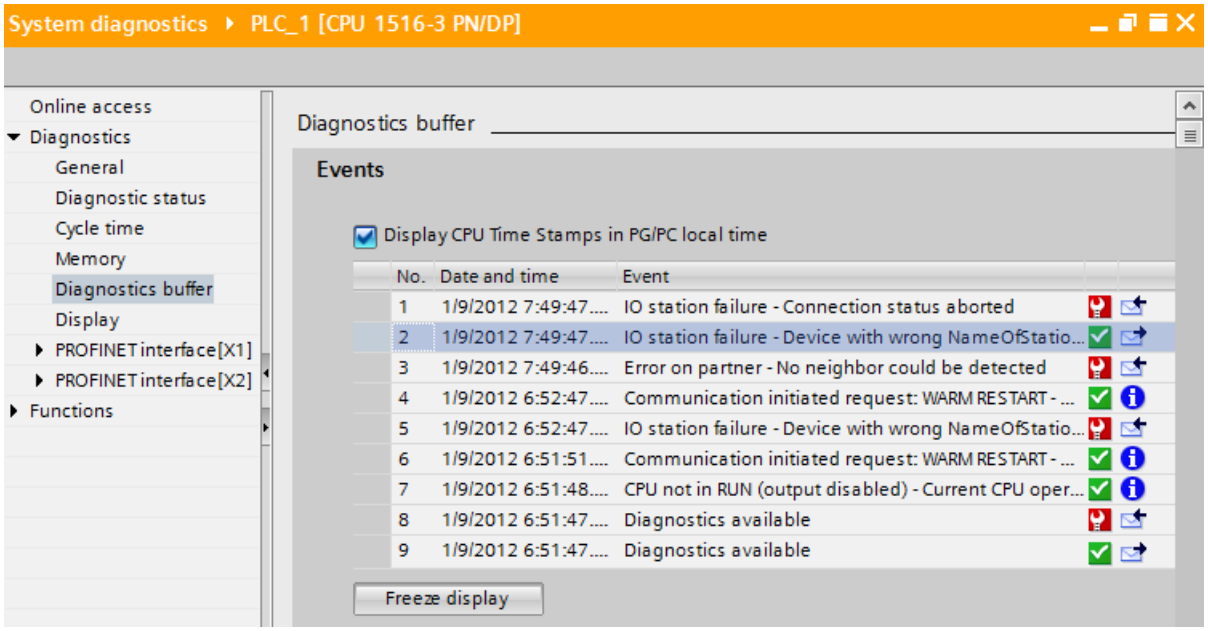


Figure 4-16 Diagnostics buffer in STEP 7

Note

Filter events

You can filter the entries in the diagnostics buffer in the settings of the "Diagnostics buffer" area to only display specific types of events. This means that specific events, such as "CPU and configuration-internal events" or "Connection diagnostics events", can be displayed separately.

4.2.2.7 "Online-Tools" task card

Online view in the "Online-Tools" task card

As soon as an online connection has been established to a CPU, the "Online-Tools" task card gives you an overview of the CPU operating mode, the cycle time and the memory usage.

- The "CPU Operator Panel" palette displays the current state of some LEDs and the mode switch of a CPU.
- The "Cycle time" palette displays the cycle time diagram and below it the measured cycle times as absolute values.
- The "Memory" palette contains the current memory usage of the associated CPU. The available memory is displayed in a bar diagram as well as a numerical value (percentage).

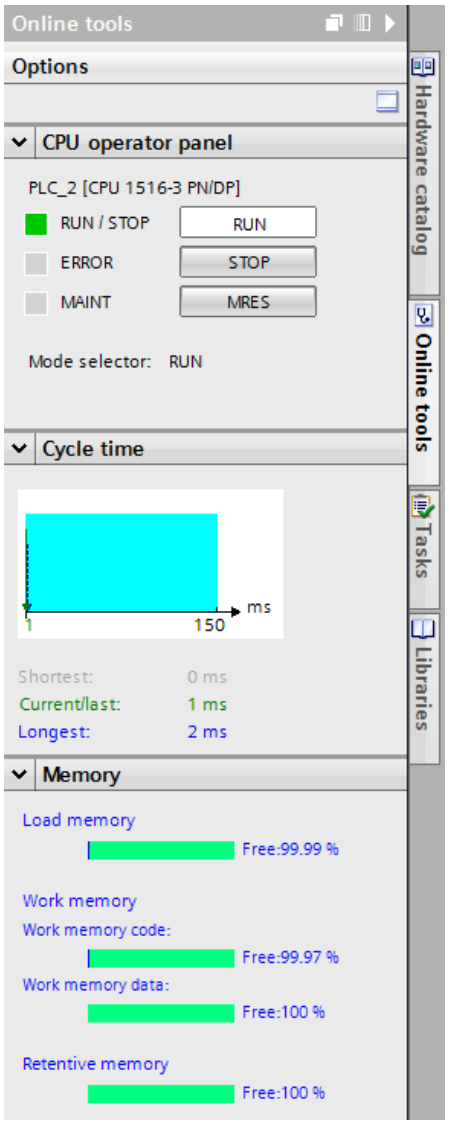


Figure 4-17 "Online-Tools" task card

4.2.2.8 Configuring the settings for I/O modules in STEP 7

You can also make settings for system diagnostics in STEP 7 for I/O modules.
The parameters you have to configure depend on the I/O module.

The settings are optional.

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.
- A design with I/O modules has been configured.

Procedure

To make settings for system diagnostics of I/O modules in STEP 7, follow these steps:

1. Select the respective I/O module in the device view.
2. Open the "Properties" tab in the Inspector window.
3. Select the area "Inputs", for example.

   You have access to the settings for system diagnostics of the I/O module. If you select "Wire break", for example, a possible wire break for the channel is flagged during operation.

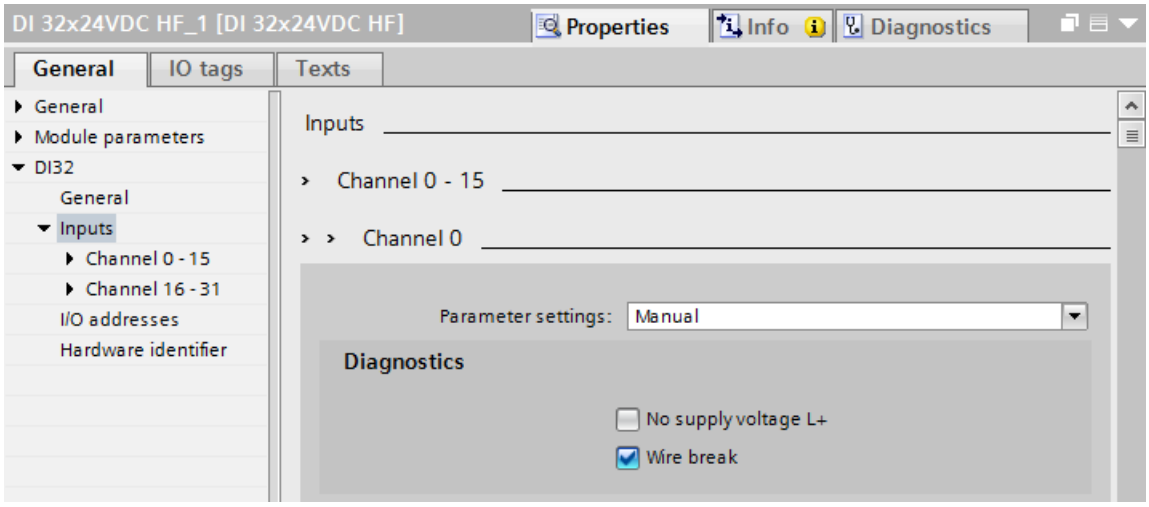


Figure 4-18 I/O setting with a digital input module

4. Save the hardware configuration.
5. Download the new hardware configuration to the CPU.

Additional information

The documentation for the respective module includes additional information on parameter assignment of I/O modules.

4.2.3 Diagnostic information by means of the web server

System diagnostics by means of the CPU web server

The S7-1500 CPUs have an integrated web server and let you display the system diagnostics information by means of PROFINET. Any web client, such as PCs, multi panels or smartphones, has read-only access to module data, user program data and diagnostic data of a CPU by using an Internet browser. This means access to CPUs is possible without installed STEP 7.

The web server offers web pages with reduced complexity which have been optimized for devices with small screens and low computing power.

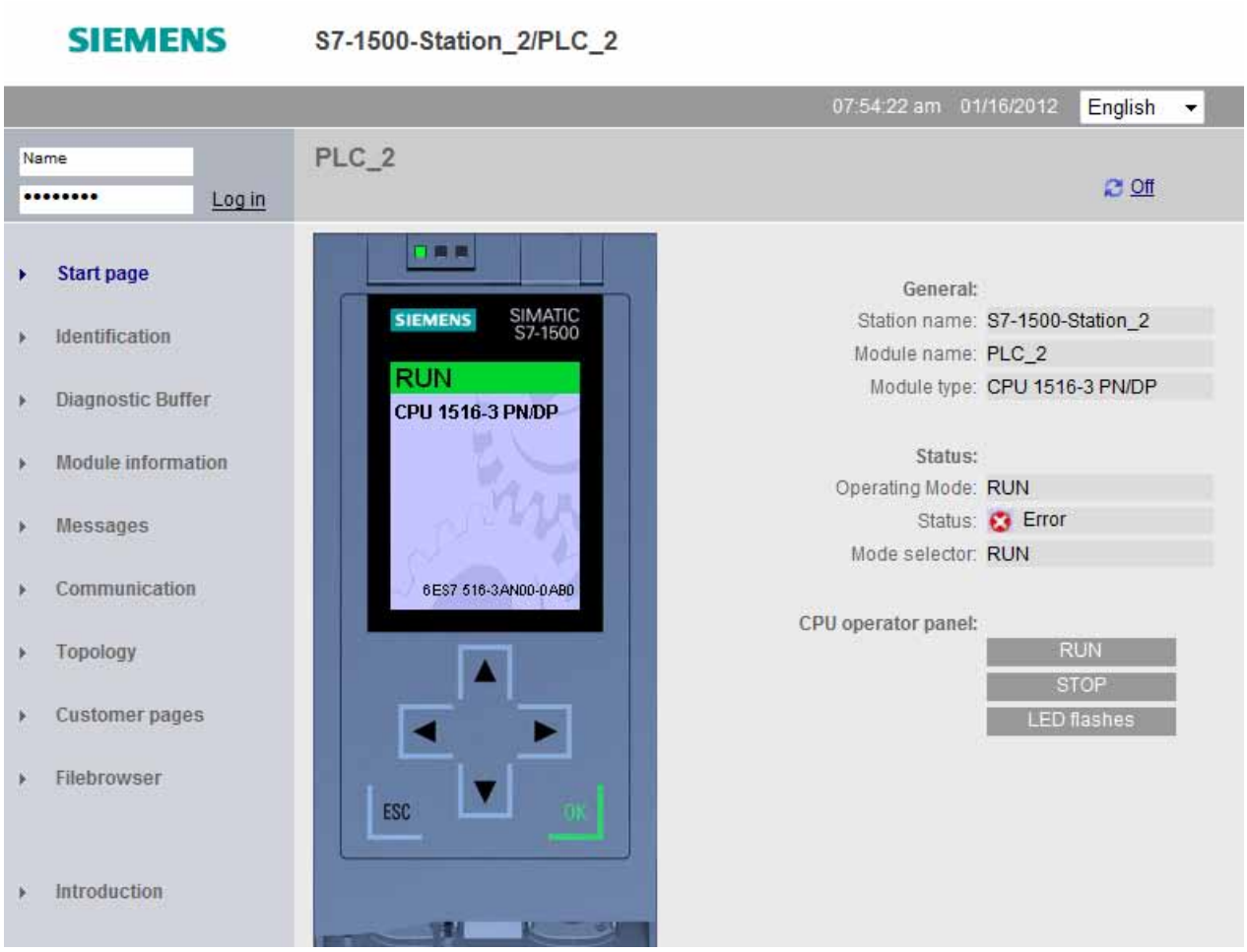


Figure 4-19 Web server, home page

The following diagnostic options are available with the integrated web server:

- Home page with general CPU information
- Identification data
- Contents of the diagnostics buffer
- Module information
- Alarms (without acknowledgment option)
- Information about communication
- Topology

Requirements

- STEP 7 is open.
- A S7-1500 CPU has been added to the project.
- The project view is open.

Procedure

Follow these steps to access the web server:

1. Open the network view.
2. Select the CPU.
3. Open the "Properties" tab in the Inspector window.
4. Select the entry "Web server" in the "General" area navigation.

   The "Web server" area is displayed.

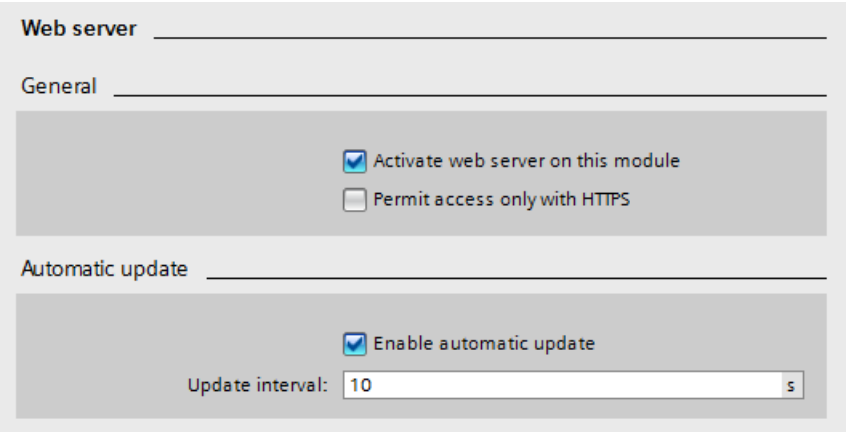


Figure 4-20 Enable the web server

5. Select the check box "Enable Web server on this module".

6. Enable the web server also for each interface by which you want to access the web server. Select the respective interface. Open the "Properties" tab in the Inspector window and select the entry "Web server access" in the "General" area navigation. Select the check box "Enable Web server for this interface".

   Automatic updating is activated in the basic setting of a configured CPU.

7. Connect the client to a PROFINET interface of the CPU or to a communication processor (e.g., CP 1543-1).
8. Open the web browser.
9. Enter the IP address of the CPU in the "Address" field of the web browser in the following format: http://a.b.c.d or https://a.b.c.d (input example: http://192.168.3.141).
10. The home page of the CPU opens. From the home page you can navigate to more information.

Note

Managing access rights

In STEP 7, you can create users, define access rights and assign passwords under "Web server > User management". Users only have access to the options that are permanently linked to the access rights.

For further information on managing access rights, please refer to "Configuring the Web server" in the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

Diagnostic option "Diagnostics buffer"

The browser displays the content of the diagnostics buffer on the "Diagnostics buffer" web page.

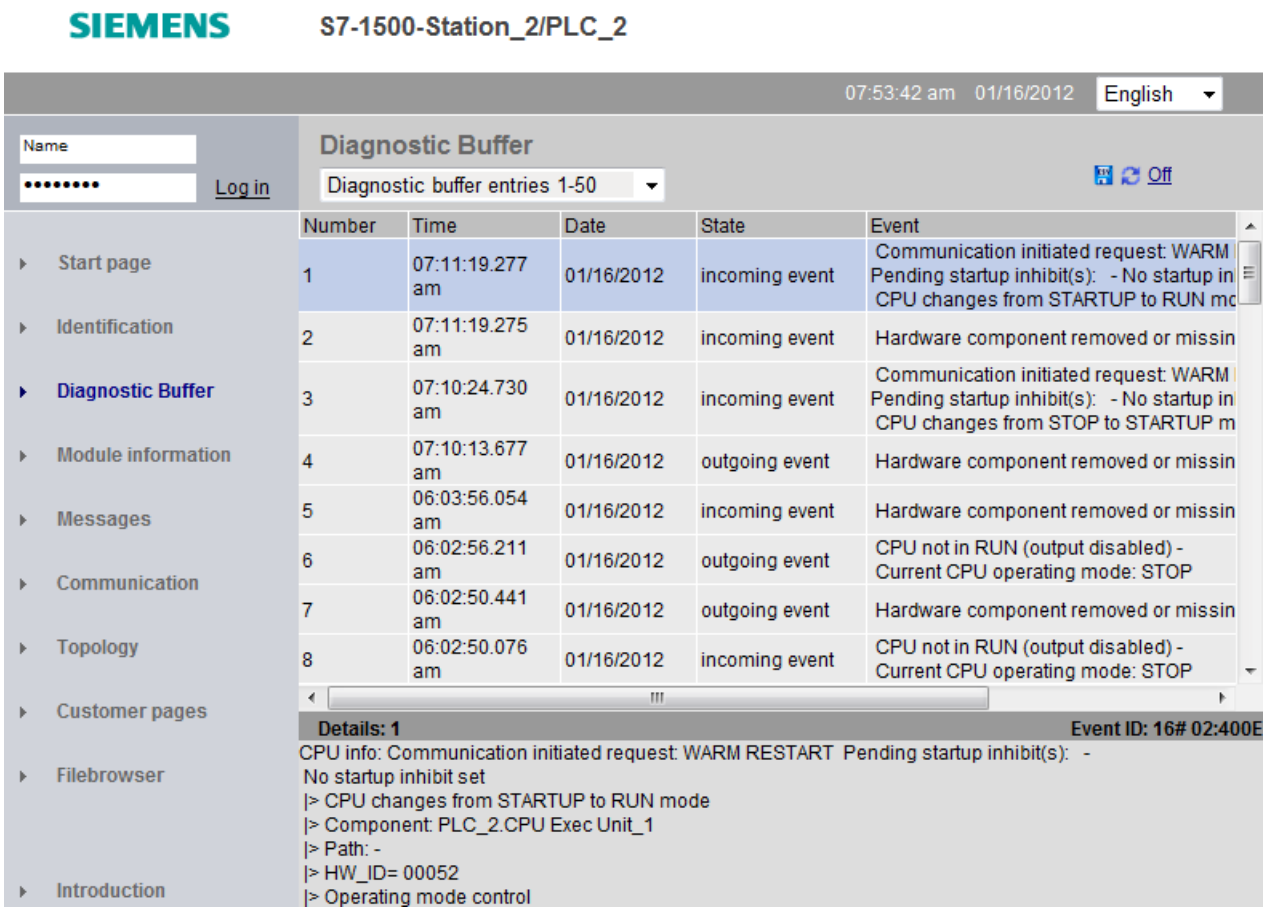


Figure 4-21 Web server, "Diagnostics buffer" view

Diagnostic option "Module information"

The status of a device is indicated by the web browser with symbols and comments on the "Module information" web page.

Modules are displayed on the "Module information" web page in the "Name" column with a link. You can get to the faulty module in hierarchical order.

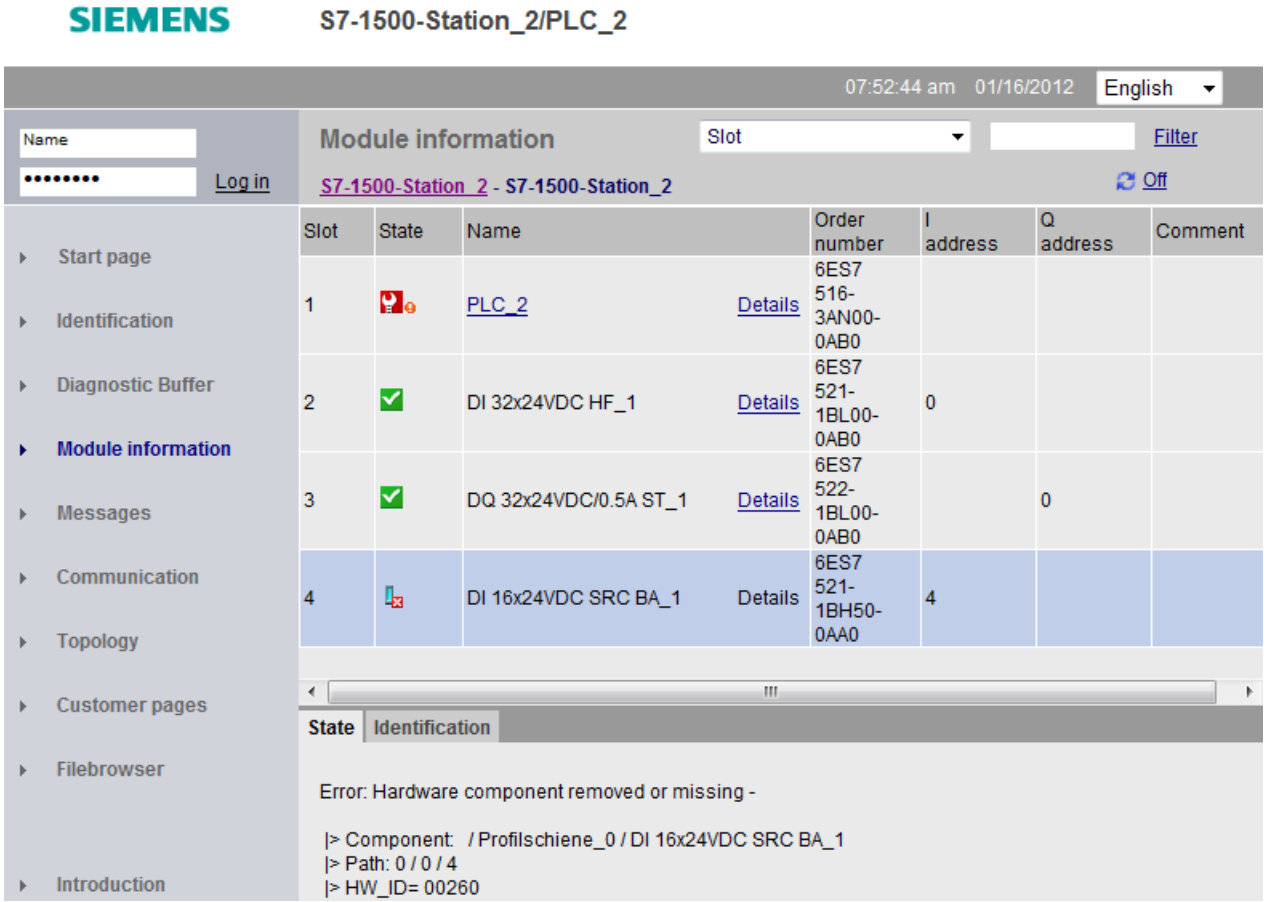


Figure 4-22 Web server, "Module information" web page

Diagnostic option "Alarms"

The web browser displays the content of the alarm buffer on the "Alarms" web page. The alarms cannot be acknowledged on the web server.

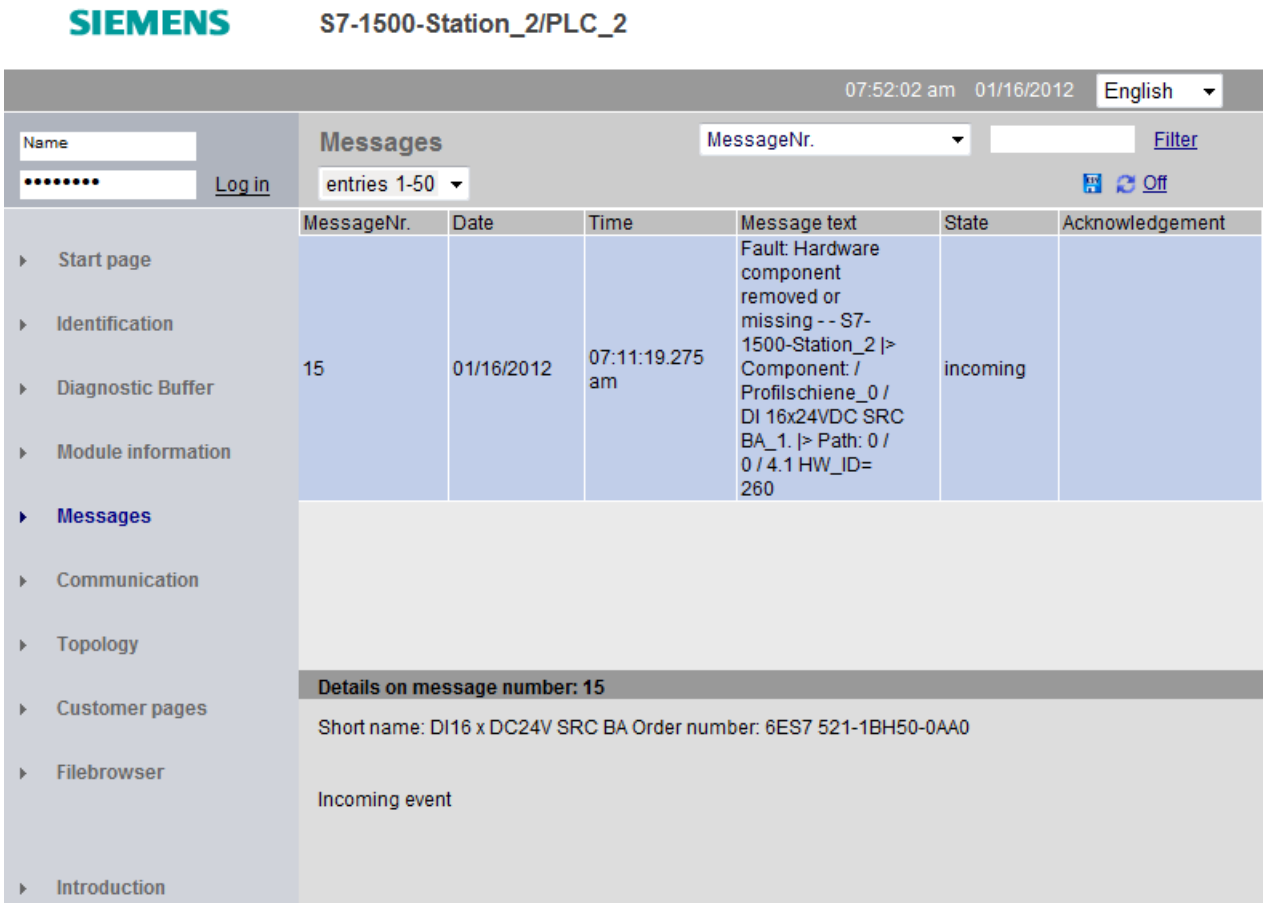


Figure 4-23 Web server, "Alarms" web page

"Topology" diagnostic option

The "Topology" web page provides information on the topological configuration and status of the PROFINET devices in your PROFINET IO system.

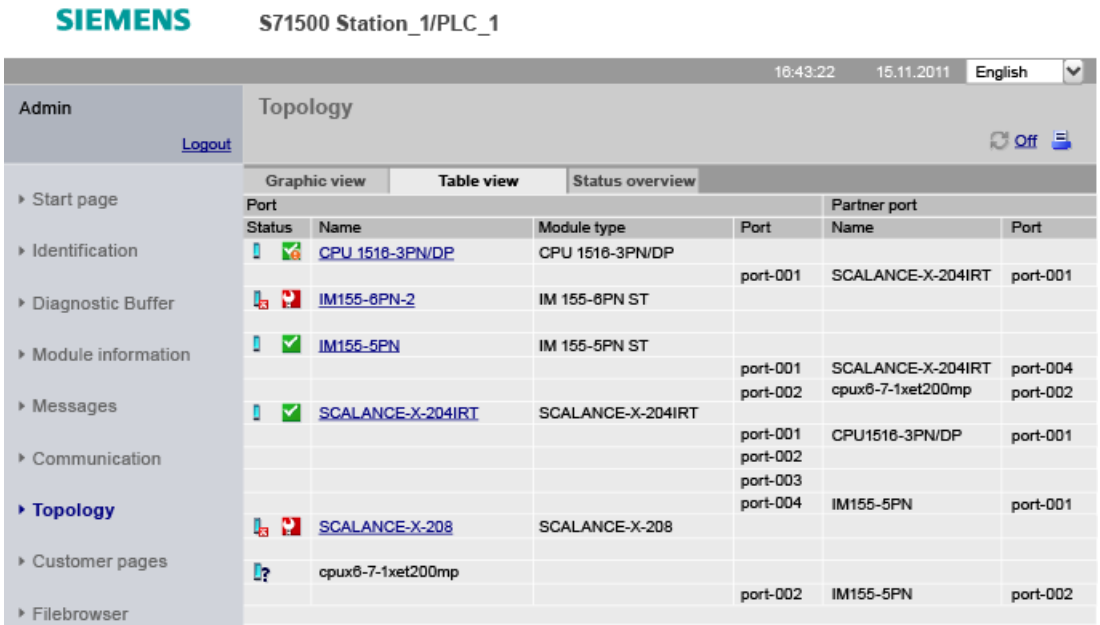


Figure 4-24 Web server, "Topology" web page

Additional information

Additional information on the topic is available in the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

4.2.4 Diagnostic information using the HMI diagnostic view

Objects for system diagnostics

The full functionality of the HIM diagnostics view is only available with Comfort Panels and WinCC RT Advanced . Basic Panels do not support the complete range of system diagnostics functions.

Two objects are available for system diagnostics on an HMI device.

System diagnostics view

The system diagnostics view reflects the current status of all accessible devices in your plant. You navigate directly to the cause of the error and the associated device. You have access to all diagnostics-capable devices that you have configured in the STEP 7 hardware and network editor.

Note

Compatibility with Basic Panels

Only the "System diagnostics view" object is available with Basic Panels.

Basic Panels do not support the "System diagnostics window" object or the graphic symbol "System diagnostics indicator".

System diagnostics window

The system diagnostics window is an operating element and display object.

The functions of the system diagnostics window are the same as for the system diagnostics view. Because the system diagnostics window is configured in the "Global screen", you can also specify, for example, if the object can be closed in WinCC Runtime.

4.2.4.1 Configuring system diagnostics

Introduction

You add a system diagnostics view to your project to get an overview of all devices available in your plant.

The system diagnostics window offers an overview of all devices available in your plant. The system diagnostics window behaves like the system diagnostics view but is only available in the global screen.

Requirements

- At least one CPU has been set up in the project.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- CPU and the HMI device are connected with each other by an HMI connection.
- You have created a screen (for the system diagnostics view).
- The global screen is open (for the system diagnostics window).
- The Inspector window is open.

Procedure

1. Double-click the "System diagnostics view" object in the "Tools" task card.
   The object is added to the screen.

Figure 4-25 Adding a system diagnostics view

2. Select the "Properties" tab in the Inspector window.
3. Select the area "Columns".
4. Enable the columns that you require in the device view for WinCC Runtime, for example:
   - Status
   - Name
   - Operating mode
   - Slot
   - Address
5. Enable the columns that you require in the device view for WinCC Runtime, for example:
   - Status
   - Name
   - Operating mode
   - Plant designation
   - Address
6. You can change the column headers in the "Columns" area, if necessary.
7. Select the "Display" area.
8. Enable "Column settings > Columns moveable" to move the columns in WinCC Runtime.
9. To close the system diagnostics window in WinCC Runtime, enable
   "Properties > Window > Closable" in the "Properties" tab of the Inspector window.

Result

The system diagnostics view has been added to the screen. The diagnostic status of the entire plant is displayed in the system diagnostics view in WinCC Runtime.

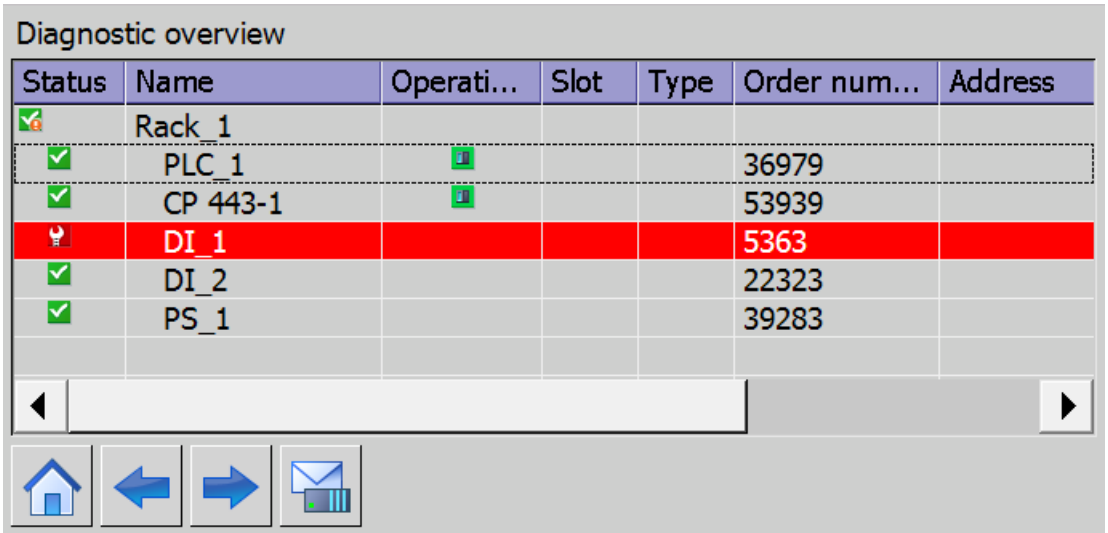


Figure 4-26 System diagnostics view in the screen

The system diagnostics window has been added to the global screen. If there is an error message in the plant, the system diagnostics window responds and displays the affected device.

4.2.4.2 Different views of the HMI diagnostics view

Introduction

There are three different views available in the system diagnostics view and the system diagnostics window.

- Device view
- Details view
- Matrix view (for master/IO systems only, PROFIBUS, PROFINET)

Device view

The device view shows all the available devices of a layer in a table. Double-clicking on a device opens either the lower-level devices or the detail view. Symbols in the first column provide information about the current state of the device.

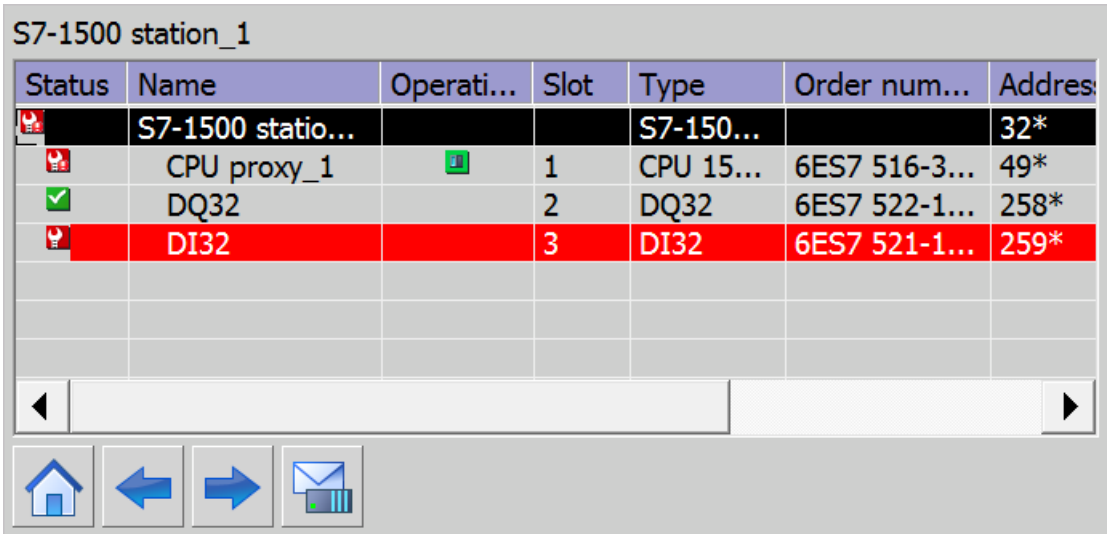


Figure 4-27 Device view

Details view

The detail view gives detailed information about the selected device and any pending errors. Check whether the data is correct in the detail view.

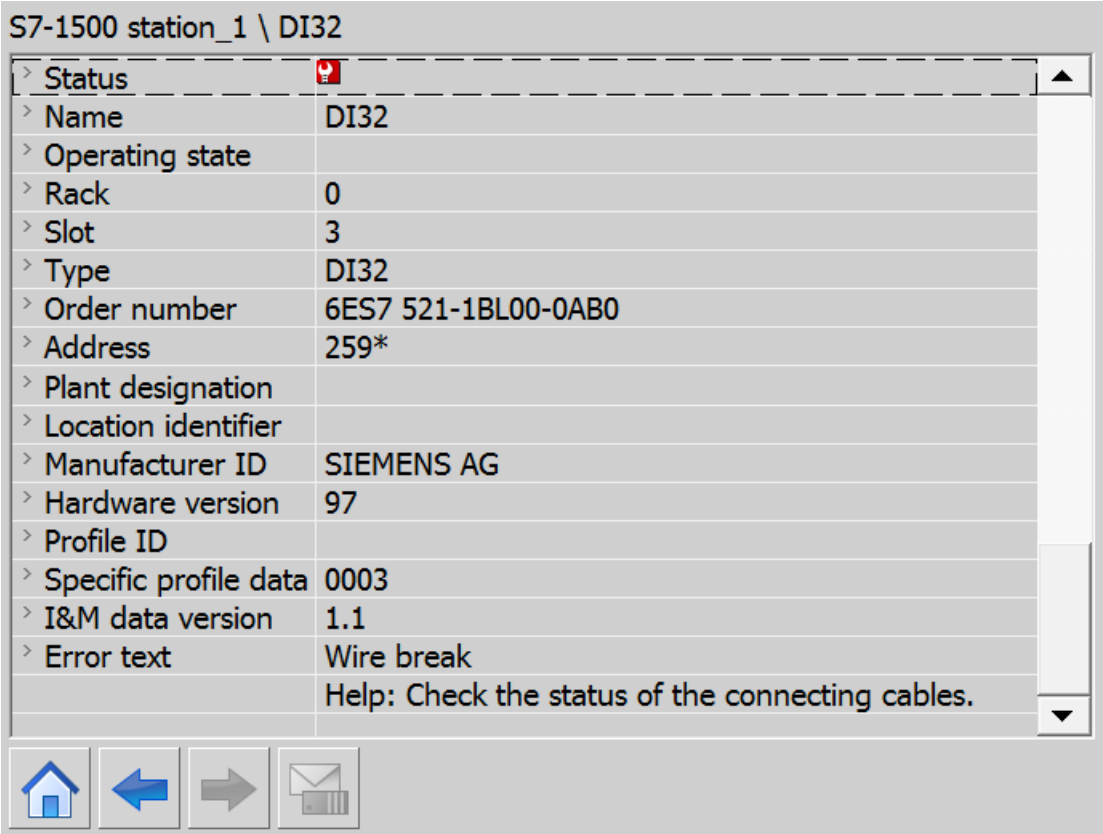


Figure 4-28 Details view

Matrix view

The matrix view is only available for distributed I/O systems. The matrix view shows the status of the devices of the PROFIBUS/PROFINET subnet.

- In PROFIBUS, the numbers assigned by PROFIBUS are used for identification (DP station number).
- In PROFINET, the IO devices are numbered consecutively from 1.

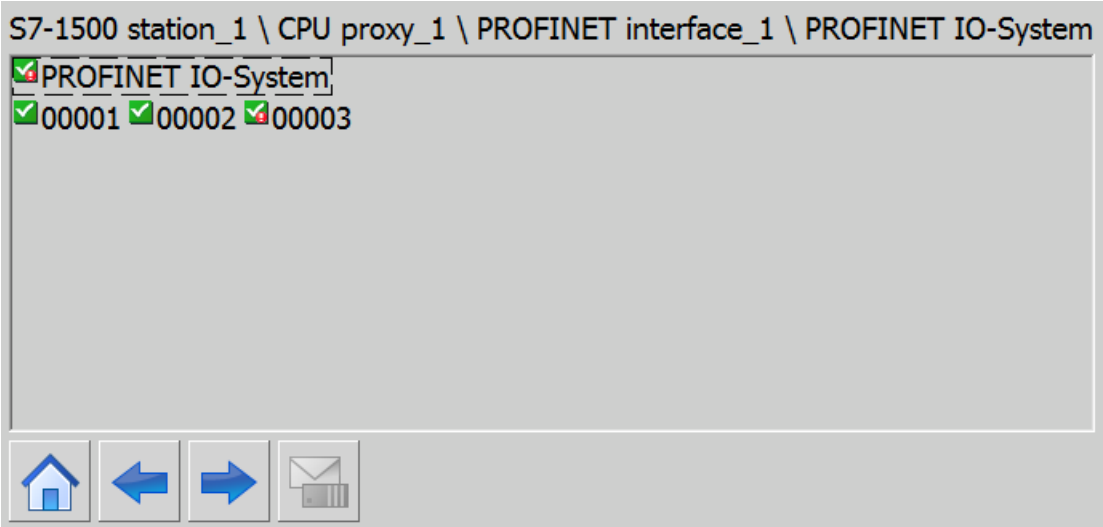


Figure 4-29 Matrix view

Navigation buttons

Button	Function
	Opens the lower-level devices or the detail view if there are no lower-level devices.
	Opens the higher-level device or the device view if there is no higher-level device.
	Opens the device view.

4.2.4.3 Inserting system diagnostics indicator

Introduction

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant.

The library object shows two different states:

- No error
- Error

Requirements

- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Libraries" task card is opened.
- The global library "Buttons and Switches > DiagnosticsButtons" is open.
- A screen is open.
- The system diagnostics window has been set up in the global screen.

Procedure

1. Select the "DiagnosticsIndicator" object in the library.
2. Drag-and-drop the library object to the position in the work area where you want to insert the object.

   The library object is added.

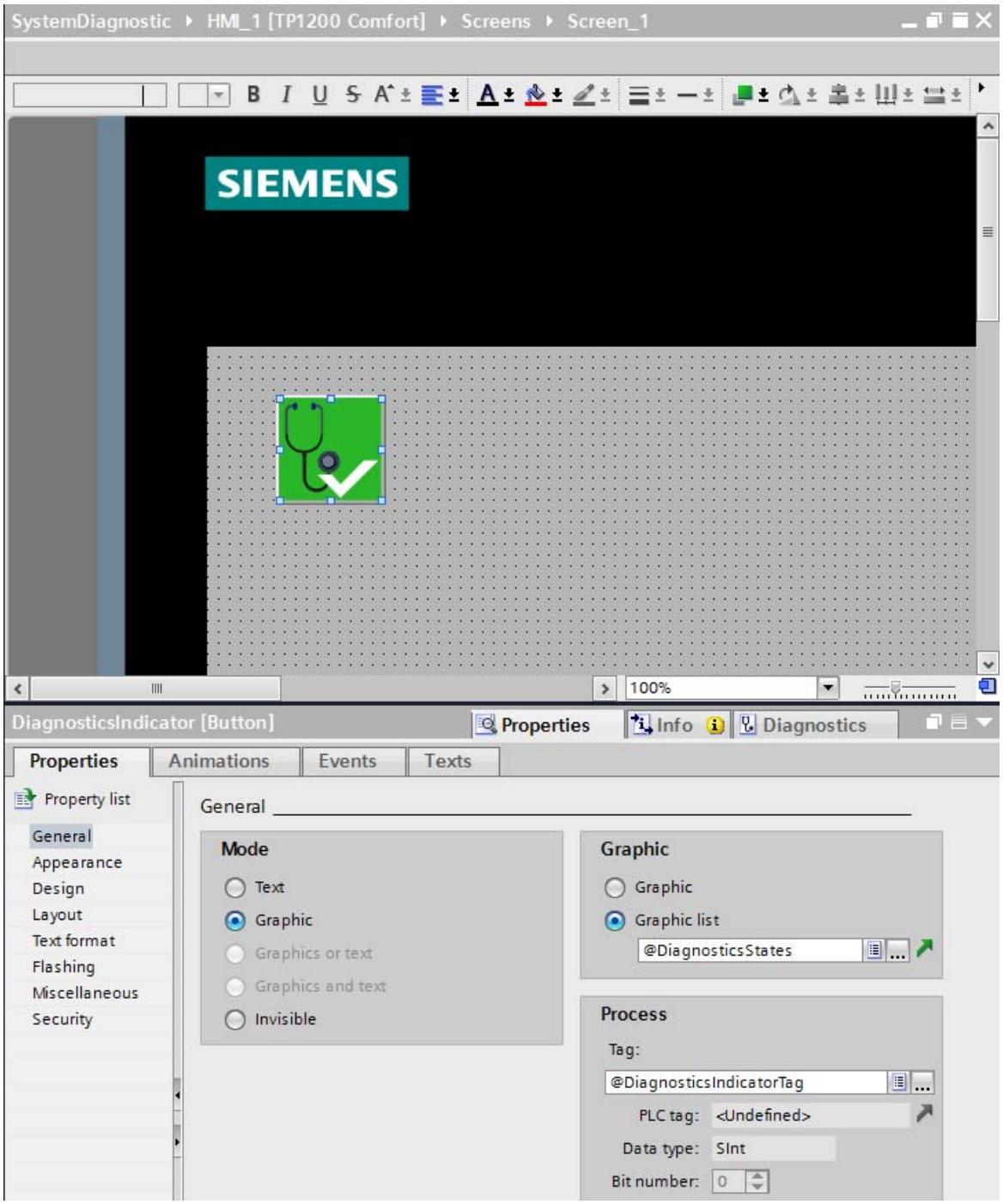


Figure 4-30 Inserting library object in the working area

3. Select the library object.
4. Open the "Events" tab in the Inspector window.

   The "ShowSystemDiagnosticsWindow" is preset for the event "Click".

Result

The system diagnostics indicator has been added to the project and connected with the system diagnostics window.

The system diagnostics indicator changes its appearance if an error message is output in WinCC Runtime. The system diagnostics window opens when you click on the system diagnostics indicator. The system diagnostics window shows the detail view of the affected device.

Configuring access protection for the system diagnostics window

Configure access protection for the system diagnostics indicator to prevent unauthorized access to the system diagnostics windows.

1. Select the "DiagnosticsIndicator" object in the screen.
2. Open the "Properties" tab in the Inspector window.
3. Select an authorization in the "Security in Runtime" area.

A logon dialog opens when you click on the system diagnostics indicator in WinCC Runtime. The system diagnostics window does not open unless you have the required authorization.

4.2.4.4 Configuring button as system diagnostics indicator

Introduction

Instead of using the object "DiagnosticsIndicator" from the library, you can, for example, configure a button in "Graphic" mode to indicate errors in your plant.

Requirements

- At least one CPU has been created.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Tools" task card is open.
- A bit graphics list has been created with two different graphics for the states.
- A screen is open.
- You have created a system diagnostics view.

Procedure

Follow these steps to configure a button as system diagnostics indicator:

1. Double-click the "Button" object in the "Tools" task card. A button is added to the screen.
2. Enable the "Properties" tab in the Inspector window and the "Graphic" mode in the "General" area.
3. Select the bit graphics list as graphics list.
4. Select the "Properties" tab in the Inspector window and select the tag @DiagnosticsIndicatorTag under "Tag" in the "General" area.
5. To assign a function to the button, select the "Events" tab in the Inspector window.
6. Select the "Click" event.
7. Click on "Add function" in the table.
8. Select "EnableSystemDiagnosticsView".
9. Select the system diagnostics view.

Result

You have configured an interface that reacts to error events from the CPU.
The button changes when an error event occurs in Runtime.

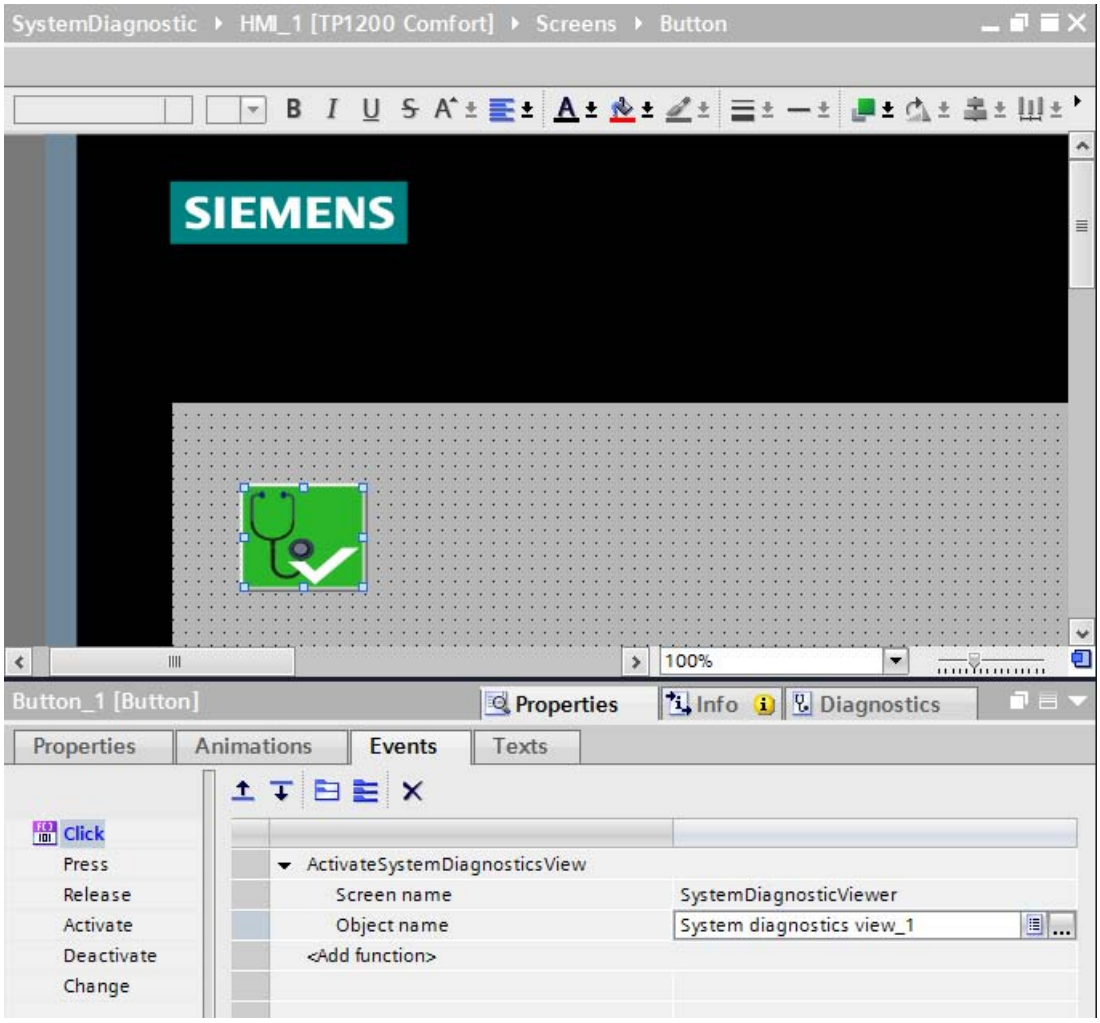


Figure 4-31 Configured button

The button has two states.

- Error

  The system diagnostics view opens when you click on the button.
  The system diagnostics view shows the detail view of the affected device.

- No error

  The system diagnostics view opens when you click on the button.
  The system diagnostics view shows the device view.

System diagnostics by means of the user program 5

5.1 Options of system diagnostics in the user program

Introduction

You can configure responses to diagnostic alarms in the user program. You can, for example, specify that your plant is stopped in case of specific diagnostic alarms.

Options of establishing diagnostics in the user program

A vendor-independent structure of data records with diagnostics information applies.
The following instructions are available for establishing the system diagnostics of a device:

Instruction	Description
RDREC	• includes error information on faulty modules • works synchronously, which means processing takes place across several calls
RALRM	• includes detailed information on the cause and location of the error • reads alarm information from all diagnostics-capable modules, regardless if they are installed centrally or are used in PROFIBUS DP or PROFINET IO
DPNRM_DG	• reads the current diagnostics data of a DP slave (DP standard diagnostics)
GEN_DIAG	• generates diagnostic information • to generate diagnostic information, the module or submodule is identified with its logical address
GET_DIAG	• provides diagnostic information • to provide diagnostic information, the module or submodule is selected
T_DIAG	• provides diagnostic and status information on a connection
RD_SINFO	• reads the start information of the OB last called
LED	• reads the status of the module LED
RST_EVOV	• resets the event counter
Get_IM_Data	• reads the Information&Maintenance data of the CPU
Transfer_IM_Data	• transmits the Information&Maintenance data of the CPU
DeviceStates	• outputs the device status
ModuleStates	• outputs the module status

Additional information

See the STEP 7 online help for additional information on the instructions for system diagnostics.

5.2 System diagnostics using process image inputs

Introduction

In addition to the option to evaluate the system diagnostics by means of diagnostic alarms, the input and output modules of the S7-1500 automation system provide diagnostic information using the process image of the inputs.

The system diagnostics described before is made available asynchronously to the program processing. To ensure the correct processing of the input data even in the case of faults, some modules offer the so-called value status (QI = Quality Information) for evaluation.

Requirement for evaluation of the value status

The diagnostic information about the process image of the inputs is transmitted synchronized with the user data. Select the "Value status" check box in the properties of the I/O module in STEP 7 if you want to evaluate the value status of the channel.

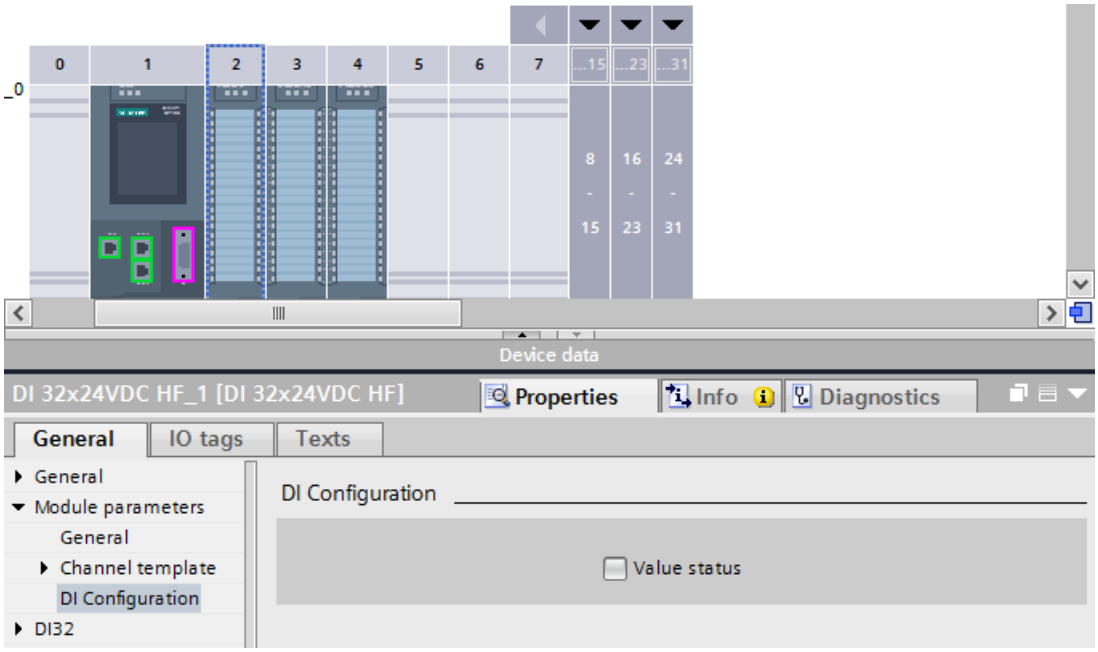


Figure 5-1 Enable value status

Example for evaluation of the value status

Two bytes are used as user datum and two more bytes are used for the value status in a 16-channel digital input module. This information is directly available in the process image of the inputs and can be called with simple binary operations.

Each user data bit is uniquely assigned one bit in the value status. The bit in the value status indicates the validity of the read-in value in the user datum.

The table below gives an overview of the functionality of the evaluation of the user datum:

Table 5- 1 Example for evaluation of the user datum in case of a wire break

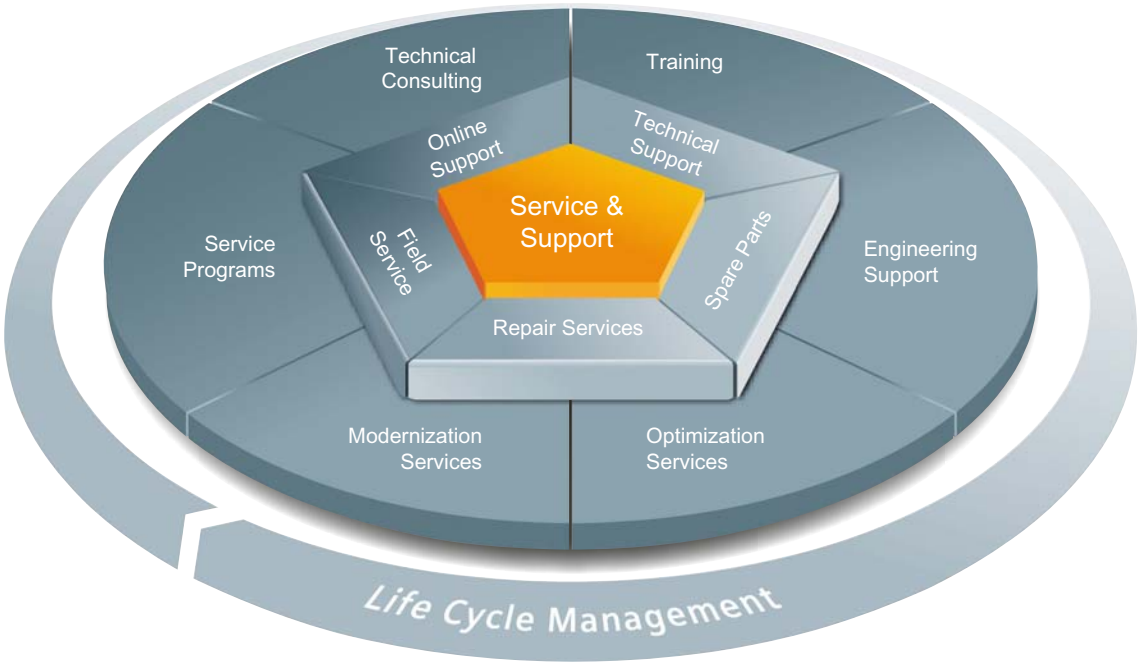
	Bit in user datum	Bit in value status	Value in user datum
Faulty channel	Logical 0	0	Invalid
Fault-free channel	Logical 0 (actual value)	1	Valid

Additional information

I/O modules reserve different bytes in the process image of the inputs. The specific manual for the used module includes specific information on allocation and assignment.

Service & Support

A



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Glossary

Alarm

An message sent to the operator due to events or states of the system.

Button (WinCC)

Object in WinCC that points out faults in the plant

Channel fault

Channel-related error of an individual channel - an I/O with inputs, for example, wire break or short circuit

Device

Modules with a network connection are referred to as device. Devices are installed on racks where they can be interconnected with other modules.

Diagnostics buffer

A buffered memory area in the CPU; it stores diagnostic events in the order of their occurrence

Firmware of the CPU

In SIMATIC, a distinction is made between the firmware of the CPU and user programs.

The firmware is a software embedded in electronic devices, which means it is permanently connected with the hardware functionally. It is usually saved in a flash memory, such as EPROM, EEPROM or ROM, and cannot be replaced by the user or only with special means or functions.

User program: see glossary entry "User program"

Global screen (WinCC)

A screen that is opened in the system diagnostics window is a global screen.

HMI device

Human Machine Interface, device for visualization and control of automation processes

HMI diagnostics view (WinCC)

The HMI diagnostics view is an object in WinCC. The HMI diagnostics view can only be used with Comfort Panels and WinCC Advanced RT.

I/O module

Device of the distributed I/O that is used as interface between the controller and the process

Industrial Ethernet

Guideline for setting up an Ethernet in an industrial environment. The main difference to the standard Ethernet is the mechanical current carrying capacity and interference immunity of the individual components.

Memory reset

Procedure to set the memories of the CPU to a defined initial state.

PLC

Programmable **L**ogic **C**ontroller: Component of the CNC by which the machine manufacturer coordinates the interaction between the NC requirements (part program), the inputs of the machine operator and the current machine state

PROFIBUS

Standard for fieldbus communication in automation technology

PROFINET

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology supported by the PROFIBUS User Organization.

Subnet

Part of a network whose parameters have to be synchronized with the devices (e.g., with PROFINET). It includes the bus components and all connected stations. Subnets can be linked by means of gateways, for example, to form a network.

System diagnostics

In the SIMATIC environment, diagnostics of devices and modules is collectively referred to as system diagnostics. System diagnostics is used, for example, to monitor the states of the following components in the system: Power supply, device, I/O.

System diagnostics indicator (WinCC)

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant and displays two states: No error, error

Topology

Structure of a network. Common structures include:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

User program

In SIMATIC, a distinction is made between user programs and the firmware of the CPU.

The user program contains all instructions, declarations and data by which a plant or process can be controlled. It is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

Firmware: see glossary entry "Firmware of the CPU"

Value status

The value status describes a specific signal state. It is constantly updated and cyclically transmitted by the field device as quality statement together with the measured value.

Web server

Software/ communication service for data exchange using Ethernet. The web server provides the documents by means of standardized transmission protocols (HTTP, HTTPS) to a web browser. Documents can be static or dynamic upon request by the web browser composed from different sources by the web server.

WinCC

Windows **C**ontrol **C**enter: a PC-based process visualization system

WinCC Runtime

Component of the basic software WinCC

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SIMATIC

S7-1500 Structure and Use of the CPU Memory

Function Manual

01/2013

A5E03461664-01

Legal information

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This documentation describes the various memory areas of the S7-1500 CPU, and shows you how to make the best use of these memory areas.

The manual also shows you how to free work memory by using recipes and Data Logs.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge about the use of computers
- Knowledge of working with the TIA Portal and STEP 7

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for all CPUs of the S7-1500 product family.

Additional support

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (www.siemens.com/industrymall).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation on the structure and use of the CPU memory

The following table lists additional documentation which supplements this description of the structure and use of CPU memory.

Table 1- 1 Documentation on the structure and use of the CPU memory

Topic	Documentation	Most important contents
STEP 7 (TIA Portal)	STEP 7 online help	• Retentivity of data blocks • Working with Data Logs • Working with recipes
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Memory reset • SIMATIC memory card
Description of the central modules	Manual CPU 1511-1 PN (http://support.automation.siemens.com/WW/view/en/59402190) Manual CPU 1513-1 PN (http://support.automation.siemens.com/WW/view/en/59186494) Manual CPU 1516-3 PN/DP (http://support.automation.siemens.com/WW/view/en/59191914)	• Size of the memory areas • Technical specifications

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Memory areas and retentive memory 2

2.1 CPU memory areas

Introduction

This chapter describes the memory structure of S7-1500 CPUs.

CPU memory areas

The following figure shows the CPU memory areas and the load memory on the SIMATIC memory card. In addition to the load memory, the SIMATIC memory card may also contain other data, such as recipes, Data Logs and HMI backups.

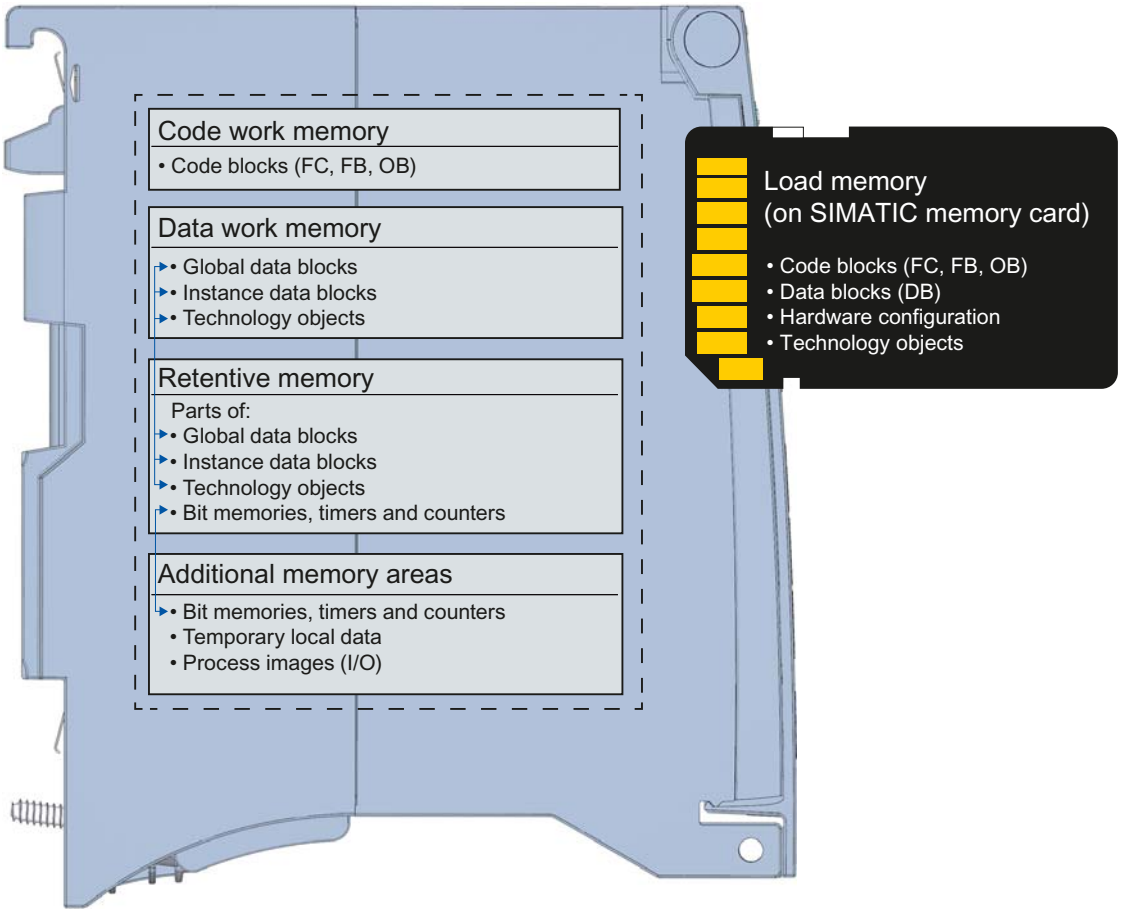


Figure 2-1 CPU memory areas

Load memory

The load memory is a non-volatile memory for code blocks, data blocks, technology objects, and hardware configuration. When these objects are downloaded to the CPU they are first saved into load memory. This memory is located on the SIMATIC memory card.

Note

To run the CPU, a SIMATIC memory card must be inserted.

Work memory

The work memory is volatile memory that contains the code and data blocks. The work memory is integrated into the CPU and cannot be extended.

In the S7-1500 CPUs, the work memory is divided into two areas:

- Code work memory: The code work memory contains runtime-relevant parts of the program code.
- Data work memory: The data work memory contains the runtime-relevant parts of the data blocks and technology objects. At the operating mode transitions POWER ON to startup and STOP to startup, tags from global data blocks, instance data blocks and technology objects are initialized with their start values; retentive tags retain their actual values as saved in the retentive memory.

Retentive memory

Retentive memory is non-volatile memory for saving a limited quantity of data in the event of power failure. The tags and operand areas that have been defined as retentive are saved in retentive memory. These data is retained beyond a power-off or power failure. All other program tags are lost under these conditions and are set to their start values upon the operating mode transitions POWER ON to startup, and STOP to startup.

The content of retentive memory is deleted by the following actions:

- Memory reset
- Reset to factory settings

Specified tags from technology objects are also stored in retentive memory. These tags are not deleted during memory reset.

You can find additional information on the "Memory reset" topic in the Commissioning chapter of the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual .

Information on memory areas in STEP 7

In STEP 7 you can view the offline and online information about the memory areas of your S7-1500 CPU.

Offline: When you are creating or modifying a program, you can determine whether it is too large for a specific CPU. You can find this information under "Program information" in the project tree, for example. On the Resources tab, you can find information about the total size of the memory areas, and the storage space that has already been allocated. In this location you can also find information about the assigned inputs and outputs. With a S7-1500 CPU, you can select the total size of the load memory in a drop-down list.

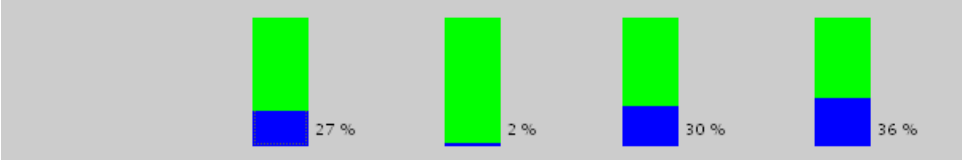
The following figure shows the drop-down list for selecting the size of the load memory:

	Objects	Load memory	Code work-memory	Data work-memory	Retain memory
1		19 %	1 %	8 %	23 %
2					
3	Total:	24 MB	1048576 bytes	5242880 bytes	484000 bytes
4	Used:	0 kB 2 MB 12 MB 24 MB 2 GB	15293 bytes	411034 bytes	110592 bytes
5	Details				
6	OB		469 bytes		
7	FC		410 bytes		
8	FB	39890 bytes	14414 bytes		
9	DB	4621700 bytes		411034 bytes	110592 bytes
10	Data types	6681 bytes	-		
11	PLC tags				0 bytes

Figure 2-2 Drop-down list for the load memory

Online: While you are online, you can check the memory utilization of your CPU in STEP 7. The online function "Memory" can be found in Online & Diagnostics under "Diagnostics > Memory".

The image below shows CPU memory utilization in the online function "Memory":



Sizes in bytes	Load memory	Code in load mem...	Data in load m...	Retentive memory
Free:	6291456	1048576	5242880	524288
In use:	2316997	17355	2299642	301234
Total:	8608453	1065931	7542522	825522

Figure 2-3 "Memory" online function

You can find additional information on your CPU's memory in the following locations in STEP 7:

- In Program information, on the Assignment list and Call structure tabs
- PLC tag table

Additional memory areas

Besides the memory areas that have been described for the user program and data, the CPU has additional memory areas available.

The additional memory areas include the following:

- Bit memories, timers and counters
- Temporary local data
- Process images

The CPU-specific sizes can be found in the technical specifications for the respective CPU.

Reference

You can find additional information on the SIMATIC memory card in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual in the SIMATIC memory card chapter.

2.2 Retentive memory areas

Introduction

The S7-1500 CPUs have memory available for storing retentive data at POWER-OFF. Details about the size of the retentive memory can be found in the technical specifications for the CPU.

In STEP 7, you can find the configured CPU's retentive memory utilization offline at "Program information > Resources" or online at Online & Diagnostics under "Diagnostics > Memory".

If you define data as retentive, its content is retained beyond program startup after STOP, or a power failure.

You can define the following data and objects as retentive:

- Bit memories, timers and counters
- Tags from global data blocks
- Tags from instance data blocks of a function block

Certain tags of technology objects are always retentive, for example, adjustment values of absolute encoders.

Bit memories, timers and counters

In STEP 7, you can define the number of retentive bit memories, timers and counters in the PLC tag table using the "Retentive memory" button.

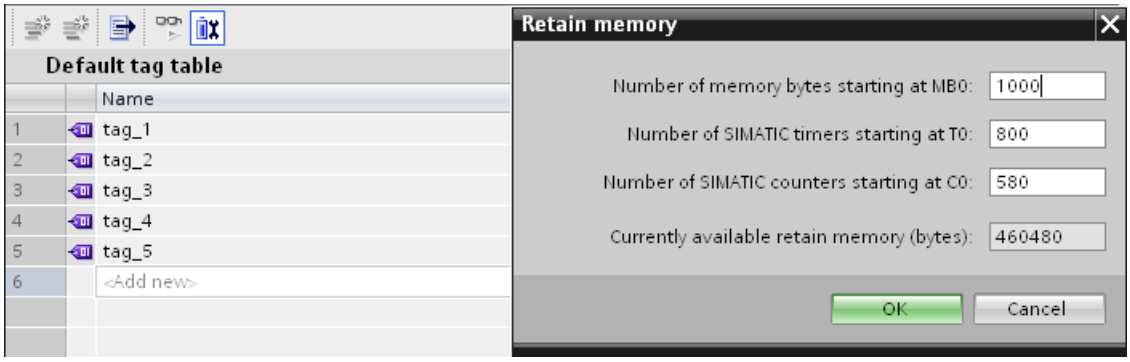


Figure 2-4 Definition of the number of retentive bit memories, timers and counters using the "Retentive memory" button

Tags from a global data block

In a global data block, you can define either individual tags from a block or all of its tags collectively as retentive, depending on the setting for the "Optimized block access" attribute:

- "Optimized block access" activated: In the declaration table of the data block, you can define individual tags as retentive.

		Name	Data type	Start value	Retain	Visible in HMI	Comment
1		Static					
2		var1	Bool	false	☑	☑	
3		var2	Bool	false	☐	☑	
4		var3	Bool	false	☑	☑	
5		var4	Bool	false	☐	☑	
6		var5	Bool	false	☑	☑	

Figure 2-5 Retentivity setting "Optimized block access" activated

- "Optimized block access" not activated: In the declaration table of the data block, you can only define the Retentivity for all tags collectively.

		Name	Data type	Offset	Start value	Retain	Visible in HMI	Comment
1		Static						
2		var6	Bool	...	false	☑	☑	
3		var7	Bool	...	false	☑	☑	
4		var8	Bool	...	false	☑	☑	
5		var9	Bool	...	false	☑	☑	
6		var10	Bool	...	false	☑	☑	

Figure 2-6 Retentivity setting "Optimized block access" not activated

Tags from an instance data block of a function block

In STEP 7, you can define the tags from the instance data block of a function block as retentive. Depending on the setting for the "Optimized block access" attribute, you can define retentivity either for individual tags from a block or for all of its tags collectively:

- "Optimized block access" activated: In the interface of the function block, you can define individual tags as retentive.
- "Optimized block access" not activated: In the instance data block, you can only define the retentivity of all tags collectively.

Creation of a data block in the user program

You use the "CREATE_DB" instruction to create a data block in the user program. Depending on the selection for the ATTRIB parameter, the generated data block either has the property "retentive" or the property "non-retentive". Setting the retentivity for individual tags is not possible here.

You can find additional information on the "CREATE_DB" instruction in the STEP 7 online help under "PLC programming > References > References (S7-1200/1500) > Extended instructions > Data block functions > CREATE_DB".

Tags of technology objects

Certain tags of technology objects are retentive, for example adjustment values of absolute encoders. STEP 7 automatically manages the retentivity of technology object tags, so you do not have to configure their retentivity.

The retentive tags of technology objects are unaffected by a memory reset. They can only be deleted by resetting to factory settings.

Reference

You can find additional information on configuring retentivity in the STEP 7 online help.

2.3 Summary of retentive behavior

Retentive behavior of the memory objects

This chapter gives an overview of the retentive behavior of memory objects for S7-1500 CPUs. Besides the retentive memory areas described so far, there are additional objects with retentive behavior, such as the diagnostic buffer. These objects do not allocate any storage space in the retentive memory.

The following table shows the retentive behavior of the memory objects at the operating mode transitions STOP to startup and POWER ON to startup, as well as the memory-influencing functions Memory Reset and Reset to Factory Settings.

Table 2- 1 Retentive behavior of the memory objects

Memory object	Operating mode transitions		Memory reset	Reset to factory settings
	STOP → STARTUP	POWER ON → STARTUP		
Actual values of the data blocks, instance data blocks	Can be set in the Properties of the DB in STEP 7.[1]		-	-
Bit memories, timers and counters -configured as retentive data	x	x	-	-
Bit memories, timers and counters - configured as non-retentive	-	-	-	-
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	x	x	x	-
Diagnostic buffer entries (retentive area)	x	x	x	-
Diagnostic buffer entries (non-retentive area)	x	-	-	-
Operating hours counter	x	x	x	-
Clock time	x	x	x	-
x = content is retained – = object is initialized				

1) For DBs with optimized access the retentive behavior is configurable for specific tags.

Diagnostic buffer

With the S7-1500 CPUs, a portion of the diagnostic buffer is retentive. The number of retentive diagnostic buffer entries depends on the type of CPU. The latest entries in the diagnostic buffer are retained after power failure, and are not affected by a memory reset The retentive portion of the diagnostic buffer can only be deleted by resetting to factory settings. The entries in the diagnostic buffer allocate no storage space in the retentive memory.

Operating hours counter

The operating hours counters of the S7-1500 CPUs are retentive and are not affected by a memory reset. By resetting to factory settings, the clock time is set to zero.

Clock time

The clock time of the S7-1500 CPUs is retentive and is not affected by a memory reset. By resetting to factory settings, the operating hours counters are set to 01/01/2012 00:00:00.

Reference

You can find additional information on Memory Reset and Resetting to Factory Settings in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

2.4 Memory behavior when loading software changes

Introduction

In the STOP and RUN modes of the S7-1500 CPU, you can load changes to the software without this affecting the actual values of tags already loaded.

In STEP 7, you load changes to the software under "Download to device > Software (only changes)".

Impact of software changes on PLC tags

You can load the following software changes without affecting the actual values of tags that have already been loaded:

- Name change
- Comment change
- Addition of new tags
- Deletion of tags
- Change of retentivity settings for Bit memories, times, and counters (Page 13)

The actual values are affected by loading the following software changes:

- Data type change
- Address change

Impacts of software changes on data blocks with memory reserve

If you are using memory reserve for data blocks ("Optimized block access" attribute and "Download without reinitialization" button activated), you can load the following software changes without this reinitializing the actual values of tags which have already been loaded:

- Start value change
- Comment change
- Addition of new tags

To load the following software changes, you must deactivate the "Download without reinitialization" button. During the next load, all actual values of the data block will be reinitialized:

- Name change
- Data type change
- Retentivity change
- Deletion of tags
- Changes to the memory reserve settings

Impacts of software changes on data blocks without memory reserve

If you are not using memory reserve, you can load the following software changes without this reinitializing the actual values of tags that have already been loaded:

- Start value change
- Comment change

When loading the following software changes, all actual values of the data block will be reinitialized:

- Name change
- Data type change
- Retentivity change
- Addition of new tags
- Deletion of tags

Memory reserve of data blocks

Each function block or data block with the "Optimized block access" attribute activated contains, by default, a memory reserve which you can use for subsequent interface changes. The memory reserve is initially not used. When you have compiled and loaded the block, and then observe that you want to reload interface changes, activate the memory reserve. All tags that you subsequently declare will be placed in the memory reserve. During the next load, the new tags are then initialized to their start values. Tags which have already been loaded are not reinitialized.

The setting for memory reserve can be found in STEP 7 in the data block properties under "Download without reinitialization".

Reference

You can find additional information on setting and activating the memory reserve, and on loading block changes, in the online help for STEP 7 under "PLC programming > Create user program > Compile and download blocks > Download blocks > Download block extensions without reinitialization".

Memory usage and application examples 3

3.1 Memory usage for recipes

Introduction

A recipe represents a collection of parameter records with the same structure. These recipe data records are located in a non-runtime-relevant data block in the load memory, and do not occupy any storage space in the work memory. You have the option of reading individual recipe data records into a data block in work memory, and to access the data in the user program. You can write a recipe data record that has been changed in the user program back to the recipe data block.

Processing sequence

- **Saving a recipe in load memory**

  The various data records of a recipe are filled in a non-runtime-relevant DB in STEP 7 and then loaded to the CPU. In order to configure a non-runtime-relevant DB, you must activate the Only store in load memory" block attribute. Thus the recipes only use storage space in load memory, and not in work memory.

- **Working with recipe data in the user program**

  The "READ_DBL" instruction reads a data record belonging to the current recipe from the DB in the load memory to a runtime-relevant DB in the work memory. As a result, the work memory only has to accommodate the data for the currently required recipe data record. The user program can now access the data of the current data record.

- **Saving back changed recipe data records**

  You can use the "WRIT_DBL" instruction to write new or changed data records of a recipe from the user program back to the load memory. The data written to load memory are portable and not affected by a memory reset. If you back up changed data records (recipes) on the PG/PC, data blocks must be uploaded and saved on the PG/PC.
  You can find information on uploading data blocks in the online help for STEP 7 under "PLC programming > Compile and download blocks > Download blocks > Download blocks from a memory card".

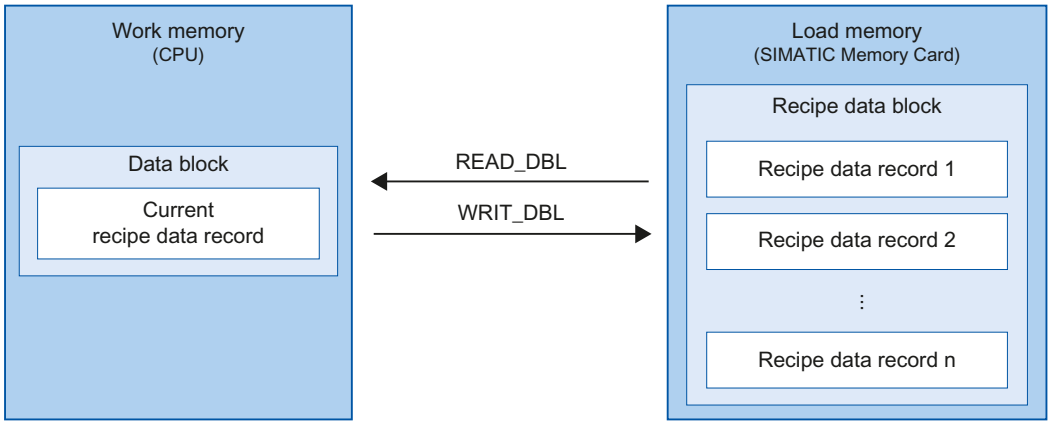


Figure 3-1 Processing sequence with "READ_DBL" and "WRIT_DBL"

Note

Instructions that access the SIMATIC memory card have a lower performance than instructions that access the work memory. The associated blocks (e.g. READ_DBL and WRIT_DBL) are therefore asynchronous. Their execution extends if necessary over several cycles.

Note

Service life of the SIMATIC memory card

Only a limited number of delete and write operations are possible on the SIMATIC memory card. Avoid repeated (cyclic) write operations by the user program

---

Import and export of recipe data

You have the option of exporting a recipe DB's recipe data records as a csv file, and of importing them from a csv file into a DB. The csv file is located in the "\recipes" directory of the SIMATIC memory card, and can be opened and processed further with a spreadsheet program such as Microsoft Excel.

You can easily manage the csv files on the SIMATIC memory card using the CPU's web server (e.g. renaming, saving to hard disk, deleting, ...). In order to prevent unwanted tampering, configure the access privileges for the web server in STEP 7. Additional information on the web server can be found in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual, in the File Browser chapter.

- **Export of recipe data**

  The "RecipeExport" instruction exports all of a recipe DB's recipe data records from load memory to a csv file on the SIMATIC memory card. The csv file has the same name as the DB's recipe. The csv file is stored in the "\recipes" directory on the SIMATIC memory card.

  Only valid and unencrypted recipe data records are exported.

- **Import of recipe data**

  The "RecipeImport" instruction imports all recipe data records from the csv file into the recipe DB in load memory. The name of the csv file must match the name of the recipe DB.

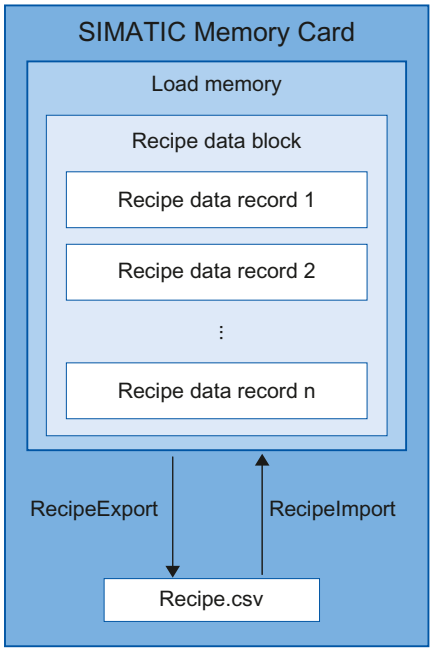


Figure 3-2 Import and export of recipe data

Reference

You can find further information on the instructions for recipes in the online help for STEP 7 under "PLC programming > References > References (S7-1200/1500) > Extended instructions > Recipes and data logging > Recipe functions".

3.2 Memory usage for data logging

3.2.1 Overview of data logging

Your controller program can store process values in Data Logs using the "Data Logging" instructions. The Data Logs are saved in csv format in the "\datalogs" directory of the SIMATIC memory card. The data records are organized in a circular Data Log of a predefined size.

The "Data Logging" instructions are used in your program to create, open and write Data Logs and to close Data Logs. You decide which tags are to be logged by creating a data block that defines a single Data Log data record. Your data block is used as temporary storage for a new Data Log data record. New actual values for the tags must be transferred into the data block during runtime by means of user program instructions. Once all tag values have been updated, you can execute the "DataLogWrite" instruction to transfer data from the data block to the Data Log.

You manage your Data Logs with the integrated Web server. On the standard "File browser" Web page, you can download or delete Data Logs. Once you have transferred a Data Log to your PC, you can analyze the data using a standard spreadsheet program such as Microsoft Excel.

The following figure shows the basic sequence for creating Data Logs:

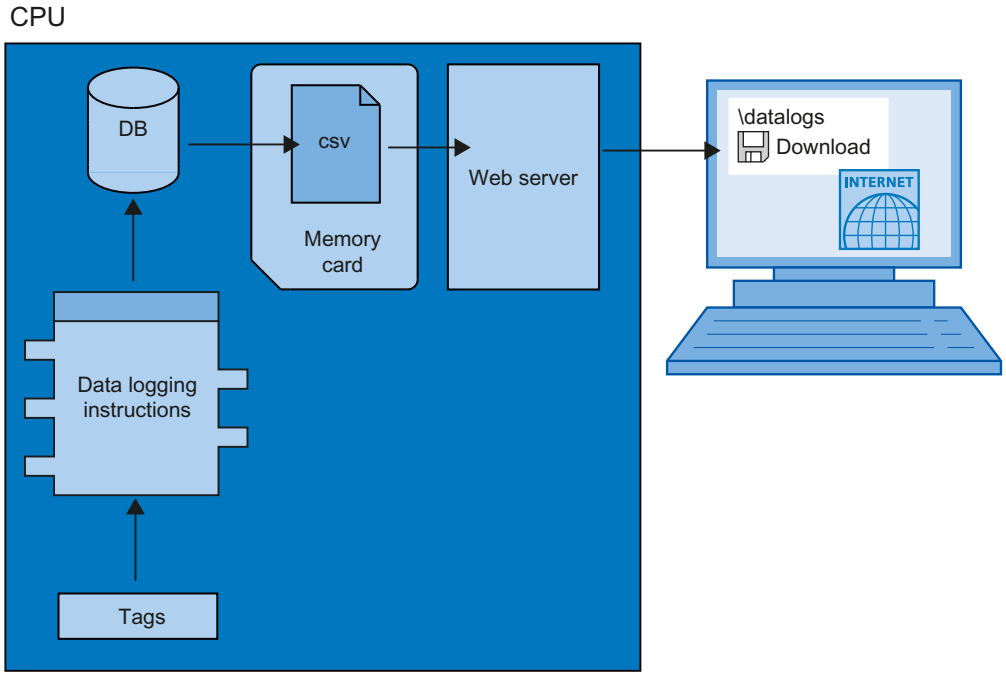


Figure 3-3 Basic procedure for creating Data Logs

3.2.2 Data structure of the data logs

Introduction

You use the "DataLogCreate" instruction to create a Data Log in STEP 7. The NAME parameter assigns the Data Log a name. The DATA and HEADER parameters specify the data type of all data elements in a Data Log data record and the header of the Data Logs. The RECORDS parameter indicates the maximum number of data records in the Data Logs.

NAME parameter for the "DataLogCreate" instruction

You use the NAME parameter to assign a name for the Data Log. This is the name under which the Data Log is saved in the "\datalogs" directory of the SIMATIC memory card.

DATA parameter for the "DataLogCreate" instruction

The DATA block parameter specifies the structure of the Data Log data records. The columns and data types of a data record in the Data Log are determined by the elements of the structure declaration or array declaration of this data buffer. Each element of a structure or an array corresponds to a column in a row in the Data Log.

HEADER parameter for the "DataLogCreate" instruction

Using the HEADER block parameter, you can assign a heading in the header row to each column in the Data Log.

RECORDS parameter for the "DataLogCreate" instruction

The RECORDS parameter specifies the maximum number of data records that can be stored in a Data Log. If the specified maximum number of data records in a Data Log is reached, the next write operation will overwrite the oldest data record.

3.2.3 Instructions for data logging

Overview

The following table gives an overview of the instructions for Data Logging. You will find the "Data Logging" instructionsin STEP 7 in the "Instructions" task card, under "Extended instructions > Recipe and data logging > Data Logging".

Table 3- 1 Overview of the "Data Logging" instructions

Name of the instruction	Description
"DataLogCreate": Create data log	You use the "DataLogCreate" instruction to create a Data Log. The Data Log is saved on the SIMATIC memory card in the "\datalogs" directory. You can use the data logging instructions to save process data. The amount of data that can be stored in a Data Log depends on the storage space available on the SIMATIC memory card.
"DataLogOpen": Open data log	You use the "DataLogOpen" instruction to open an existing Data Log on the SIMATIC memory card. Before you can write new data records to a Data Log, the Data Log must be open. The Data Log is automatically opened when the "DataLogCreate" and "DataLogNewFile" instructions are executed. A maximum of 10 Data Logs can be open at any one time. You can select the Data Log to be opened using either the ID or the name of the Data Log.
"DataLogWrite": Write data log	You use the "DataLogWrite" instruction to write a data record to an existing Data Log. Use the ID parameter to select the Data Log to which the data record is to be written. Before a new data record can be written, the Data Log must be opened.
"DataLogClose": Close data log	You use the "DataLogClose" instruction to close an open Data Log. You use the ID parameter to select the Data Log. All open Data Logs are closed when the CPU switches to STOP.
"DataLogNewFile": Data log in new file	You use the "DataLogNewFile" instruction to create a new Data-Log with the same properties as an existing Data Log. By creating new Data Logs, you prevent cyclic overwriting of existing data records. When the instruction is called, it creates a new Data Log on the SIMATIC memory card with the name defined at the NAME parameter. Use the ID parameter to specify the ID of the existing Data Log whose properties you want to apply to the new Data Log. The ID of the new Data Log is then output at the ID parameter.
"DataLogClear": Clear data log	Use the "DataLogClear" instruction to delete all data records from an existing Data Log. The header of the Data Log is not deleted (see the description of the parameter HEADER of the "DataLogCreate" instruction (Page 26)).
"DataLogDelete": Delete data log	You use the "DataLogDelete" instruction to delete a Data Log from the SIMATIC memory card. Select the Data Log to be deleted using the NAME and ID parameters.

Reference

You can find further information on "Data Logging" instructions in the online help for STEP 7 under "PLC programming > References > References (S7-1200/1500) > Extended instructions > Recipes and data logging > Data Logging".

3.2.4 Example program for data logging

This example program shows the storing of 3 process values for counter state, temperature, and pressure in a Data Log.

The example shows the basic function of the instructions for Data Logs. The complete program logic is not shown.

Note

General use of Data Logs

- Data Logs are automatically opened after execution of the "DataLogCreate" and "DataLogNewFile" instructions.
- Data Logs are automatically closed when the CPU switches from RUN to STOP and upon CPU restart.
- Before data can be written to a Data Log with the "DataLogWrite" instruction, the Data Log must be open.
- No more than ten Data Logs can be open simultaneously, even if there are more than ten Data Logs.

Tags of the data block

The following figure shows the tags of the "My_Datalog_Vars" data block. These tags are used by the "Data Logging" instructions "DataLogCreate" and "DataLogNewFile". The "MyDataLogName" and "MyNEWDataLogName" tags are called in the NAME block parameter, and give the Data Logs a name. The "MyData" structure is called in the DATA block parameter and specifies the structure of the csv file. The three MyData tags temporarily store new values. The tag values at these DB addresses are transferred to a Data Log using the "DataLogWrite" instruction. The "MyDataLogHeaders" tag is called in the HEADER block parameter and specifies a header for the Data Log.

My_Datalog_Vars

	Name	Data type	Start value
1	Static		
2	MyNEWDataLogName	String	'MyNEWDataLog'
3	MyDataLogName	String	'MyDataLog'
4	MyDataLogID	DWord	0
5	MyDataLogHeaders	String	'Count,Temperature,Pressure'
6	MyData	Struct	
7	MyCount	Int	0
8	MyTemperature	Real	0.0
9	MyPressure	Real	0.0

Figure 3-4 Declaration table with the data block's tags

Network 1

A rising edge at REQ starts the creation of the Data Log.

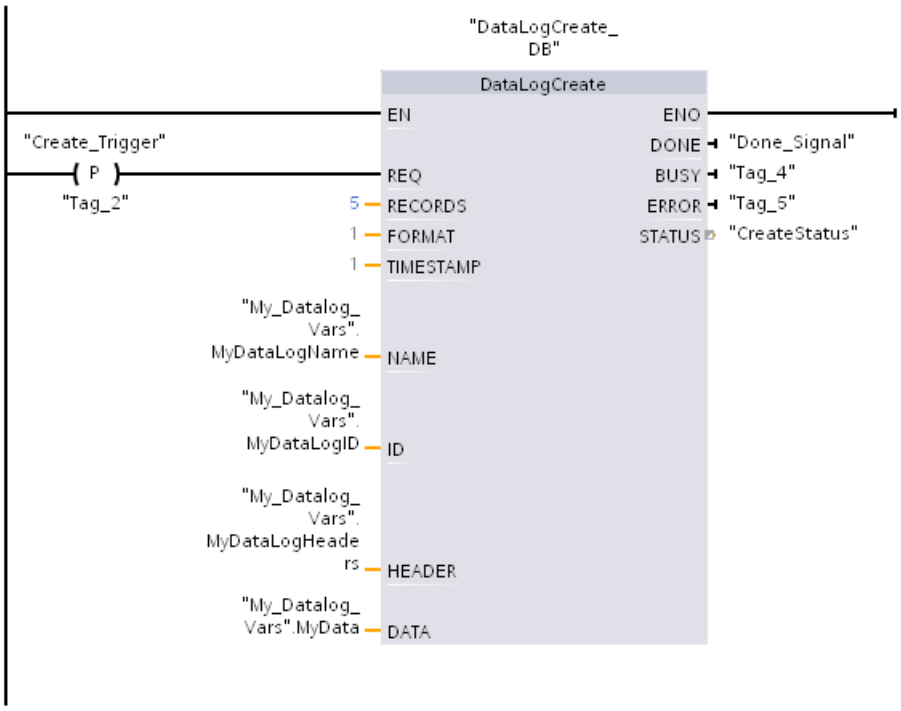


Figure 3-5 Network 1

Network 2

Detect the output DONE from "DataLogCreate", because after the execution of "DataLogCreate" it is only set to 1 for a call.

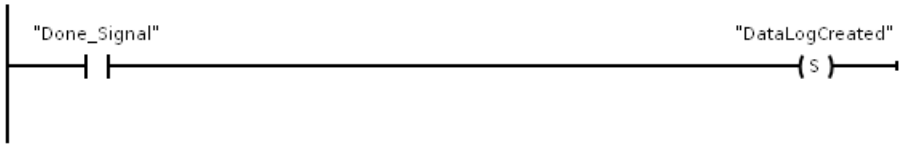


Figure 3-6 Network 2

Network 3

A rising edge triggers the point in time at which new process values are stored in the MyData structure.

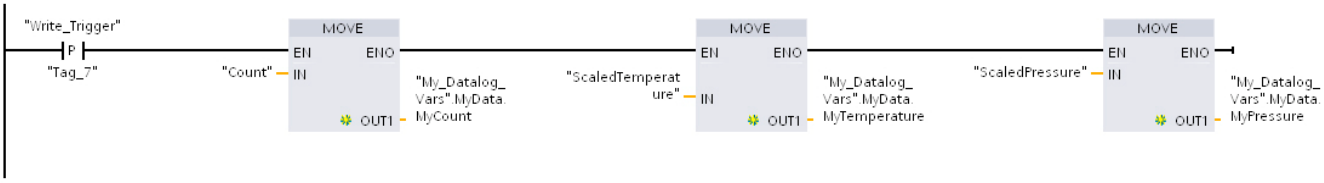


Figure 3-7 Network 3

Network 4

The state of the input EN is based on the point in time at which the execution of "DataLogCreate" was completed. One execution of "DataLogCreate" extends over multiple cycles, and must be completed before a write operation is executed. The rising edge at input REQ is the event, that triggers an activated write operation.

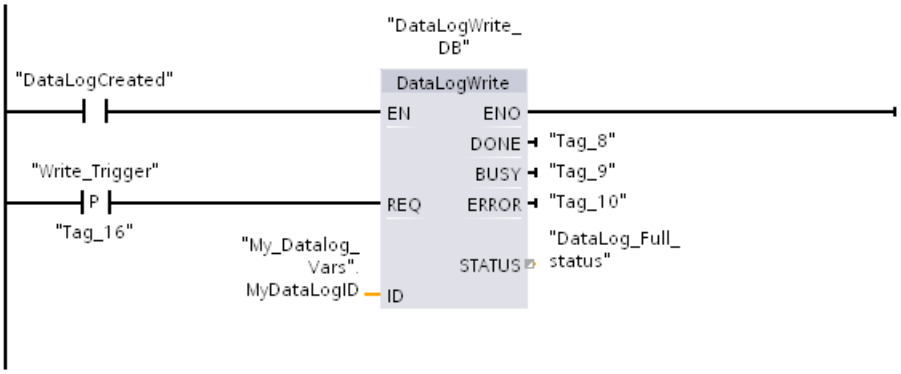


Figure 3-8 Network 4

Network 5

Close the Data Log once the last data record has been written. After execution of the "DataLogWrite" instruction, which writes the last data record, the STATUS output is set to "1".

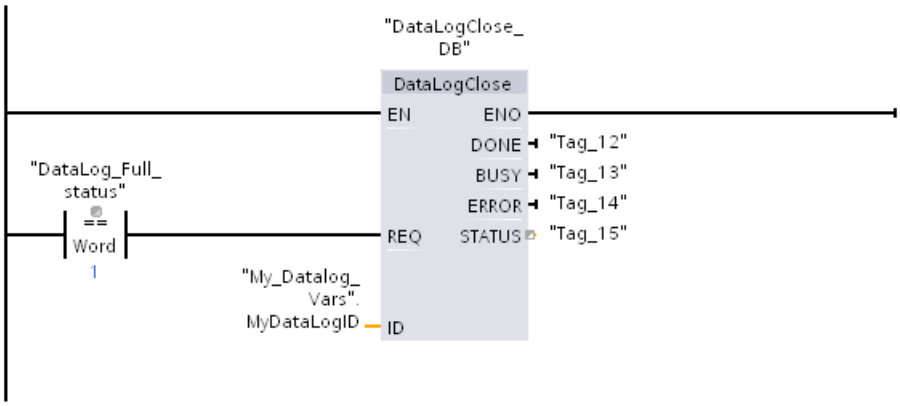


Figure 3-9 Network 5

Network 6

A rising edge at the REQ input of the instruction "DataLogOpen" simulates the user pressing a button on an HMI device which opens a Data Log. If you open a Data Log in which all data records have been allocated process data, the next execution of the "DataLogWrite" instruction will overwrite the oldest data record. You can, however, also retain the old Data Log and instead create a new Data Log. This is shown in network 7.

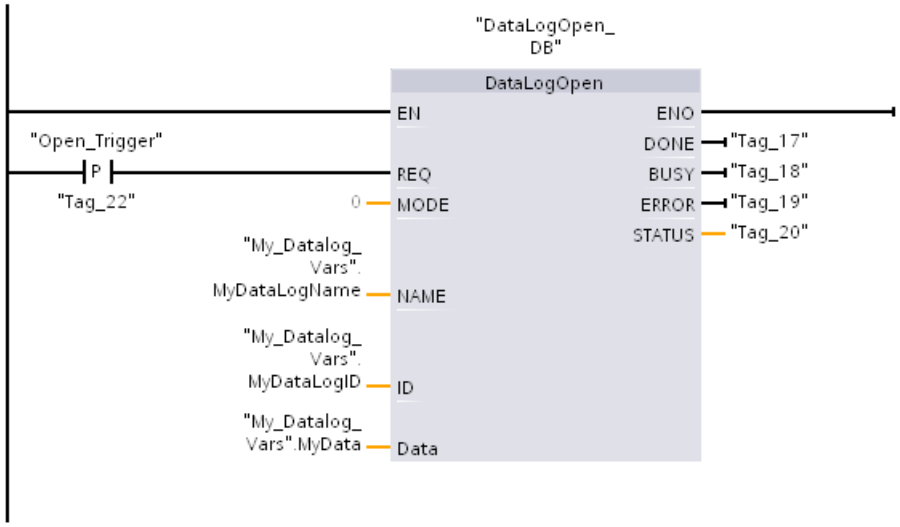


Figure 3-10 Network 6

Network 7

The ID parameter is an IN/OUT type. First, you enter the ID value of the existing Data Log whose structure you want to copy. Once the "DataLogNewFile" instruction has been executed, a new and unique ID value for the new Data Log will be written back to the address of the ID reference. The required detection DONE bit = TRUE is not shown. An example for the logic of the DONE bit can be found in networks 1, 2 and 4.

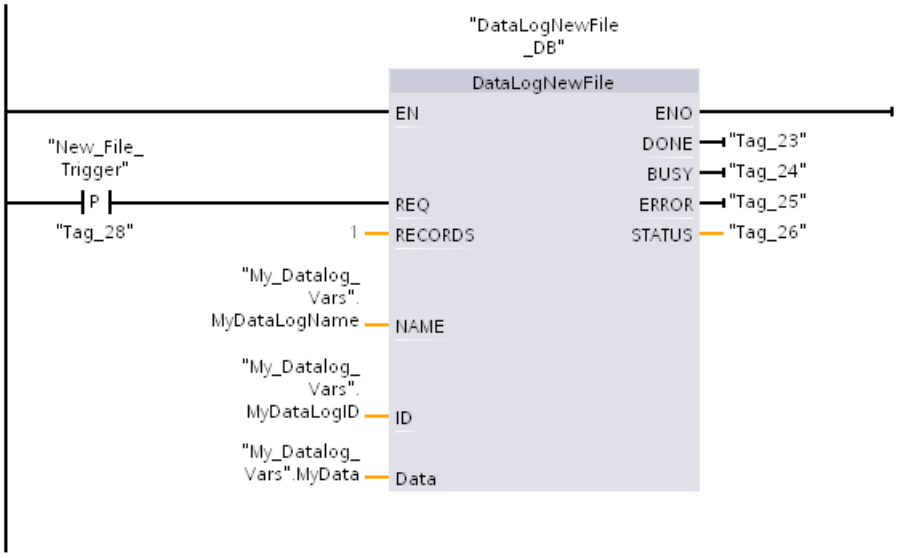


Figure 3-11 Network 7

The Data Logs created in the example program can be found on the S7-1500 CPU Web server standard "File browser" Web page in the "\datalogs" folder.

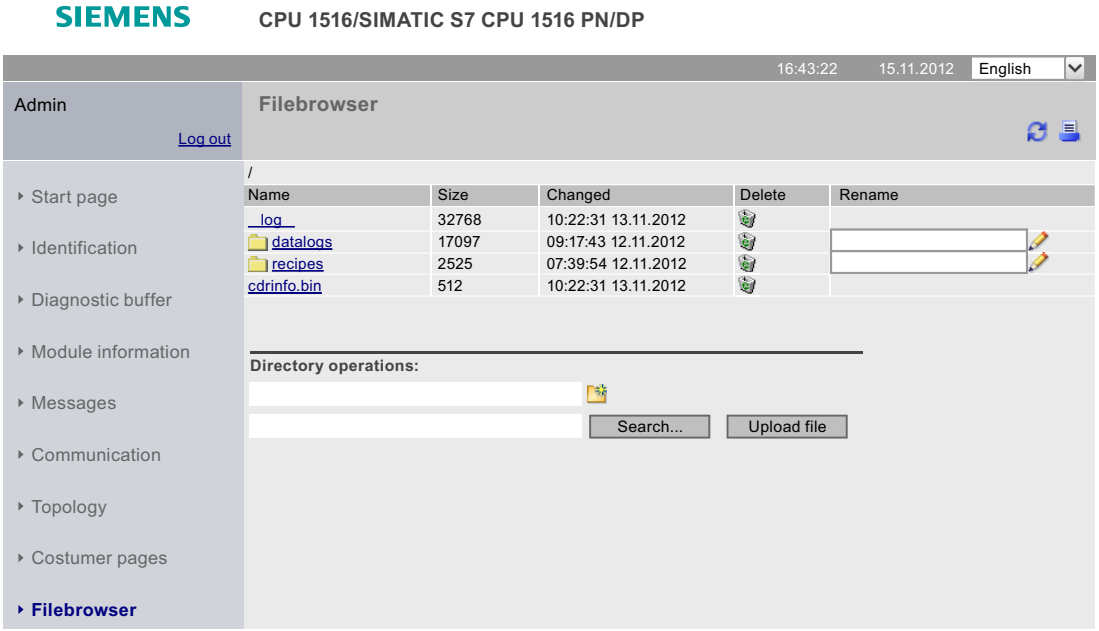


Figure 3-12 Standard "File browser" web page of the web server

In the file browser, you can download, delete or rename the Data Logs created in the example program.

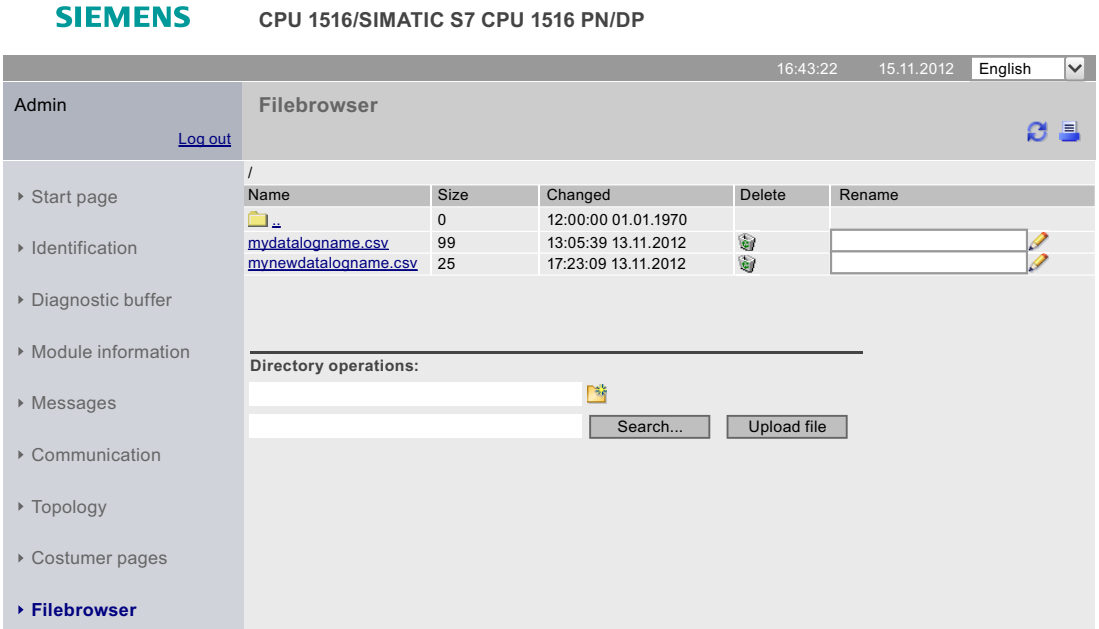


Figure 3-13 Sample Data Logs in the "\datalogs" folder of the file browser

Table 3- 2 Downloaded examples of data logs displayed in Microsoft Excel

Two data records written in a Data Log which contains a maximum of five data records.

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	1	1/3/2012	10:16:47	5	5,00E+00	5,00E+00
3	2	1/3/2012	10:16:48	5	5,00E+00	5,00E+00
4	//END					
5						

Five data records written in a Data Log which contains a maximum of five data records.

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	1	1/3/2012	10:08:23	1	9,86E+01	3,52E+01
3	2	1/3/2012	10:08:39	2	1,00E+02	3,73E+01
4	3	1/3/2012	10:08:54	3	9,99E+01	3,68E+01
5	4	1/3/2012	10:09:11	4	9,95E+01	3,64E+01
6	5	1/3/2012	10:09:28	5	9,92E+01	3,74E+01
7						

After another data record has been written, the 6th write operation overwrites the oldest data record (record 1) with data record 6. Another write operation overwrites data record 2 with data record 7, etc.

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	6	1/3/2012	10:09:42	6	9,87E+01	3,58E+01
3	2	1/3/2012	10:08:39	2	1,00E+02	3,73E+01
4	3	1/3/2012	10:08:54	3	9,99E+01	3,68E+01
5	4	1/3/2012	10:09:11	4	9,95E+01	3,64E+01
6	5	1/3/2012	10:09:28	5	9,92E+01	3,74E+01
7						

Glossary

Bit memory

Bit memory is a memory area of the CPU, which can be addressed from any code block (FC, FB, OB). You have read/write access to this memory area. The bit memory area can be used to store temporary results, for example.

Counters

In STEP 7, counting tasks are performed using counters. You can modify the contents of the "counter cells" using STEP 7 instructions (for example, count up/down).

Data block

Data blocks store information for the program. They can be defined in two ways: either that all code blocks can access them (global data block), or that they are assigned to a specific FB or SFB (instance data block).

Data log

Data logs are csv files for the storage of tag values. The data logs are saved on the SIMATIC memory card in the "\datalogs" directory. Data records of tag values are written to a data log by means of instructions in the user program

Global data block (DB)

Every function block, every function, and every organization block can read the data from a global data block, or write its own data to a global data block. This data is retained in the data block, even when the data block is exited.

Instance data block (IDB)

A data block is assigned to each call of a function block in the STEP 7 user program. The instance data block stores the values of input, output and in/out parameters, as well as local block data.

Local data

This memory area accepts the temporary local data of a block for the duration of processing.

Memory reset

During memory reset the CPU is shifted into the configured initial state.

Optimized block access

Data blocks with optimized access have a no fixed defined structure. In the declaration, the data elements only receive a symbolic name, and no fixed address within the block. The elements are automatically so arranged in the block's available memory area, that its capacity is optimally exploited.

In these data blocks, you can only address tags symbolically. For example, you would access the "FillState" tag in the "Data" DB as follows:

"Data".FillState

Optimized access offers the following advantages:

- The data is structured and saved in a manner that is optimal for the CPU used. This allows you to increase CPU performance.
- Access errors, from HMI, for example, are not possible.
- You can selectively define individual tags as retentive.

Process images (I/O)

The CPU transfers the values from the input and output modules in this memory area. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. At the end of the cyclic program the process image of the outputs is transmitted as signal state to the output modules.

Reset to factory setting

Resetting to factory settings restores the CPU settings to the delivery state.

Restart

Restart occurs at the transitions from STOP to STARTUP, and POWER ON to STARTUP. Before processing the cyclic program processing, the CPU first processes the startup OB or OBs.

Restart has the following effects on the memory areas of the CPU:

- The process images are deleted.
- The retentive tags of data blocks retain the values saved in retentive memory.
- All retentive bit memories, timers, and counters retain the values saved in retentive memory.
- All non-retentive user data is initialized:
  - Data blocks receive their start value
  - Bit memories, timers, and counters with "0"

SIMATIC memory card

Memory for the user program for programmable modules and communication processors. You can also use the SIMATIC memory card for changing user software and user data.

Standard access

Data blocks with standard access have a fixed structure. In the declaration, the data elements receive both a symbolic name and a fixed address within the block. The address is displayed in the "Offset" column.

In these data blocks, you can address tags both symbolically and absolutely.

"Data".FillState

DB1.DBW2

Timers

In STEP 7, programmed time processes are performed using timers. The content of timer cells is automatically updated by the operating system, asynchronously to the user program. STEP 7 instructions are used to define the precise function of the timer cell (for example, on-delay time) and to trigger their execution (for example, start).

User program

The user program contains all instructions, declarations and data for signal processing required to control a plant or a process. The user program is assigned to a programmable module (for example, CPU, CM) and can be structured in smaller units.

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SIMATIC

S7-1500, ET 200MP, ET 200SP Communication

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This function manual provides you with an overview of the communications options, the CPUs, communications modules and processors of the S7-1500, ET 200MP and ET 200SP systems.

The documentation deals with the following topics:

- Overview of the communications services
- Properties of the communications services
- Overview of the user activities for setting up the communications services

Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation engineering
- Knowledge of the industrial automation system SIMATIC
- Experience of working with STEP 7 (TIA Portal)

Scope of the documentation

This documentation is basic documentation for all products of the S7-1500, ET 200MP and ET 200SP systems. The product documentation is based on this documentation.

Conventions

STEP 7: In this documentation "STEP 7" is used as a synonym for "STEP 7 V12 (TIA Portal)" and subsequent versions of the configuration and programming software.

This documentation contains pictures of the devices described. The pictures may differ slightly from the devices supplied.

You should also pay particular attention to notes such as the one shown below:

Note

The notes contain important information on the product, handling the product or on part of the documentation to which particular attention should be paid.

Additional support

You will find information about the technical support available in the appendix Service & Support (Page 79).

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers all aspects of your automation system.

The complete documentation for the S7-1500, ET 200SP and ET 200MP systems consists of the system manuals, function manuals and manuals of the products.

The STEP 7 information system (online help) also supports you when configuring and programming your automation system.

Overview of the documentation on communication

The following table shows an overview of other recommended documentation on the topic of communication.

In the sections of this function manual, you will also find references to specific documentation relating to the topics covered.

Table 1- 1 Documentation on communication

Topic	Documentation	Most important contents
General information on industrial communication	Brochure (http://www.automation.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_8097497&InfoType=brochures) Industrial Communication	• Bus systems for industry • Devices and supported communications services
General information on PROFINET	Brochure (http://www.automation.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_8097497&InfoType=brochures) PROFINET	• Overview • Application examples • Hardware • Software
General information on PROFIBUS	Brochure (http://www.automation.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_8097497&InfoType=brochures) PROFIBUS	• Overview • Application examples • Hardware • Software
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	• Configuring and programming with the engineering software

Topic	Documentation	Most important contents
Networks	Manual SIMATIC NET: Twisted-Pair and Fiber-Optic networks (http://support.automation.siemens.com/WW/view/en/8763736)	• Ethernet networks • Network configuration • Network components
Security	Industrial Ethernet Security (http://support.automation.siemens.com/WW/view/en/56577508) manual	• Overview and description of the security functions in Industrial Ethernet
PROFINET	PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• PROFINET basics • PROFINET functions • PROFINET diagnostics
System description	S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) system manual	• Application planning • Installation • Connecting • Commissioning
Modules of the S7-1500 automation system	Manuals for the S7-1500 (http://support.automation.siemens.com/WW/view/en/56926743) product family	• Interrupt, error and system alarms • Technical specifications (including communications services)

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

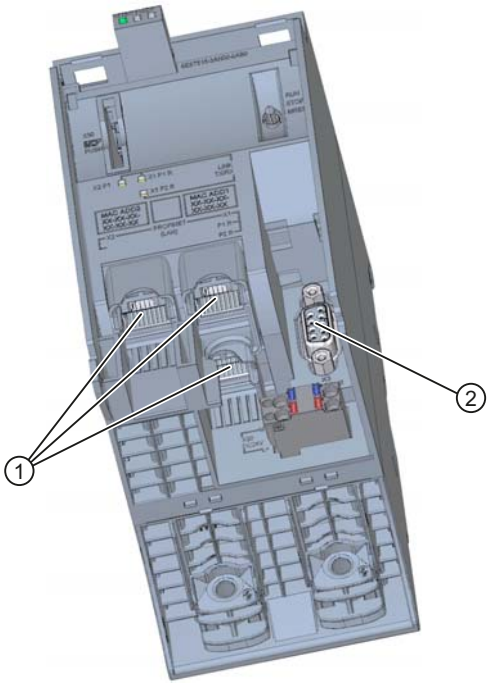
2

CPUs, communications modules and processors of the S7-1500, ET 200MP and ET 200SP systems provide you with interfaces for communication via PROFINET, PROFIBUS and a point-to-point link.

CPUs, communications modules and communications processors in S7-1500

PROFINET and PROFIBUS DP interfaces are integrated in the S7-1500 CPUs. The CPU 1516-3 PN/DP for example has two PROFINET interfaces and one PROFIBUS DP interface. Other PROFINET and PROFIBUS DP interfaces are available by using communications modules (CM) and communications processors (CP).

CPU 1516-3 PN/DP



① PROFINET interfaces

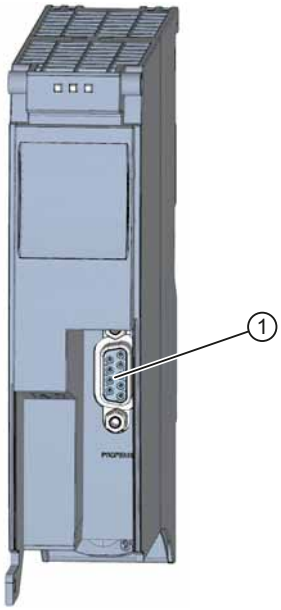
② PROFIBUS DP interface

Figure 2-1 Interfaces of the CPU 1516-3 PN/DP

Interfaces of communications modules

Interfaces of communications modules behave in exactly the same way as integrated interfaces of S7-1500 CPUs of the same interface type (for example PROFIBUS DP). They are used to expand the CPU with suitable interfaces (for example CM 1542-5 with a PROFIBUS DP interface).

CM 1542-5



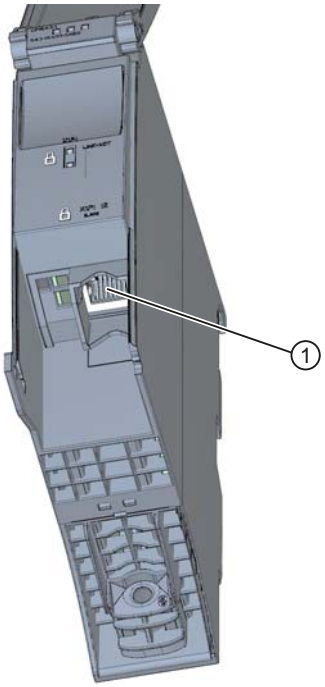
① PROFIBUS DP interface

Figure 2-2 PROFIBUS DP-Interface of the CM 1542-5

Interfaces of communications processors

Interfaces of communications processors provide different functionalities compared with the integrated interfaces of the S7-1500 CPUs. CPs allow special applications, for example the CP 1543-1 provides Industrial Ethernet security functions for protecting PROFINET networks via its PROFINET interface.

CP 1543-1



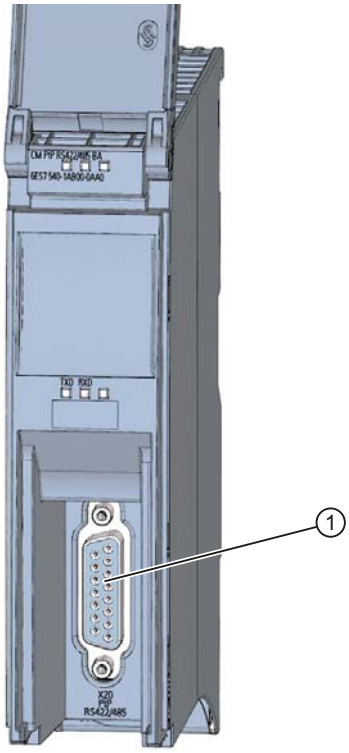
① PROFINET interface

Figure 2-3 PROFINET-Interface of the CP 1543-1

Interfaces of communications modules for point-to-point links

The communications modules for point-to-point links provide communication via their RS-232, RS-422 or RS-485 interfaces, for example Freeport or Modbus communication.

CM PtP RS422/485 BA

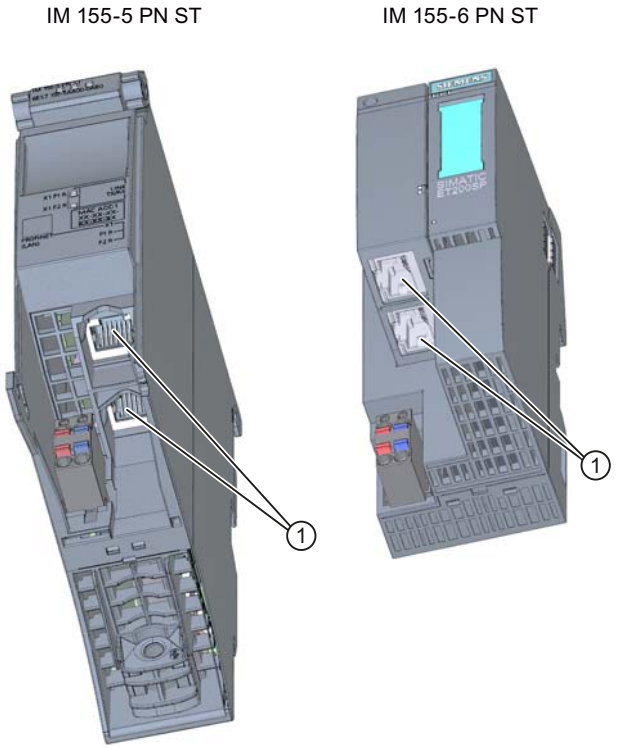


① Interface for point-to-point linking

Figure 2-4 Interface for point-to-point linking of the CM PtP RS422/485 BA

Interfaces of interface modules

PROFINET and PROFIBUS DP interfaces of interface modules (IM) in the ET 200MP and ET 200SP are used to connect the distributed I/O ET 200MP and ET 200SP to PROFINET or PROFIBUS.



① PROFINET interfaces

Figure 2-5 PROFINET interfaces IM 155-5 PN ST (ET 200MP) and IM 155-6 PN ST (ET 200SP)

Communications services

The communications services described below use the interfaces and communications mechanisms provided by the system via CPUs, communications modules and processors.

Communications services 3

3.1 Overview of communications services

Selecting the communication service

Depending on your automation task, various communications services are available. The selection of the communications service influences the following:

- The functionality available
- The time at which the connection is established
- The activities you need to perform
  (for example configuring connections, programming instructions)

Overview of communication services

The table below is an overview of the communications services provided.

Table 3- 1 Communications services

Communication service	Functionality	Via interface:		
		PN	DP	serial
PG communication	On commissioning, testing, diagnostics	X	X	-
HMI communication	On operator control and monitoring	X	X	-
Open communication using TCP/IP	Data exchange via PROFINET with the TCP/IP protocol With connection configuration: Instructions TSEND_C/TRCV_C or TSEND/TRCV Without connection configuration: Instructions TCON, TSEND, T_RCV, T_DISCON or TSEND_C and TRCV_C	X	-	-
Open communication using ISO-on-TCP	Data exchange via PROFINET with the ISO-on-TCP protocol With connection configuration: Instructions TSEND_C/TRCV_C or TSEND/TRCV Without connection configuration: Instructions TCON, TSEND, T_RCV, T_DISCON or TSEND_C and TRCV_C	X	-	-

Communication service	Functionality	Via interface:		
		PN	DP	serial
Open communication with UDP	Data exchange via PROFINET with the UDP protocol With connection configuration: Instructions TSEND_C/TRCV_C or TSEND/TRCV Without connection configuration: Instructions TCON, TSEND, T_RCV, T_DISCON or TSEND_C and TRCV_C	X	-	-
Open communication via ISO (only CPs with PROFINET interface)	Data exchange via PROFINET with the ISO protocol With connection configuration: Instructions TSEND_C/TRCV_C or TSEND/TRCV	X	-	-
E-mail	Sending process alarms via e-mail With the user program: Instruction TMAIL_C	X	-	-
FTP (only CPs with PROFINET interface)	File management and file access via FTP (File Transfer Protocol); CP can be FTP client and FTP server FTP client via user program: Instruction FTP_CMD	X	-	-
Fetch/Write (only CPs with PROFINET interface)	Server services via TCP/IP, ISO-on-TCP and ISO Via special instructions for Fetch/Write	X	-	-
Open communication via FDL (only CMs with DP interface)	Data exchange via PROFIBUS with the FDL protocol With connection configuration: Instructions TSEND_C/TRCV_C or TSEND/TRCV	-	X	-
S7 communication	Data exchange client/server or client/client With connection configuration: Instructions PUT/GET, BSEND/BRCV or USEND/URCV	X	X	-
Point-to-point link	Data exchange via point-to-point with Freeport, 3964 (R), USS or Modbus protocol Via special instructions for PtP, USS or Modbus	-	-	X
Web server	Data exchange via the Internet, for example for diagnostics	X	-	-
SNMP (Simple Network Management Protocol)	Data exchange via standard protocol SNMP, for network diagnostics and parameter assignment	X	-	-
Time-of-day synchronization	Via NTP (Network Time Protocol); CPU is client	X	-	-
	CPU is time master or time slave	-	X	-

Further information

- You will find the detailed description of the communications services in this manual starting at section PG communication (Page 23).
- You will find information about the Fetch/Write services in the STEP 7 online help.
- You will find the description of the Web server functionality in the function manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).
- You will find information about the standard protocol SNMP on the Service & Support pages on the Internet (http://support.automation.siemens.com/WW/view/en/15166742).
- You will find information on time-of-day synchronization in the system manual S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792).

3.2 Overview of connection resources

Connection resources

Some communications services require connections. Connections occupy resources on the CPUs, CPs and CMs involved (for example memory areas in the operating system of the CPU). In most cases one resource per CPU/CP/CM is occupied for a connection.
In HMI communication, up to 3 connection resources are required per HMI connection.

The connection resources available depend on the CPU being used, the CPs and CMs and must not exceed a defined upper limit for the automation system.

Connection resources available on an S7-1500 automation system

The maximum configuration limits within an automation system are decided by the CPU. The available connection resources of a CPU/CP/CM are automatically distributed among the interfaces as required.

Each CPU has reserved connection resources for PG, HMI and Web server communication in its project engineering. There are also resources available that can be used for all HMI, S7 communication and open communication.

When are connection resources occupied?

The occupation of connection resources depends on how the connection is set up, automatically, programmed or configured (see section Setting up a connection (Page 18)).

Further information

You will find more detailed information on the occupation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 63).

3.3 Setting up a connection

Automatic connection

STEP 7 sets up a connection automatically (for example PG or HMI connection) if you have connected the PG/PC interface to an interface of the CPU physically and have made the interface assignment in STEP 7 in the "Go online" dialog.

Programmed setup of the connection

You set up the connection in the program editor of STEP 7 in the context of a CPU by assigning instructions for communication, for example TSEND_C.

Regardless of whether the communication is via an integrated interface of the CPU, of a CP or CM you use the same instructions.

When specifying the connection parameters (in the Inspector window, in the properties of the instruction), you are supported by the convenient user interface.

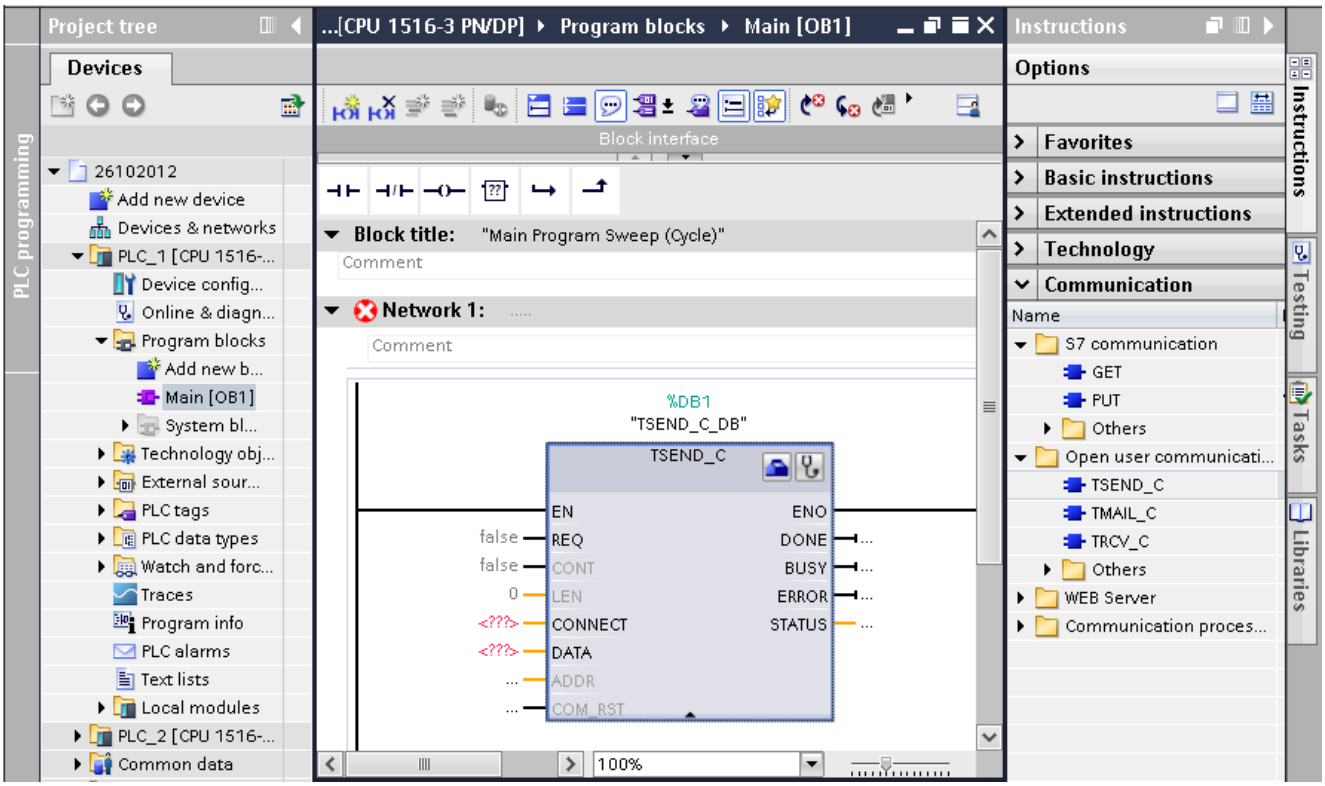


Figure 3-1 Programmed setup

Configured setup of the connection

You set up the connection in the network view of the Devices & networks editor of STEP 7 in the context of a CPU.

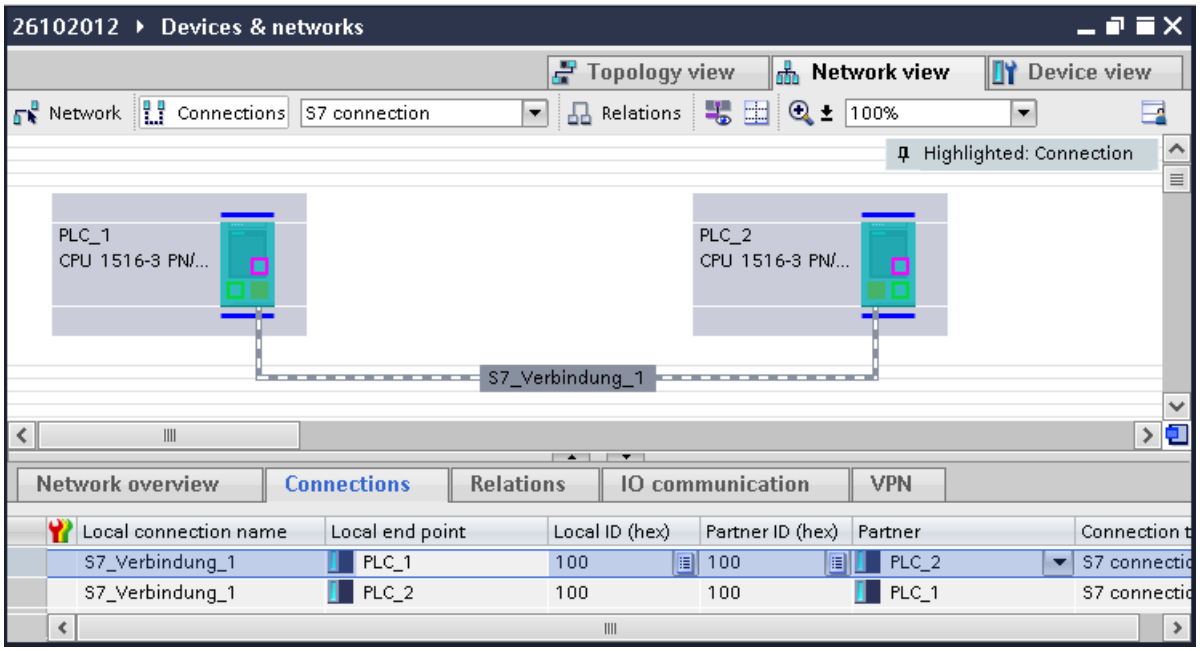


Figure 3-2 Configured setup

Summary

You can often choose between a configured or a programmed connection setup. Programmed connection setup allows connection resources to be released following data transfer. With configured connection setup, you are supported in the management of connection resources in STEP 7.

Table 3- 2 Setting up the communications service

Communication service	Automatically	Programmed setup	Configured setup
PG communication	X	-	-
HMI communication	X	-	X
Open communication using TCP/IP	-	X	X
Open communication using ISO-on-TCP	-	X	X
Open communication with UDP	-	X	X
Open communication with ISO	-	-	X
E-mail	-	X	-
FTP	-	X	-
Open communication with FDL	-	-	X
S7 communication	-	-	X

Further information

You will find more detailed information on the occupation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 63).

3.4 Data consistency

Definition of data consistency

The size of the data area that cannot be changed at the same time by competing processes is known as a consistent data area. A data area that is larger than the consistent data area can be corrupted as a whole. This means that a self-contained data area that is larger than the consistent data area may consist of new and old consistent data fields at any one time.

Example

An inconsistency can occur when an instruction for communication is interrupted, for example by a hardware interrupt OB with higher priority. If the user program in this OB now changes the data that has already been partly processed by the instruction, the transferred data originates:

- partly from the time prior to hardware interrupt processing
- partly from the time after the hardware interrupt processing.

This means that the data is inconsistent (data that does not belong together).

Effect

No inconsistency occurs if the system-specific maximum size of the consistent data is kept to. The S7-1500 CPUs allow a maximum of 462 bytes (see below).

If more data than the system-specific maximum size needs to be transferred consistently, you yourself must ensure that the data remains consistent in the application. This can, for example extend the interrupt reaction time of the CPU.

Data consistency with S7-1500

Use of instructions for access to common data:

If the user program contains instructions for communication that access common data, for example TSEND/TRCV, you can coordinate access to this data area yourself, for example using the "DONE" parameter. The data consistency of the data areas that are transferred locally with an instruction for communication can therefore be ensured in the user program.

Use of PUT/GET instructions or Write/Read via HMI communication:

In S7 communication with the PUT/GET instructions or Write/Read via HMI communication, you need to take into account the size of the consistent data areas during programming or configuration because there is no instruction in the user program of the target device (server) that can coordinate the data transfer in the user program.

System-specific maximum data consistency for S7-1500:

With an S7-1500, communication data is transferred in blocks of up to 462 bytes consistently into or out of the user memory during the program cycle. Data consistency is not ensured for larger data areas. Where defined data consistency is required, the length of communication data in the user program of the CPU must not exceed 462 bytes. You can then access these data areas consistently, for example from an HMI device using Read/Write tags.

Maximum data consistency for point-to-point CM:

With communication via a CM for a point-to-point link, the data consistency is ensured by the Send/Receive instructions in the user program. The maximum data consistency is 4 KB.

Further information

- You will find the maximum amount of consistent data in the CPU, CM or CP manuals in the Technical specifications.
- You will find further information on data consistency in the description of the instructions in the STEP 7 online help.

PG communication 4

Properties

Using PG communication, the CPU or another module capable of communication exchanges data with an engineering station (for example PG, PC). The data exchange is possible via PROFIBUS and PROFINET subnets. Changing between subnets is also supported.

PG communication provides functions needed to load programs and configuration data, run tests, and evaluate diagnostic information. These functions are integrated in the operating system of the module capable of communication.

A PG/PC can be connected to a CPU online. The PG/PC can operate a maximum of 4 online connections at one time (for example to 4 CPUs).

Procedure for setting up PG communication

For PG communication, you need to set up an online connection from the PG/PC to the module capable of communication:

1. Connect the PG/PC interface to the required interface physically, for example the PROFINET interface of the CPU.
2. Select the CPU in the Project tree in STEP 7.
3. Select the "Online > Go online" menu command.

4. In the "Go online" dialog, select the PG/PC interface (for example Ind. Ethernet adapter).

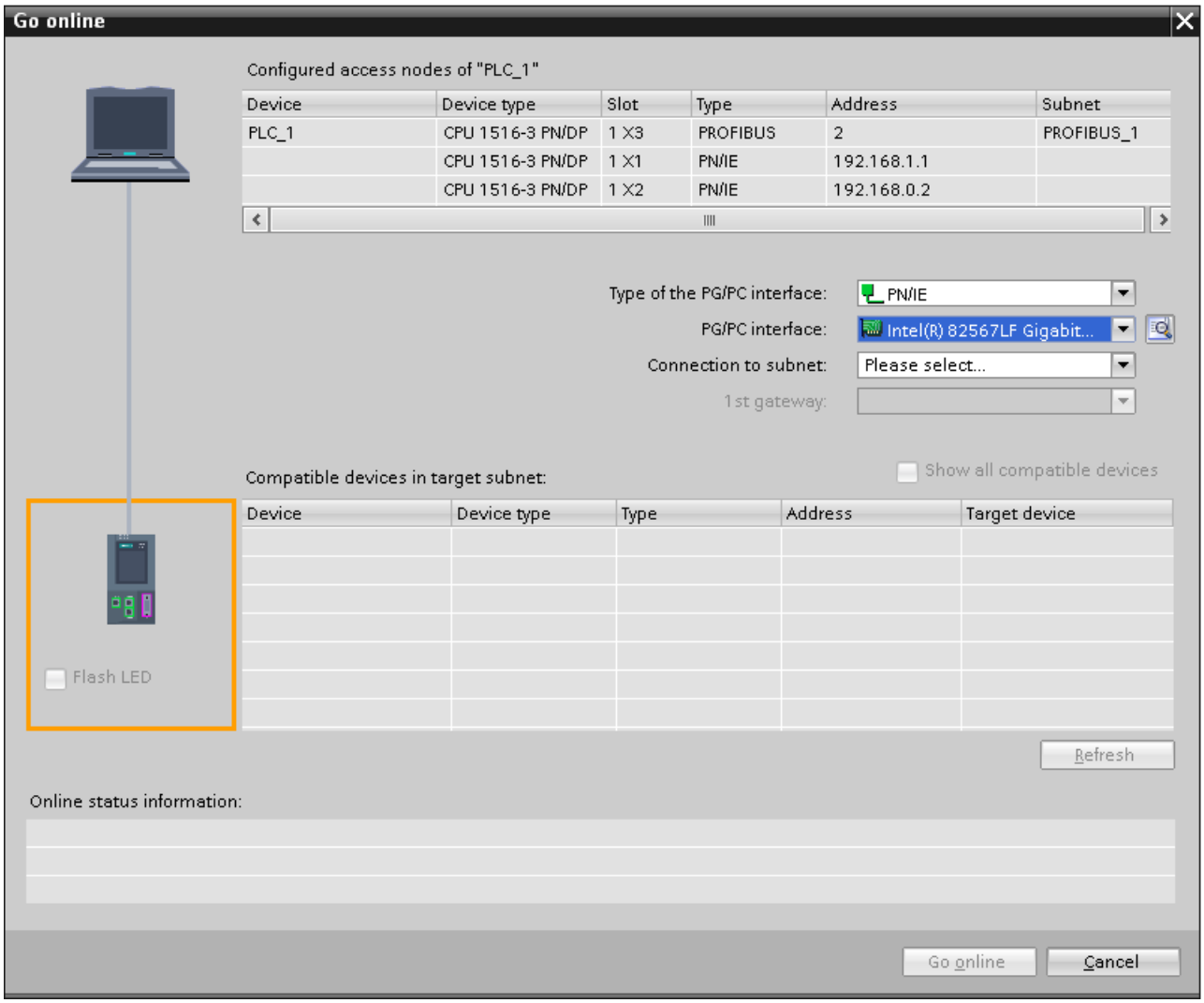


Figure 4-1 Setting up PG communication

5. In the "Compatible devices in the target subnet" table, select the relevant CPU and confirm with "Connect".

Further information

You will find further information on "Go online" in the STEP 7 online help.

HMI communication 5

Properties

Using HMI communication, the CPU exchanges data for operator control and monitoring with one or more HMI devices (for example HMI Basic/Comfort/Mobile Panel) via the PROFINET or PROFIBUS DP interface. The data exchange is via HMI connections.

If you want to set up connections from a CPU to several HMI devices, use, for example:

- the PROFINET and PROFIBUS DP interfaces of the CPU
- additional CPs and CMs with the relevant interfaces
- additional PROFINET switches with a suitable number of connectors for the HMI devices

Procedure for setting up HMI communication

1. Configure the HMI device in an existing configuration with a CPU in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and then "HMI connection" from the drop-down list.
3. By means of drag-and-drop, connect the interface of the HMI device with an interface of the CPU. If the required subnet does not yet exist, this is created automatically.

4. In the "Connections" tab, select the row of the HMI connection.

   In the "General" area of the "Properties" tab, you see the properties of the HMI connection, some of which you can change.

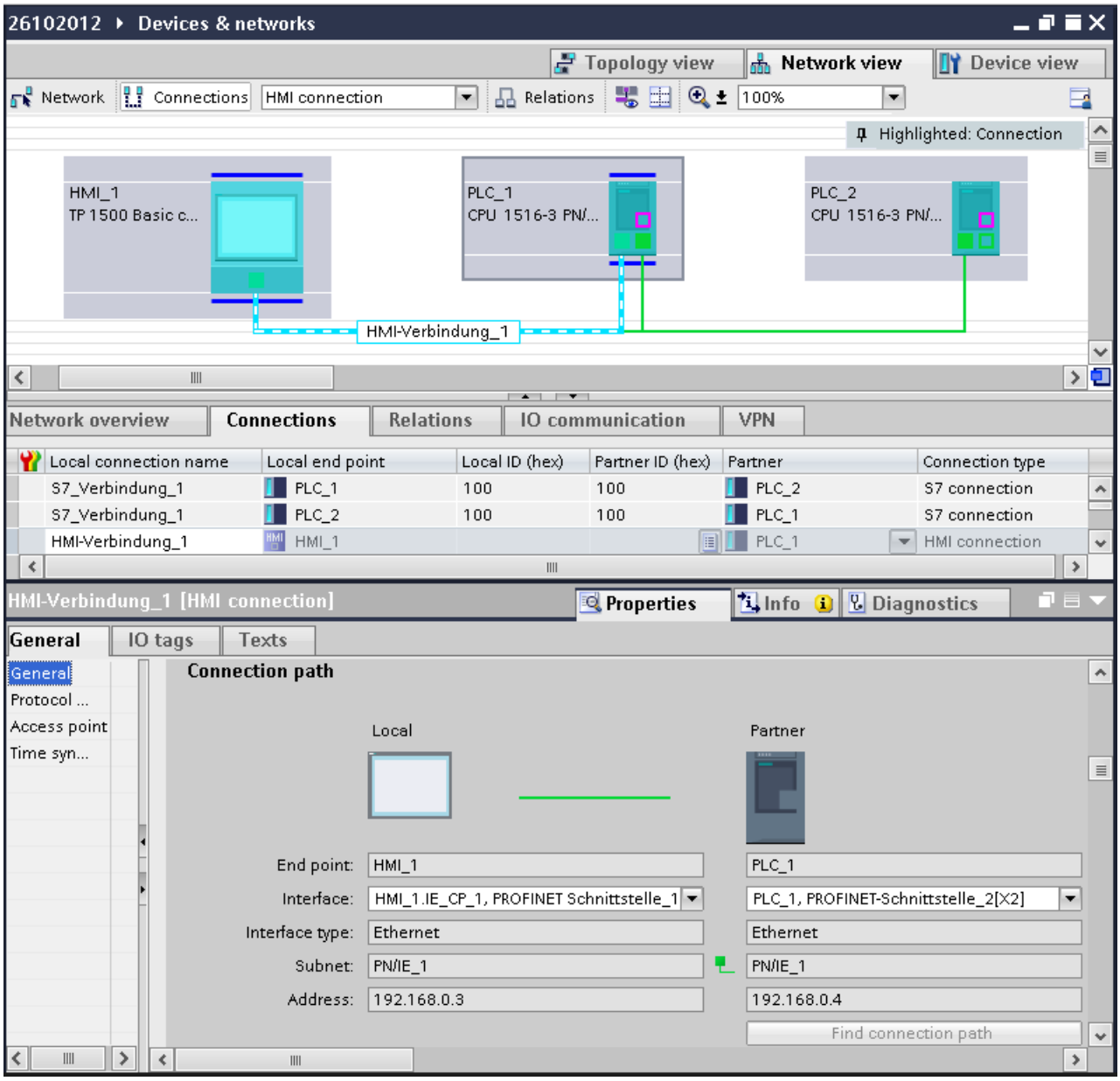


Figure 5-1 Setting up HMI communication

5. Download the hardware configuration to the CPU.
6. Download the hardware configuration to the HMI device.

Further information

You will find further information on setting up HMI connections in the STEP 7 online help.

Open communication 6

6.1 Overview of open communication

Features of open communication

Using open communication, the CPU exchanges data with another module capable of communication within a subnet. The main features of open communication are as follows:

- Open standard (communication possible with CPUs or PCs from other manufacturers)
- Communication via various protocols (in STEP 7 known as "Connection types")
- High degree of flexibility in terms of the data structures transferred; this allows open data exchange with any communications devices as long as these support the connection types available.
- Open communication in S7-1500 possible with:
  - Integrated interfaces of the CPU
  - CP 1543-1 (PROFINET)
  - CM 1542-5 (PROFIBUS)

6.2 Protocols for open communication

Protocols for open communication

For open communication, the following protocols are available for S7-1500 automation systems:

Table 6- 1 Protocols for open communication

Protocol	Via interface
TCP according to RFC 793	PROFINET
ISO-on-TCP according to RFC 1006	PROFINET
ISO according to RFC 8073	PROFINET (only CP 1543-1)
UDP according to RFC 768	PROFINET
E-mail	PROFINET
FTP	PROFINET (only CP 1543-1)
FDL	PROFIBUS DP (only CM 1542-5)

Protocols for communication via PROFINET: TCP, ISO-on-TCP, ISO, UDP

Prior to data transfer, these protocols establish a (logical) connection to the communications partner. Connection-oriented protocols are used when potential loss of data needs to be avoided. Usually several logical connections can be established via a physical cable. With ISO-on-TCP, ISO and UDP, information about the length and end of a data packet is also sent, this is not the case with TCP.

The following is possible with UDP:

- Unicast to one or broadcast to all devices on PROFINET via the PROFINET interface of the CPU or the CP 1543-1
- Multicast to all recipients of a multicast group via the PROFINET interface of the CP 1543-1

Protocol for communication via PROFIBUS: FDL

Data transfer via an FDL connection (Fieldbus Data Link) is suitable for the transfer of related blocks of data to a communications partner on PROFIBUS that supports the sending and reception of data according to the FDL service SDA (Send Data with Acknowledge) according to EN 50170 Vol 2. Both partners have the same rights; in other words, each partner can initiate sending and receiving event-driven.

In keeping with the FDL service SDN (Send Data with No Acknowledge) according to EN 50170, Vol 2, the following is possible with FDL:

- Broadcast to all devices on PROFIBUS
- Multicast to all recipients of a multicast group

E-mail and FTP protocols

The sending of process data from data blocks is, for example, possible using e-mail.

The FTP connection (FTP = File Transfer Protocol) is used to handle FTP job sequences.

Communication is controlled solely by suitable instructions in the user program.

6.3 Instructions for open communication

Introduction

You set up open communication via the relevant connection (for example TCP connection) as follows:

- by programming in the user programs of the communications partners or
- by configuring the connection in STEP 7 in the Devices & networks editor

Regardless of whether you set up the connection by programming or configuring, instructions are always required in the user programs of both communications partners for sending and receiving the data.

Regardless of whether the communication is via an integrated interface of the CPU, of a CP or CM you use the same instructions.

Setting up the connection using the user program

If the connection is set up by programming, the connection establishment and termination is implemented using instructions in the user program.

In certain areas of application it is an advantage not to set up the communications connections statically by configuring in the hardware configuration, but to have them set up by the user program. You can set up the connections via a specific application program-controlled and therefore when necessary dynamically. Programmed connection setup also allows connection resources to be released following data transfer.

The following instructions are available:

- Instructions **with** automatic connection management:
  - TSEND_C: establish connection and send data
  - TRCV_C: establish connection and receive data
- Instructions **without** automatic connection management:
  - TCON: establish connection
  - TDISCON: terminate connection
  - TSEND and TRCV: send and receive data

We recommend that you use the instructions with automatic connection management, TSEND_C and TRCV_C in the user program.

Use the TCON, TDISCON and TSEND/TRCV instructions when you want to program connection establishment and termination yourself.

Data blocks for parameter assignment of the connection data

A data structure is necessary for each communications connection that contains the parameters for establishing the connection (for example system data type "TCON_IP_v4" for TCP).

The system data types (SDT) are provided by the system and have a predefined structure that cannot be changed.

The various protocols have their own data structures (see table below). The parameters are stored in a data block ("connection description DB") for example of the system data type TCON_IP_v4.

There are two ways in which you can specify the DB with the data structure:

- Have the data block created automatically in the properties in the program editor during parameter assignment of the connection (recommendation; possible for TCP, ISO-on-TCP and UDP)
- Create the data block manually, assign parameters to it and write it directly to the instruction (necessary for e-mail and FTP)

You can modify the connection parameters in the "connection description DB".

Protocols, usable instructions and system data types for programmed setup

Table 6- 2 Instructions for programmed setup of the connection

Protocol	Setting up the connection using the user program	System data type
Usable instructions:		
TCP	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV (termination of the connection possible with TDISCON)	• TCON_IP_v4
ISO-on-TCP		• TCON_IP_RFC
UDP		• TCON_IP_v4
E-mail	• TMAIL_C	• TMail_v4 • TMail_v6 • TMail_FQDN
FTP	• FTP_CMD	• FTP_CONNECT_IPV4* • FTP_CONNECT_IPV6* • FTP_CONNECT_NAME*

*User-defined data type

Setting up the connection with connection configuration

When setting up by configuring the connection, the address parameters of the connection are specified in the Devices & networks editor of STEP 7.

To send and receive the data, use the same instructions as when the connections are set up by programming:

Table 6- 3 Instructions for sending/receiving with configured connections

Protocol	Send/receive with configured connections
Usable instructions:	
TCP	Send/receive data via: • TSEND_C/TRCV_C or • TSEND/TRCV
ISO-on-TCP	
UDP	
ISO	
FDL	
E-mail	Not supported
FTP	Not supported

Further information

You will find the following described in the STEP 7 online help:

- the user and system data types
- the instructions for open communication
- the connection parameters

You will find information about the occupation and release of connection resources in the section Occupation of connection resources (Page 63).

6.4 Setting up open communication with TCP, ISO-on-TCP, UDP, ISO and FDL

Introduction

The procedure for setting up open communication via TCP, ISO-on-TCP, UDP, ISO and FDL is essentially the same.

Below you will find the description of programmed setup and setting up using a connection configuration based on the example of TCP.

Procedure for setting up a connection with the user program (possible for TCP, ISO-on-TCP and UDP)

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the required instruction from the "Instructions" task card, "Communication" area, "Open user communication", for example TSEND_C and drag it to a network of OB1.
4. Set the connection parameters in the Inspector window of the program editor in the properties of the instruction:
   - Select the partner for the communications connection (e.g. CPU in the same project or "Unspecified" for example for a PC).
   - Specify the data block for storing the connection data.
   - Select the connection type for the open communication, in the example "TCP".
   - Specify which of the communications partners establishes the connection actively.

5. Interconnect the "DATA" parameter of the TSEND_C instruction with the user data, for example in a data block.

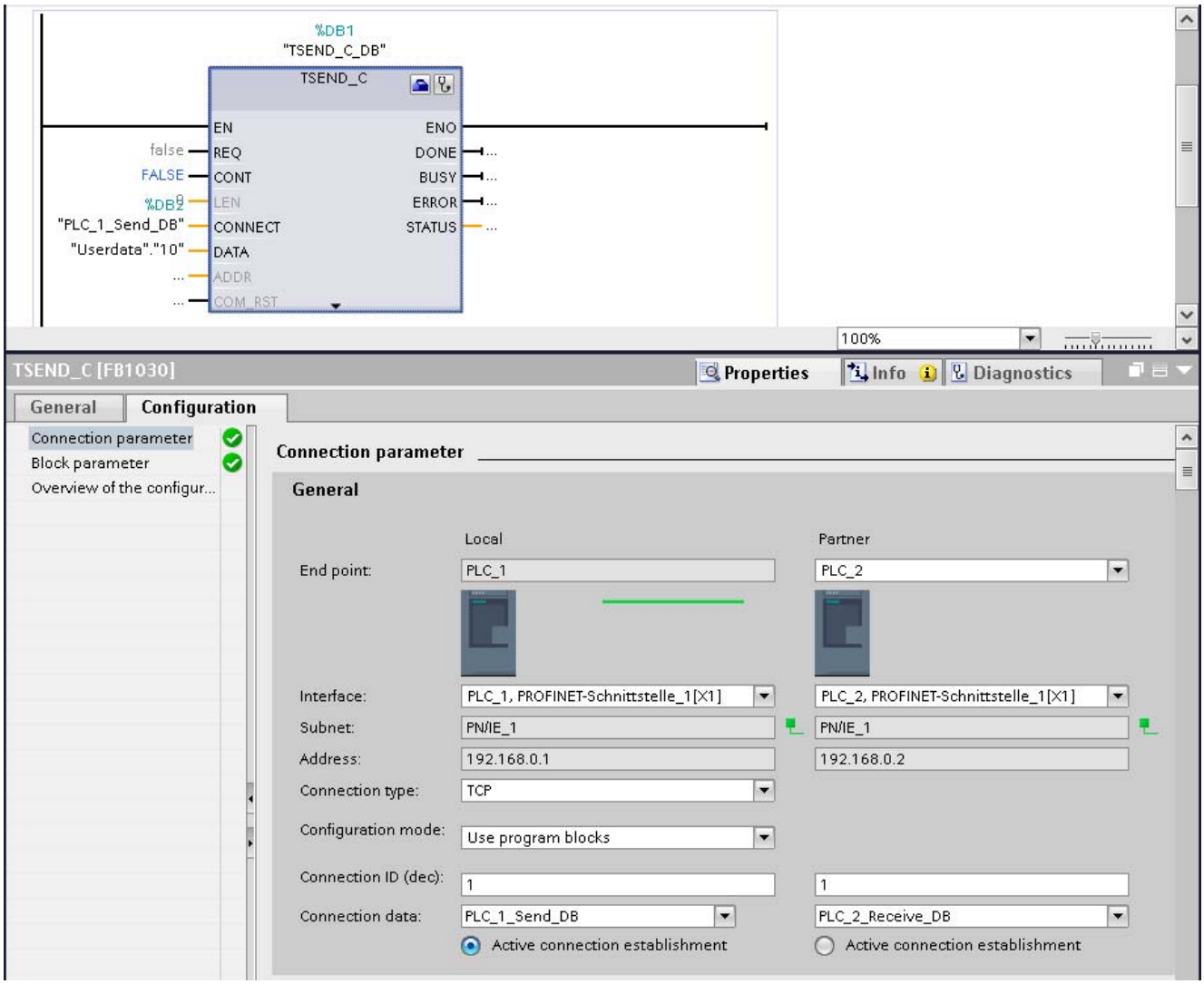


Figure 6-1 Programming open communication

6. Download the hardware configuration and user program to the CPU.

Based on the procedure described above, set up the connection on the partner CPU with the instruction for receiving, TRCV_C, and download it to the CPU.

Procedure for setting up a connection by configuring the connection

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and then select the required connection type for the open communication from the drop-down list, for example the entry "TCP connection".
3. Connect the relevant interfaces of the communications partners using drag-and-drop. If the required subnet does not yet exist, this is created automatically.

   As an alternative or for connections to unspecified partners:

   – Select "Add new connection" in the shortcut menu of the CPU.

   – In the next dialog "Create new connection", select the required local interface of the CPU and "Unspecified" as the connection partner.

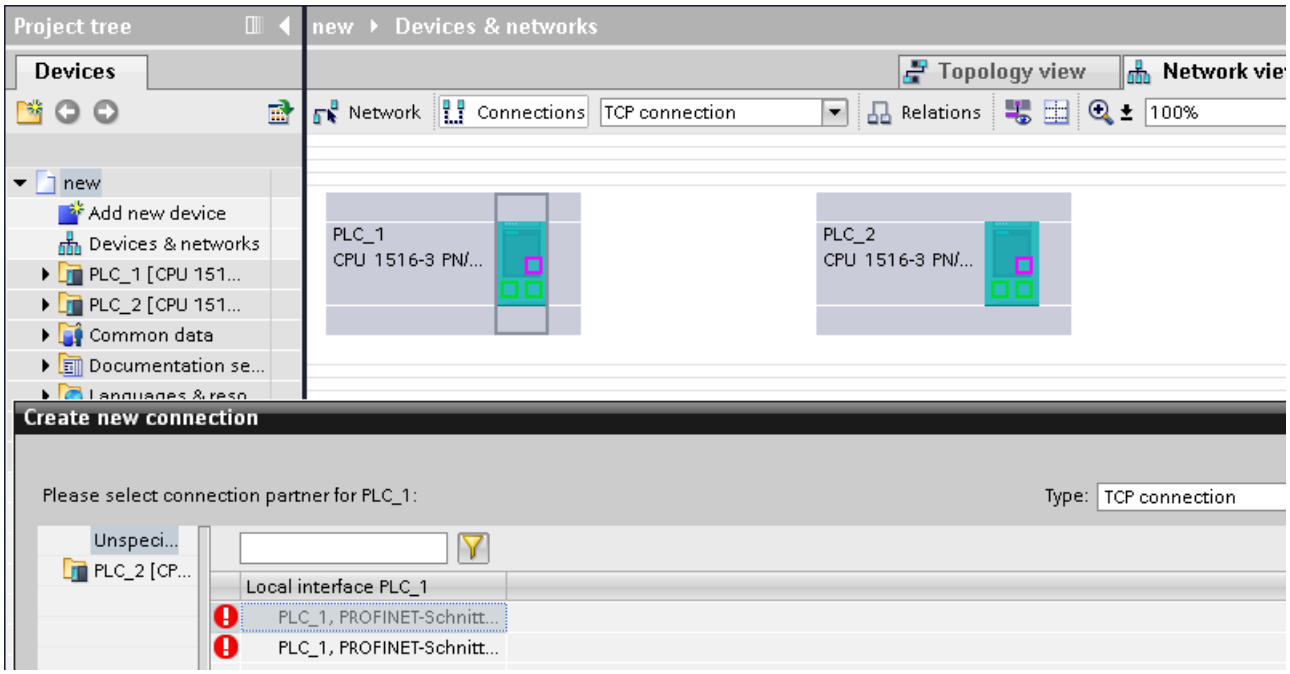


Figure 6-2 Setting up a connection to an unspecified partner

4. In the "Connections" tab, select the row of the connection.

5. Set the properties of the connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For connections to an unspecified partner, set the address of the partner.

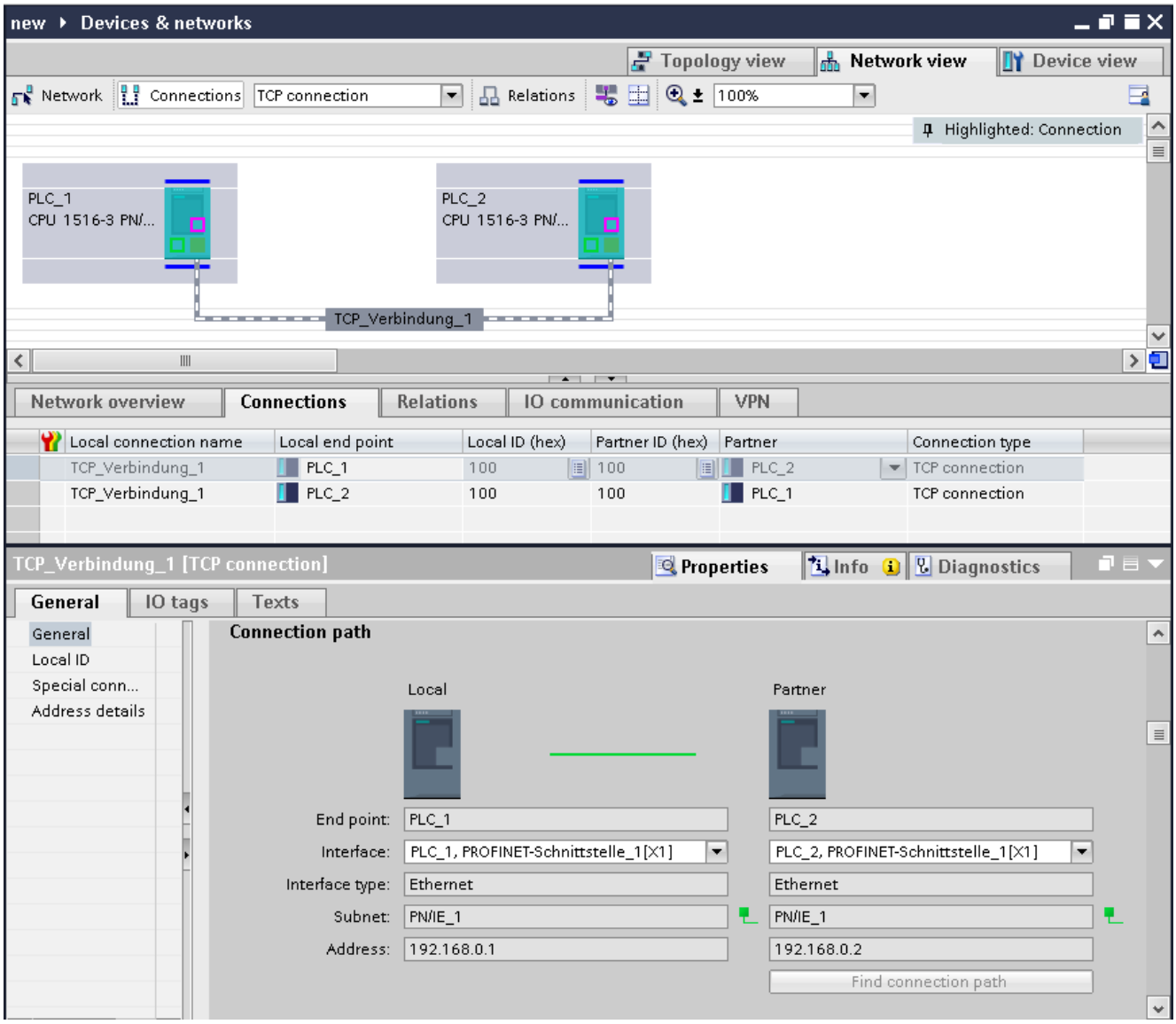


Figure 6-3 Setting up open communication with connection configuration

6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. Select the required instruction from the "Instructions" task card, "Communication" area, "Open user communication", for example TSEND_C and drag it to a network of OB1.
8. In the Inspector window of the program editor, select the configuration type "Use configured connection" in the properties of the instruction.

9. Interconnect the "DATA" parameter of the TSEND_C instruction with the user data, for example in a data block.
10. Download the hardware configuration and user program to the CPU.

Based on the procedure described above, set up the connection on the partner CPU with the instruction for receiving, TRCV_C, and download it to the CPU.

Point to note with ISO connections with CP 1543-1

If you use the "ISO connection" connection type, you will need to enable the "Use ISO protocol" check box in the properties of the CP so that addressing using MAC addresses will work.

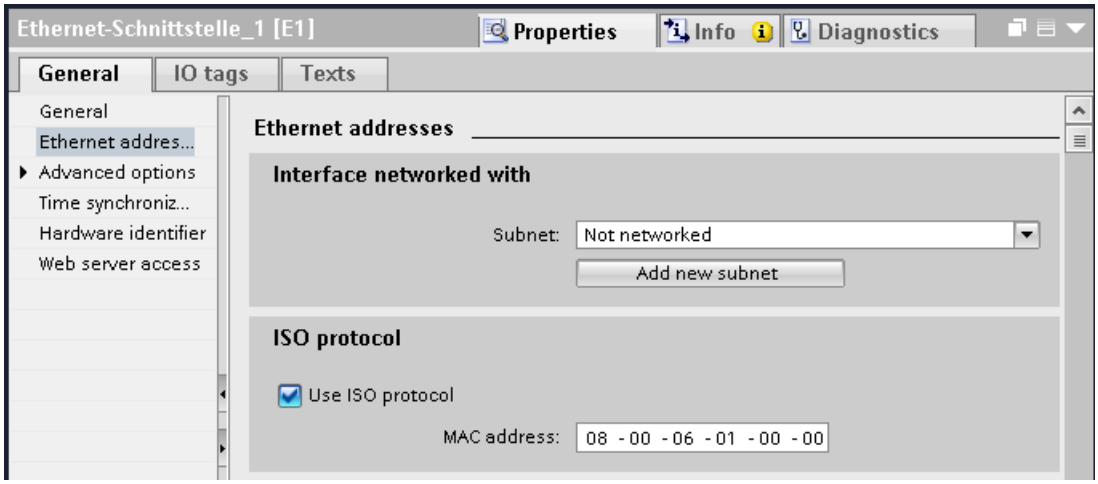


Figure 6-4 Select CP 1543-1 ISO protocol

Further information

You will find the following described in the STEP 7 online help:

- the instructions for open communication
- the connection parameters

6.5 Setting up e-mail and FTP

Setting up a connection for e-mail or FTP using the user program

When you set up the connections described up to now, you are supported by STEP 7 when entering the connection parameters. The entries are made in the Inspector window of the program editor in the context of the relevant instruction.

For communication using e-mail and FTP, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

Procedure for setting up communication using e-mail

A CPU can send e-mails. To send e-mails from the user program of the CPU, use the TMAIL_C instruction.

Requirement: The SMTP server can be reached via the PROFINET subnet.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. Set the address parameters for the SMTP server in the TMAIL_C instruction.
3. Specify a DB with the TMAIL_v4, TMail_v6 or TMail_FQDM data structure (contains the parameters required to establish the connection):
   – Create the data block, assign the parameters and write it directly to the instruction.

     You can modify the connection parameters in the DB.
4. Download the hardware configuration and user program to the CPU.

FTP client and server functionality

Data can be sent by a CPU to an FTP server and can be received from the FTP server. Communication with FTP is only possible for the S7-1500 using the CP 1543-1.
The CP can be an FTP server, FTP client or both. FTP clients can also be third-party systems/PCs.

For the FTP server functionality, configure the CP accordingly in STEP 7.

With the FTP client functionality, you implement, for example the establishment and termination of an FTP connection, the transfer and deletion of data on the server.
For the FTP client functionality, use the FTP_CMD instruction.

Procedure for setting up FTP server functionality

Requirement: The FTP server can be reached via the PROFINET subnet.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.
2. Make the following settings in the properties of the CP under "FTP configuration":
   - Select the "Use FTP server for S7 CPU data" check box.
   - Assign the CPU, a data block and a file name under which the DB for FTP will be stored.

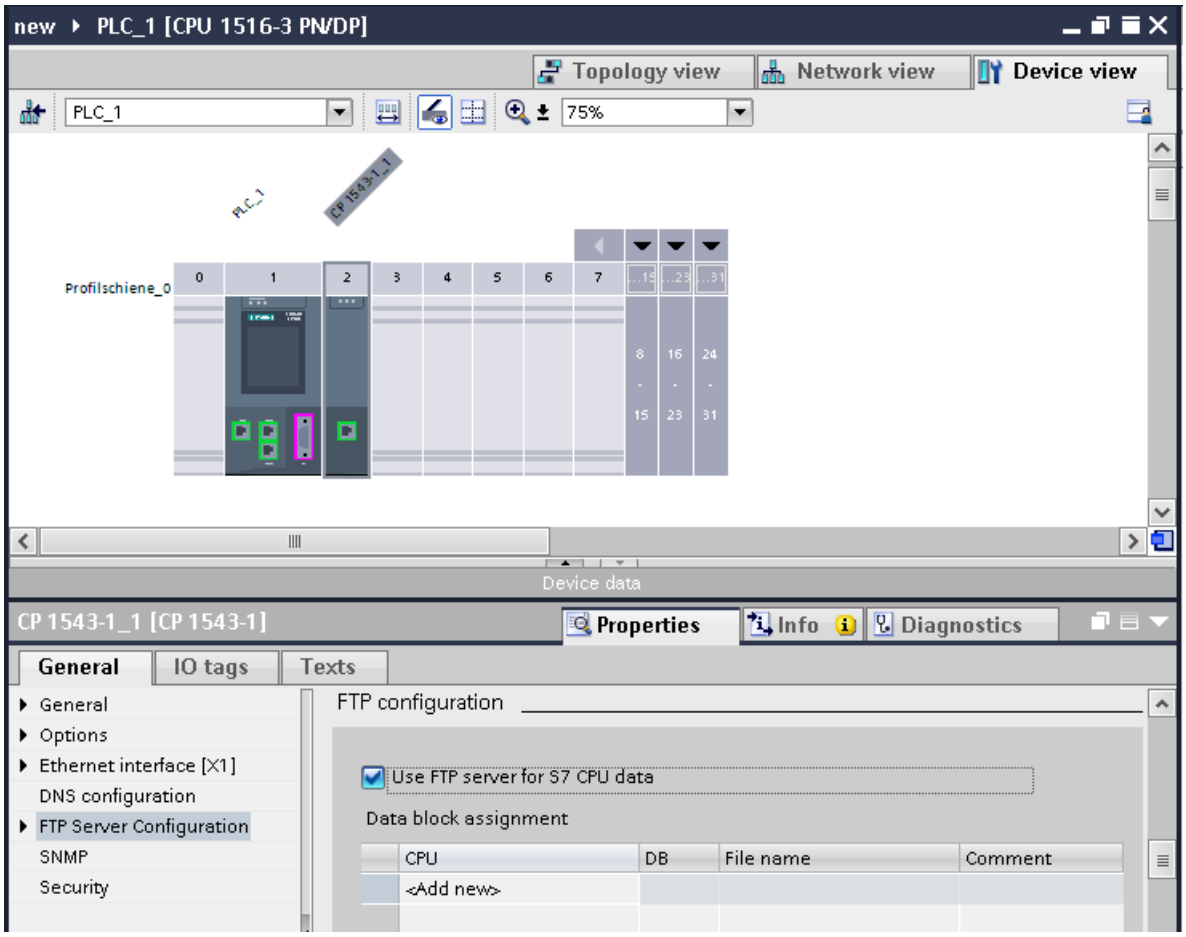


Figure 6-5 Setting up the FTP configuration

3. Download the hardware configuration to the CPU.

Procedure for setting up FTP client functionality

Requirement: The FTP server can be reached via the PROFINET subnet.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.
2. Call the FTP_CMD instruction in the user program of the CPU.
3. Set the connection parameters for the FTP server in the FTP_CMD instruction.
4. Specify a DB with the FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME data structure:
   – Create the data block and write it directly to the instruction.
5. For the connection to the FTP server, specify the following in the DB:
   – the user name, the password and the IP address for the FTP access in the relevant data type (FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME)
6. Download the hardware configuration and user program to the CPU.

Further information

You will find the following described in the STEP 7 online help:

- the system data types
- the instructions for open communication
- the connection parameters

6.6 Establishment and termination of open communications relations

Establishment and termination of open communications relations

Table 6- 4 Establishment and termination of open communications relations

Setting up the connection	Establishing the communications relation	Terminating the communications relation
With the user program	After downloading the user program to the CPUs: The passive communications partner sets up the local connection access by calling TSEND_C/TRCV_C or TCON. Calling TSEND_C/TRCV_C or TCON on the active partner starts connection establishment. If the connection could be established, there is positive feedback to the instructions in the user program. If the connection aborts, the active partner attempts to re-establish the connection.	• Using the TSEND_C/TRCV_C or TDISCON instructions • When the CPU changes from RUN to STOP mode • When power is cycled on a CPU
By configuring a connection	After downloading the connection configuration and the user program to the CPUs: The passive communications partner sets up the local connection access by calling TSEND_C/TRCV_C. Calling TSEND_C/TRCV_C on the active partner starts connection establishment. If the connection could be established, there is positive feedback to the instructions in the user program.	By deleting the connection configuration in STEP 7 and downloading the changed configuration to the CPU. Otherwise the connection is not terminated following data transfer; in other words, the connection remains established. Advantage: The execution time of the instructions is shorter the next time data is transferred because the connection does not need to be established again.

S7 communication 7

Characteristics of S7 communication

S7 communication as homogeneous SIMATIC communication is characterized by vendor-specific communication between SIMATIC CPUs (not an open standard). S7 communication is used for migration and for connecting to existing systems (S7-300, S7-400).

For S7-1500 automation systems, we recommend that you use open communication (see section Open communication (Page 27)).

Properties of S7 communication

With S7 communication, the CPU exchanges data with another CPU via its integrated PROFINET or PROFIBUS DP interface or via a CP/CM with a suitable interface. The remote application acknowledges; in other words, as soon as the receiving CPU has received the data, it acknowledges this to the sending CPU.

The data is exchanged via configured S7 connections. S7 connections can be configured at one end or at both ends.

S7 connections configured at one end

With an S7 connection configured at one end, the connection partner is the server for this connection (client/server communication). The S7 connection is configured on the client, suitable instructions are called in the user program and the configuration and user program are downloaded. On the server, the data is made available by the system without instructions in the user program.

One special case with S7 connections configured at one end is S7 communication with an unspecified partner (unspecified S7 connection). This makes it possible to use S7 connections beyond the boundaries of a project. The connection partner is unknown to the local project (unspecified) and is configured in another STEP 7 or third-party project.

S7 connections configured at both ends

With S7 connections configured at both ends, both partners can send and receive data. The configuration and the instruction calls in the user program are downloaded to the CPUs of both connection partners (client/client communication).

A connection configured at both ends can also be an unspecified S7 connection (see above). Configuration etc is necessary on both connection partners.

Instructions for S7 communication

For S7 communication with S7-1500, the following instructions can be used:

- PUT/GET for connections configured at one or both ends
- BSEND/BRCV for connections configured at both ends
  - for reliable data transfer
- USEND/URCV for connections configured at both ends
  - for fast unreliable transfer of data regardless of the timing of the processing by the communications partner; for example for operating and maintenance messages

Note

Data blocks for PUT/GET instructions

When using the PUT/GET instructions, you can only use data blocks with absolute addressing. Symbolic addressing of data blocks is not possible.

Summary

Table 7- 1 Summary of S7 communication

Communication service	Model	Via interface	Configure S7 connections	Call instruction in the user program
S7 communication	Client/client	PROFINET PROFIBUS DP*	configured at both ends: in each client	In client 1: BSEND, USEND or PUT In client 2 accordingly: BRCV, URCV or GET
	Client/server	PROFINET PROFIBUS DP	configured at one end: in client	In client: PUT and GET

*when DP slave is active

PROFIBUS DP interface of the CM 1542-5 in slave mode

You will find the "Test, commissioning, routing" check box in the properties of the PROFIBUS DP interface in STEP 7. Using this check box, you decide whether the PROFIBUS DP interface of the DP slave is an active or passive device on PROFIBUS.

- Check box enabled: The slave is an active device on PROFIBUS.
  S7 connections configured at both ends can be set up for this DP slave.
- Check box disabled: The DP slave is a passive device on PROFIBUS.
  Only S7 connections configured at one end can be set up for this DP slave.

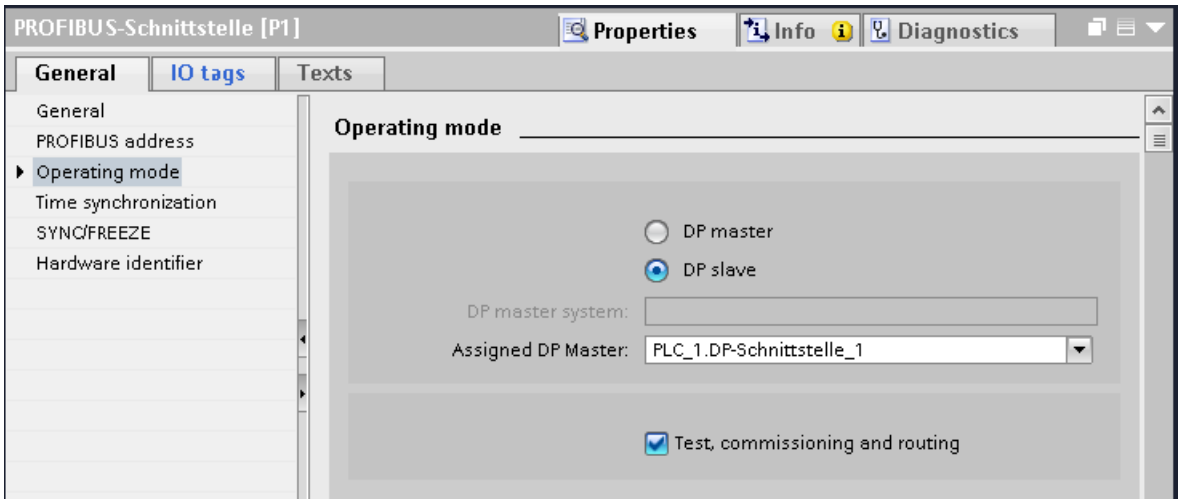


Figure 7-1 "Test, commissioning, routing" check box

Procedure for setting up S7 communication

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and the "S7 connection" entry from the drop-down list.
3. Connect the relevant interfaces of the communications partners using drag-and-drop. If the required subnet does not yet exist, this is created automatically.

   As an alternative or for S7 connections to unspecified partners:

   – Select "Add new connection" in the shortcut menu of the CPU.

   – In the next dialog "Create new connection", select the required local interface of the CPU and "Unspecified" as the connection partner.

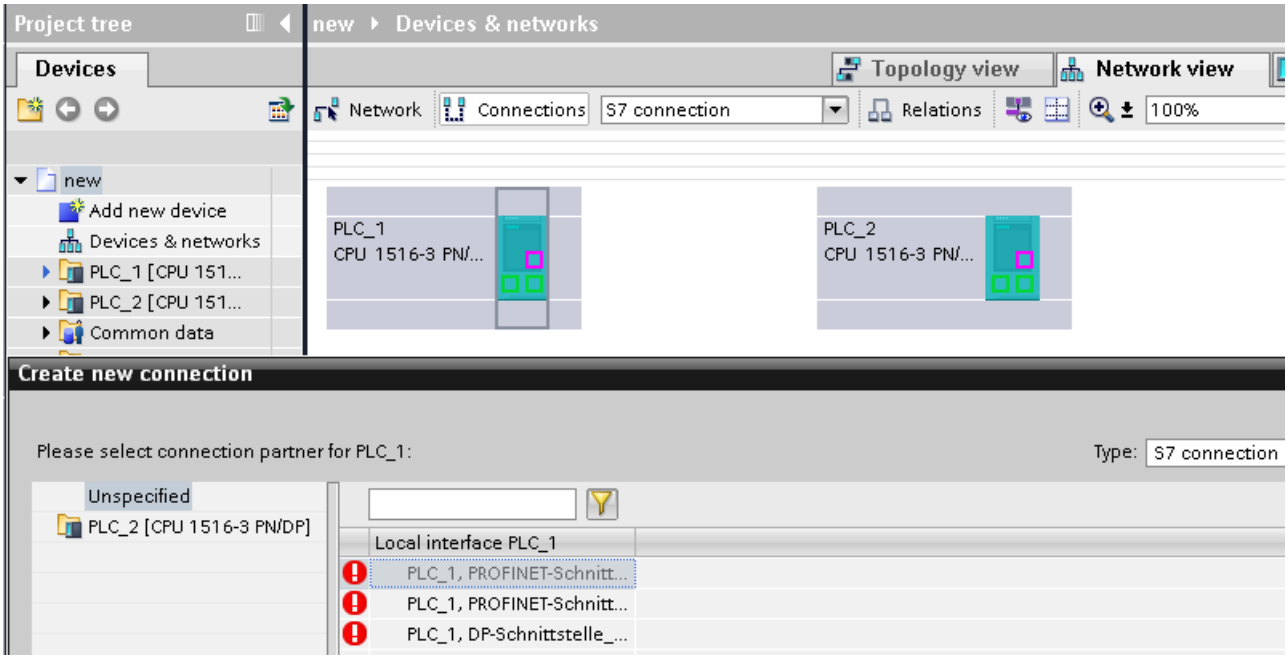


Figure 7-2 S7 connection to an unspecified partner

4. In the "Connections" tab, select the row of the S7 connection.

5. Set the properties of the S7 connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For S7 connections to an unspecified partner, set the address of the partner.

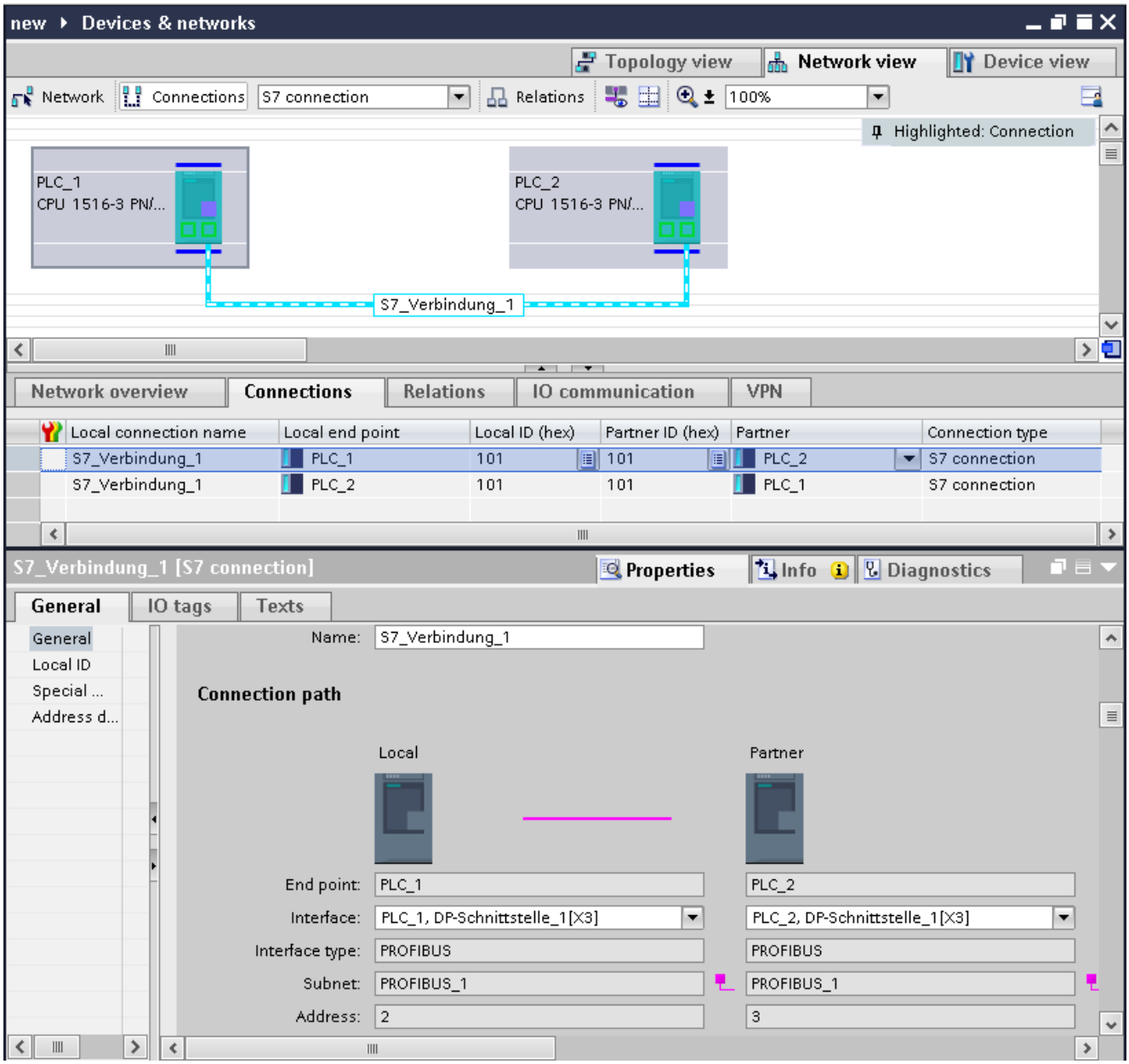


Figure 7-3 Setting up S7 communication

6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.

7. In the program editor, call the relevant instructions for S7 communication in the user program of the client (configured at one end) or in the user programs of the clients (configured at both ends). Select, for example, the PUT and GET instructions from the "Communication" area of the "Instructions" task card and drag them to a network of OB1.

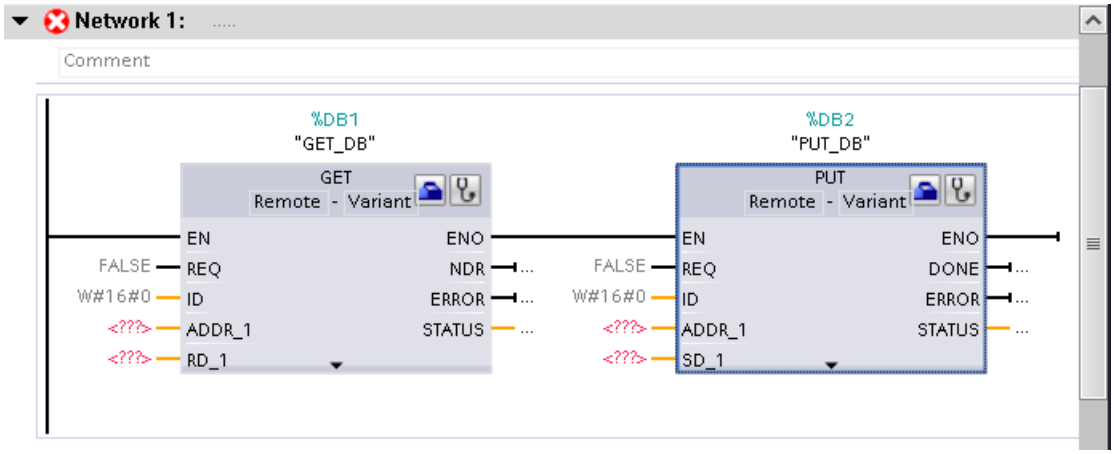


Figure 7-4 PUT/GET instructions

8. Assign the parameters for the instructions indicating which data will be written to where and which data will be read from where.
9. Download the hardware configuration and user program to the CPU(s).

S7 communication via CP 1543-1

If you set up S7 communication via the PROFINET interface of the CP 1543-1, you can select the transport protocol for data transfer in the properties of the S7 connection under "General":

- "TCP/IP" check box enabled (default): ISO-on-TCP protocol (RFC1006): for S7 communication between S7-1500 CPUs
- "TCP/IP" check box disabled: ISO protocol (RFC8073): Addressing using MAC addresses

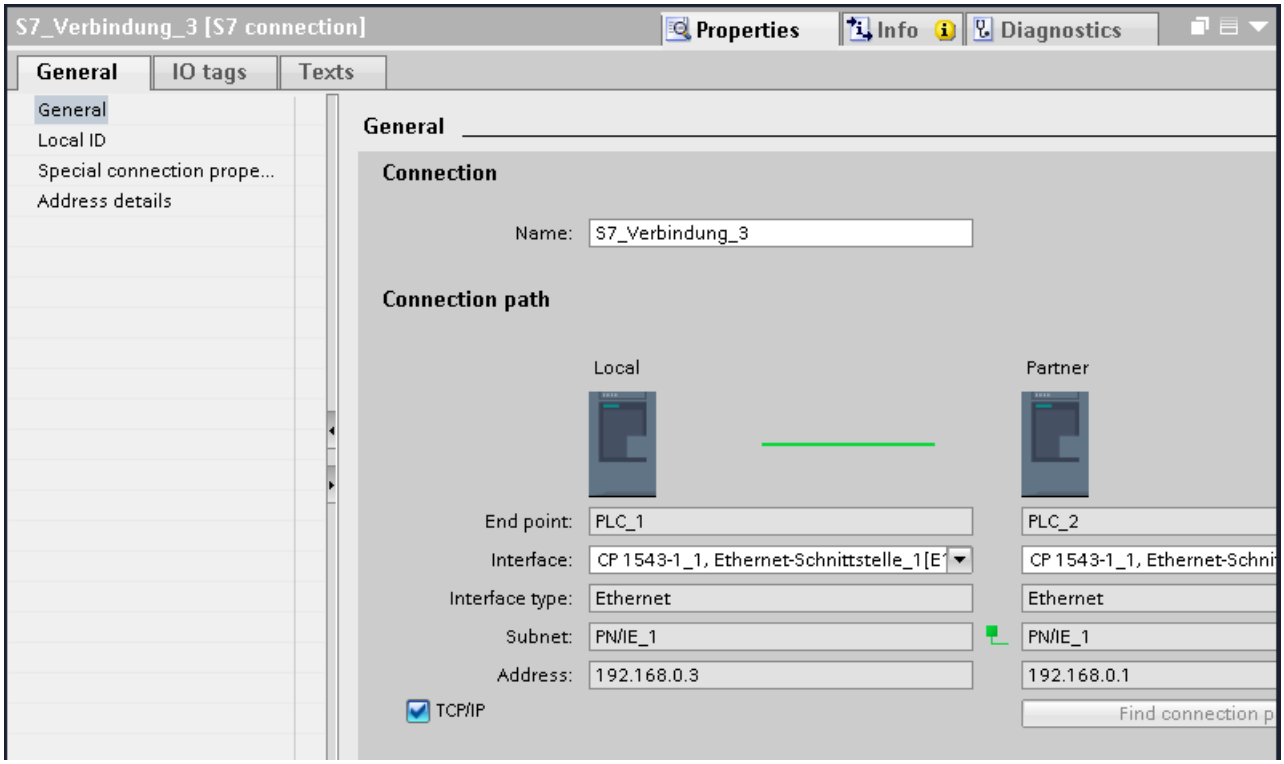


Figure 7-5 Selecting the CP 1543-1 transport protocol

Procedure for setting up an S7 connection via different subnets

You have the option of using an S7 connection via PROFIBUS and PROFINET subnets (routing via S7 connections).

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Network" button.
3. Connect the relevant interfaces with the PROFIBUS and PROFINET subnet using drag-and-drop.
4. Select the "Connections" button and the "S7 connection" entry from the drop-down list.

5. In our example, connect a PROFINET interface of CPU 1 with a PROFINET interface of CPU 3 using drag-and-drop.

   The S7 connection between CPU 1 and CPU 3 is set up.

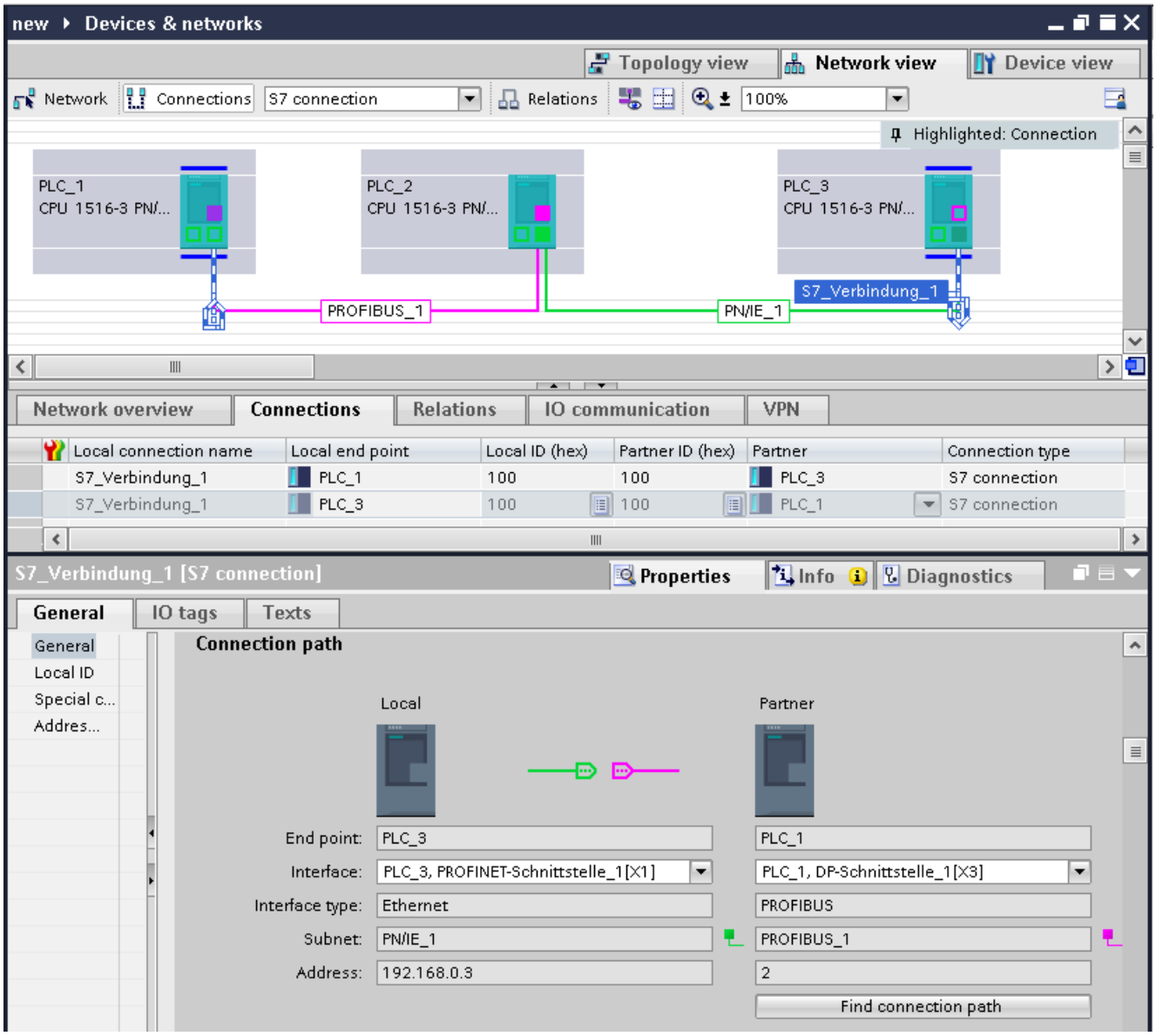


Figure 7-6 S7 connections via different subnets

Further information

You will find detailed information on configuring S7 connections and how to use the instructions for S7 communication in the user program in the STEP 7 online help.

Point-to-point link

8

Functionality

A point-to-point link for S7-1500, ET 200MP and ET 200SP is established via communications modules (CMs) with serial interfaces (RS 232, RS 422 or RS 485):

- S7-1500/ET 200MP:
  - CM PtP RS232 BA
  - CM PtP RS422/485 BA
  - CM PtP RS232 HF
  - CM PtP RS422/485 HF
- ET 200SP:
  - CM PtP

The bidirectional data exchange via a point-to-point link works between communications modules or third-party systems or devices capable of communication. In general there are only 2 communications partners involved in communication ("point-to-point").
With RS 422/485, more than two communications partners are possible.

Protocols for communication via a point-to-point link

- Freeport protocol
- Procedure 3964(R)
- Modbus protocol in RTU format (RTU: Remote Terminal Unit)
- USS protocol (universal serial interface protocol)

The protocols use different layers according to the ISO/OSI reference model:

- Freeport: uses layer 1 (physical layer)
- 3964 (R), USS and Modbus: use layer 1 and 2 (physical layer and data link layer; therefore greater transmission reliability than with Freeport)

Properties of the Freeport protocol

- The recipient recognizes the end of the data transfer by means of a selectable end criterion (e.g. character delay time elapsed, receipt of end character, receipt of a fixed amount of data).
- It is not possible to recognize whether the sent data arrived free of errors at the recipient.

Properties of procedure 3964 (R)

- When the data is sent, control characters are added (start, end and block check character).
- Connection establishment and termination makes use of control characters.
- If errors occur, data transfer is repeated.

Data exchange using Freeport or 3964 (R) communication

The data to be sent is stored in the user program of the corresponding CPU in data blocks (send buffer). A receive buffer is available on the communications module for the received data. A suitable data block is set up on the CPU.

In the user program of the CPU, the "Send_P2P" and "Receive_P2P" instructions handle the data transfer between the CPU and CM.

Procedure for setting up Freeport or 3964 (R) communication

1. Configure an S7-1500 structure with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. Assign the parameters for the interface of the CP (protocol, protocol parameters, addresses) in the "General" area in the "Properties" tab.

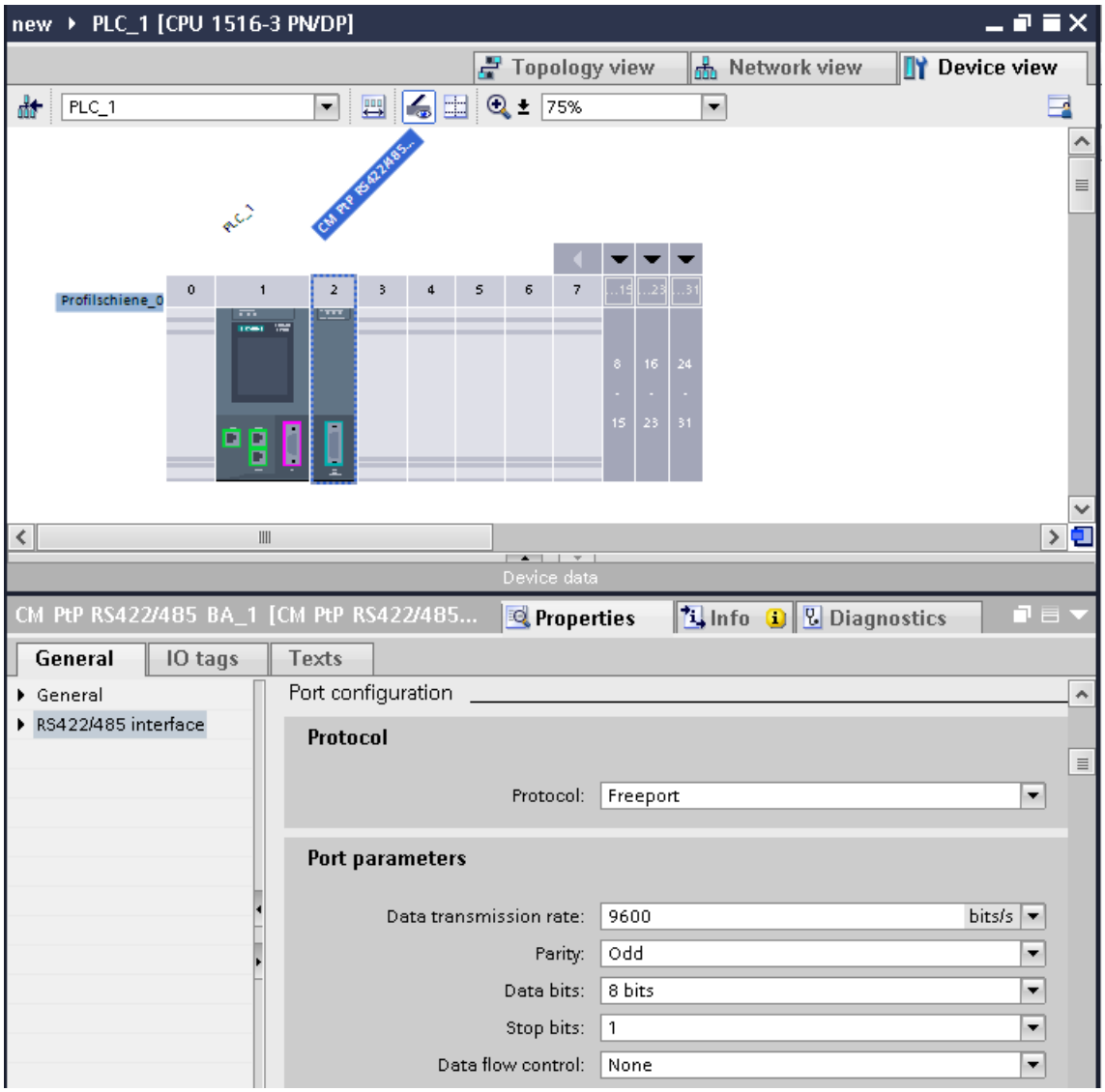


Figure 8-1 Setting up PtP communication

3. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
4. Select the "Send_P2P" and "Receive_P2P" instructions from the "Communication" area of the "Instructions" task card and drag them to a network of OB1.
5. Assign the parameters for the instructions according to your configuration.
6. Download the hardware configuration and user program to the CPU.

Otherwise: Dynamic configuration via the user program

In certain types of application it is an advantage to set up communication dynamically; in other words, program-controlled by a specific application.

Typical applications for this, could be, for example manufacturers of serial machines. To make the user interfaces as convenient as possible for their customers, these manufacturers adapt the communications services to the particular operator entries.

Instructions for Freeport communication

There are 3 instructions available for the dynamic configuration in the user program for Freeport communication. The following applies to all 3 instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "Send_Config" instruction is used for the dynamic configuration, for example of time intervals and breaks in transmission (serial transmission parameters) for the relevant port.
- The "Receive_Config" instruction is used for dynamic configuration, for example of conditions for the start and end of a message to be transferred (serial receive parameters) for the relevant port.

Instructions for 3964 (R) communication

There are 2 instructions available for dynamic configuration in the user program for 3964 (R) communication. The following applies to the instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "P3964_Config" instruction is used for the dynamic configuration of protocol parameters.

Properties of the USS protocol

- Simple, serial data transfer protocol with cyclic message frame traffic in half duplex mode that is tailored to the requirements of drive technology.
- Data transfer works according to the master-slave principle.
  - The master has access to the functions of the drive and can read and write the drive parameters.
- Broadcast to all slaves is possible.

Data exchange using USS communication

The communications module is the master. The master continuously sends frames (job frames) to the up to 16 drives and expects a response frame from each addressed drive.

A drive must send a response frame if:

- it has a received a frame without errors and
- it was addressed in this frame.

A drive must not send if these conditions are not met or the drive was addressed in the broadcast.

The connection to the relevant drive exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

Procedure for setting up USS communication

1. Configure an S7-1500 structure with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for USS communication according to your task in the "Communication" area of the "Instructions" task card and drag them to a network of OB1:
   - The "USS_Port_Scan" instruction allows you to communicate via the USS network.
   - The "USS_Drive_Control" instruction is used to exchange data with the drive.
   - The "USS_Read_Param" instruction is used to read out parameters from the drive.
   - The "USS_Write_Param" instruction is used to change parameters on the drive.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Properties of the Modbus protocol (RTU)

- Communication takes the form of serial, asynchronous transfer with a transmission speed of up to 115.2 kbps, half duplex.
- Data transfer works according to the master-slave principle.
- The Modbus master can send jobs for reading and writing operands to the Modbus slave:
  - Reading inputs, timers, counters, outputs, memory bits, data blocks
  - Writing outputs, memory bits, data blocks
- Broadcast to all slaves is possible.

Data exchange using Modbus communication (RTU)

The communications module can be a Modbus master or Modbus slave. A Modbus master can communicate with one or more Modbus slaves (the number depends on the physical interface). Only the Modbus slave explicitly addressed by the Modbus master is permitted to return data to the Modbus master. The slave detects the end of the data transfer and acknowledges it. If an error occurs, it provides an error code to the master.

Procedure for setting up Modbus communication (RTU)

1. Configure an S7-1500 structure with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for Modbus communication according to your task in the "Communication" area of the "Instructions" task card and drag them to a network of OB1:
   - The "Modbus_Comm_Load" instruction configures the port of the CM for Modbus communication.
   - The "Modbus_Master" instruction is used for Modbus master functionality.
   - The "Modbus_Slave" instruction is used for Modbus slave functionality.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Further information

- You will find more detailed information on communication via point-to-point connections and basics of serial data transmission in the function manual CM PtP communication module - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).
- You will find a description of how to use the instructions for point-to-point links in the user program in the STEP 7 online help.
- You will find information about the communications modules with a serial interface in the manual of the particular communications module.

Routing 9

9.1 S7 routing

Definition of S7 routing

S7 routing is the transfer of data beyond network boundaries. You can send information from a transmitter to a receiver across several networks.

Application

S7 routing is possible via PROFINET and PROFIBUS subnets. With the PG/PC, you can reach devices beyond subnet boundaries, for example to do the following:

- download user programs
- download a hardware configuration or
- run test and diagnostics functions

An S7 connection between two CPUs via different subnets

You have the option of setting up an S7 connection from a CPU to another CPU via different subnets (PROFIBUS and PROFINET). The procedure is described based on an example in the section S7 communication (Page 41).

CPUs, CMs and CPs in S7-1500

CPUs, CMs and CPs in S7-1500 can be routers for:

- CPUs, CMs and CPs S7-1500
- S7-300, S7-400 CPUs
- HMI devices
- PGs/PCs

S7 routing gateways: PROFINET - PROFINET

The gateway from one subnet to one or more other subnets is on the device that has the interfaces to the relevant subnets. In the following figure, CPU 1 is the router between subnet 1 and subnet 2.

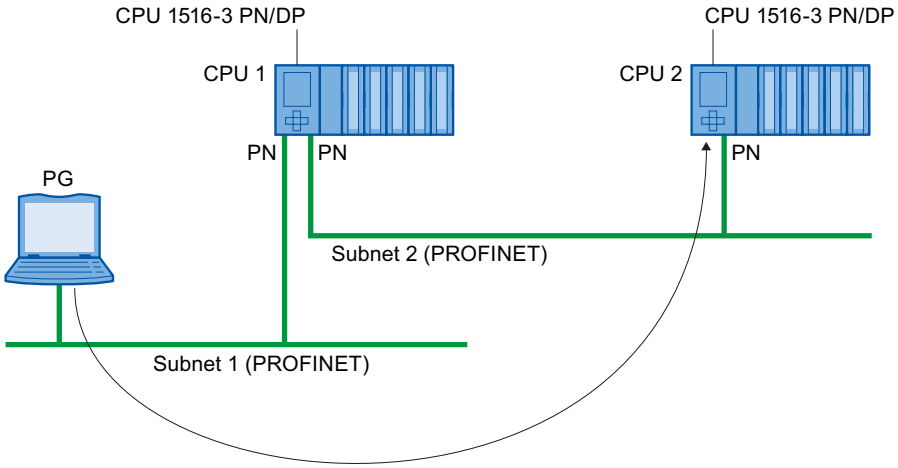


Figure 9-1 S7 routing: PROFINET - PROFINET

S7 routing gateways: PROFINET - PROFIBUS

The following figure shows the access from a PG via PROFINET to PROFIBUS.
CPU 1 is the router between subnet 1 and subnet 2; CPU 2 is the router between subnet 2 and subnet 3.

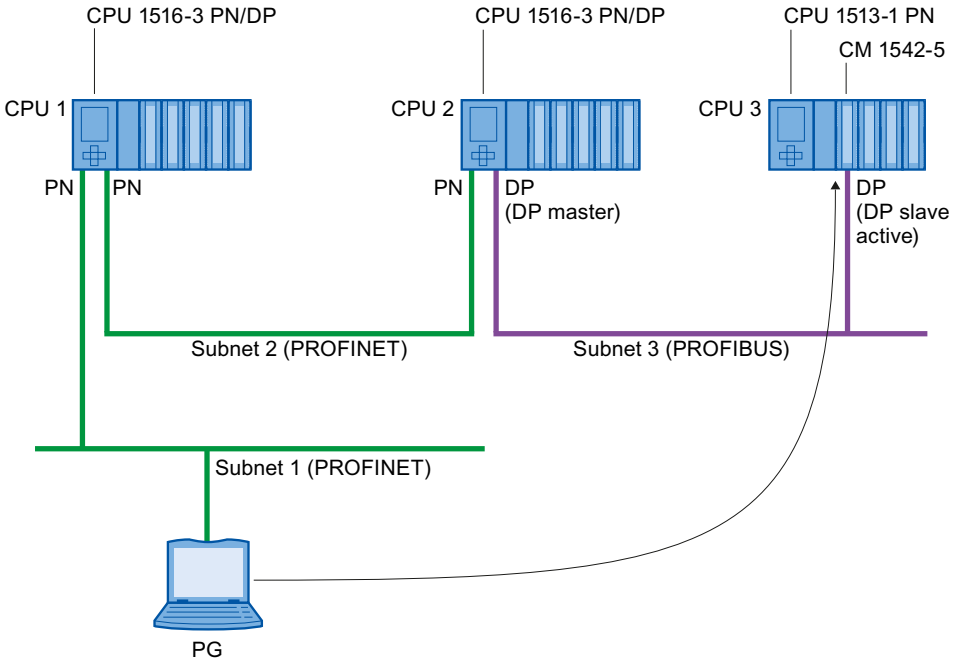


Figure 9-2 S7 routing: PROFINET - PROFIBUS

Requirements for S7 routing

- The CPUs, CMs or CPs are "capable of routing".
- All devices that can be reached in a network have been configured in a project in STEP 7 and downloaded.
- All devices using the gateway must receive the routing information about the paths to other subnets. The devices obtain the routing information by downloading the hardware configuration to the CPUs.

  In a topology with several subnets, the following order must be kept to when downloading: First download the hardware configuration to the CPU(s) directly connected to the same subnet as the PG/PC, then download the CPUs of the other subnets starting with the nearest subnet through to the subnet furthest away.
- The PG/PC you want to use to establish a connection via a gateway must be assigned to the subnet it is physically connected to.
- For PROFIBUS subnets: Either the CPU must be configured as DP master or, if it is configured as a DP slave, the "Test, commissioning, routing" check box must be selected in the properties of the DP interface of the DP slave.

Using S7 routing

For the CPU, select the PG/PC interface and the subnet in the "Go online" dialog of STEP 7. S7 routing is performed automatically.

Number of connections for S7 routing

The number of connections available for S7 routing on the CPUs, CMs or CPs can be found in the technical specifications in the manuals of the relevant CPU/CM/CP.

S7 routing: Example of an application

The figure below shows the example of an application for remote maintenance of a station using a PG. The connection to other subnets is here established via modem connection.

You configure a remote connection via TeleService in STEP 7 using "Online access" or "Go online".

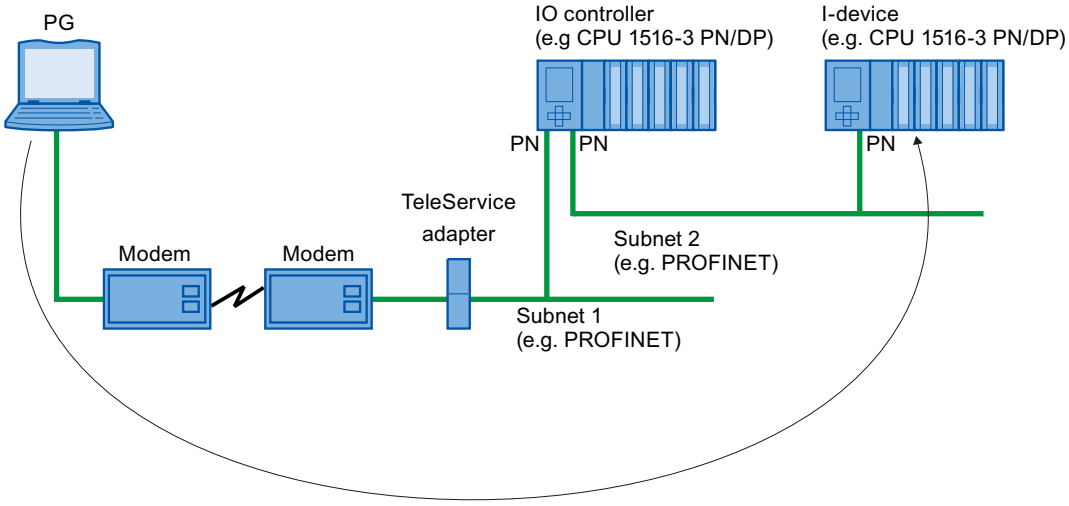


Figure 9-3 Remote maintenance of a plant using TeleService

Further information

- The occupation of connection resources with S7 routing is described in the section Occupation of connection resources (Page 63).
- You will find detailed information on setting up TeleService in the STEP 7 online help.
- You will find further information on S7 routing and TeleService adapters on the Internet.

9.2 Data record routing

Definition of data record routing

Data can be sent from an engineering station connected to PROFINET via PROFIBUS to field devices. The field devices themselves do not have to support data record routing, since they do not forward the information received.

The data sent using data record routing include the parameter assignments for the participating field devices (slaves) and device-specific information (e.g. setpoint values, limit values). The structure of the target address for data record routing depends on the data contents, i.e. the DP slave to which the data is sent.

With the PG/PC, data record routing can also be used to read a parameter record that exists on the field device, edit it and return it to the field device if the PG/PC is assigned to a different subnet than that of the target slave.

Use case for data record routing

Data record routing is used, for example, when field devices of different manufacturers are being used in a network. The field devices are addressed using standardized data records (PROFIBUS standard) for parameter assignment and diagnostics. An engineering station with SIMATIC PDM can reach field devices via several subnets using a data record gateway.

Support of data record routing

Data record routing is supported by SIMATIC PDM that needs to be installed on the engineering station.

There are other use cases in which STEP 7 automatically executes data record routing.
Example: An engineering system is connected to the PROFINET subnet and requests special PROFIBUS data records from a PROFIBUS DP slave. The PROFINET/PROFIBUS gateways are set automatically in the "Go online" dialog of STEP 7.

Example of data record routing

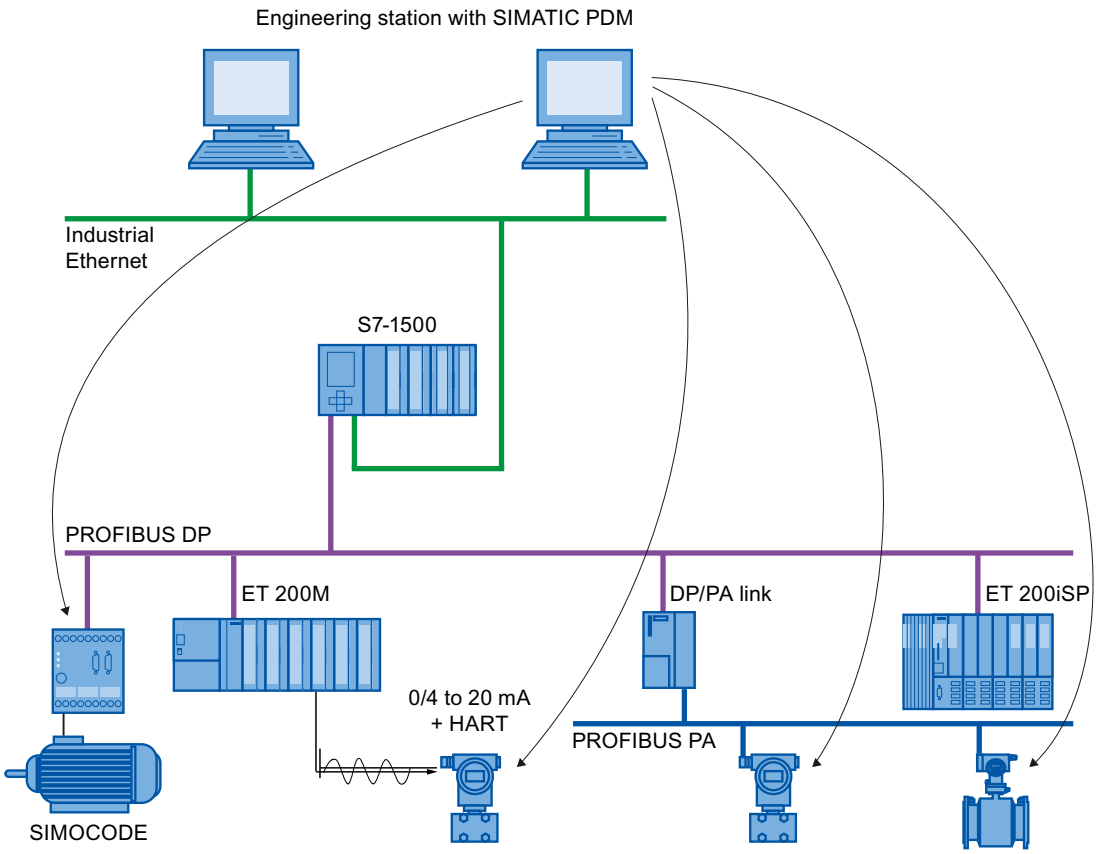


Figure 9-4 Example of data record routing

Further information

- Whether or not the CPU, CP or CM you are using supports data record routing can be found in the relevant manuals.
- The occupation of connection resources with data record routing is described in the section Occupation of connection resources (Page 63).
- You will find information on SIMATIC PDM and data record routing in the manual Process Control System PCS 7 SIMATIC PDM 8.0 (http://support.automation.siemens.com/WW/view/en/57355963).
- You will find further information on configuration with STEP 7 in the STEP 7 online help.

Connection resources 10

10.1 Occupation of connection resources

Occupation of connection resources with automatic connection

As soon as you have connected the PG or HMI device to a CPU physically and have gone online in STEP 7, connection resources are occupied.

Occupation of connection resources with programmed connection setup

With programmed connections, a connection resource is used when the instruction for establishing the connection (TSEND_C or T_CON) is called.

With suitable parameter assignment of the instructions TSEND_C/TRCV_C or by calling the TDISCON instruction, the connection can be terminated following data transfer. If the connection is terminated, the connection resources on the CPU/CP/CM are available again. If the connection remains, the execution time of the instructions during the next data transfer is shorter because the connection does not need to be established again.

Occupation of connection resources with configured connection setup

With configured connections, the connection resource is occupied as soon as the hardware configuration is downloaded to the CPU.

Following transfer of data, the connection is not terminated. The connection resource is permanently occupied. To release the connection resource again, you need to delete the configured connection in STEP 7 and download the modified configuration to the CPU.

Monitoring the maximum possible number of connection resources

With **automatic** connections, the CPU monitors the status of the connection resources on the CPU. Once the reserved connection resources have been used up, further resources can be used (as long as connection resources are available for the automation system).

If the establishment and termination of the connections is **programmed** in the user program, you yourself will need to make sure that the limits are kept to on the automation system.

If you have **configured** connections in STEP 7, STEP 7 monitors the connection resources to ensure that the maximum possible number on an automation system is not exceeded. STEP 7 signals a violation of this with a suitable warning.

Configured connections: Display of the connection resources in STEP 7 (offline view)

You can display the reserved and available connection resources of an S7-1500 automation system in the hardware configuration. You will find the connection resources in the Inspector window in the properties of the CPU.

516-3 PN/DP]

IO tags | Texts

Connection resources

	Station resources			Module resour...	Module reso...	Module reso...
	Reserved		Dynamic	PLC_2 [CPU 15..	CP 1543-1_1..	CM 1542-5_1..
Maximum number of resources:		10	246	128	118	48
	Maximum	Configured	Configured	Configured	Configured	Configured
PG communication:	4	-	-	-	-	-
HMI communication:	4	4	6	6	4	0
S7 communication:	0	-	23	2	0	21
Open user communication:	0	-	118	39	52	27
Web communication:	2	-	-	-	-	-
Other communication:	-	-	-	-	-	-
Total resources used:		4	147	47	56	48
Available resources:		6	99	81	62	0

Figure 10-1 Reserved and available connection resources (offline view)

Module-specific connection resources (offline view)

The columns of the module-specific connection resources contain the following for the CPU, CPs and CMs of an S7-1500 automation system:

- how many connection resources are available as maximum for CPU/CP/CM
- how many of these were configured for which communications connections
- how many connection resources were configured in total and therefore used up
- how many connection resources are still available

The display is per module and not per interface.

In the example, the CPU provides a maximum of 128 connection resources.
For the CPU, 6 HMI, 2 S7 and 39 open communication connections were configured occupying a total of 47 resources on the CPU. 81 resources of the CPU remain available.
For the CP 1543-1, 56 of the 118 available resources are occupied, 62 resources remain available. All 48 available resources are used for the CM 1542-5.

Station-specific connection resources (offline view)

The maximum number of available connection resources on the automation system (in the station) depends on the CPU being used. If the CPU-dependent limit is reached, it does not matter whether the CPU, CPs and CMs have further module-specific connection resources. For this station, the connection resources are used up.

In the example there are 246 + 10 reserved connection resources available for the automation system.

The 10 connection resources are reserved:

- 4 for PG communication required by STEP 7 for example for test and diagnostics functions or downloading to the CPU
- 4 for HMI communication, that are occupied by the first HMI connections configured in STEP 7
- 2 for communication with the Web server that are occupied after connecting a Web browser if the Web server of the CPU is activated

A maximum of 246 connection resources are dynamic; in other words, available for various communications services on the automation system. In this example, 147 of these connection resources are already configured for various communications services and modules. This leaves 99 connection resources available for the automation system.

The warning triangle in the column of the dynamic station resources is therefore displayed because the sum of the maximum available connection resources of CPU, CP and CM (= 294 connection resources) exceeds the station limit of 256.

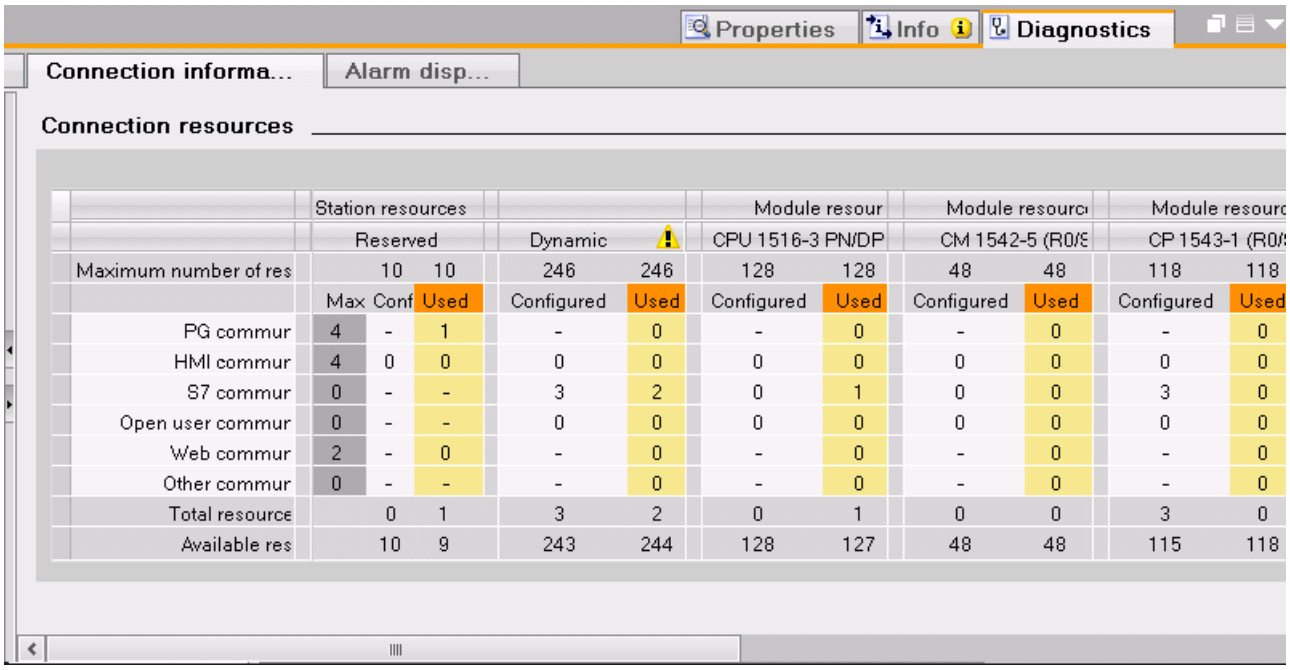
Note

Available connection resources exceeded

STEP 7 signals a warning when the station-specific connection resources are exceeded. In this case, either use a CPU with a higher maximum number of available station-specific connection resources or reduce the number of communications connections.

Display of the connection resources in STEP 7 (online view)

If you have selected a CPU in the network view of the Devices & networks editor of STEP 7 that is connected online, you can display the current status of the occupied and unoccupied connection resources for this automation system in the "Connection information" tab in the "Diagnostics" area.



	Station resources					Module resour		Module resourc		Module resourc	
	Reserved			Dynamic		CPU 1516-3 PN/DP		CM 1542-5 (R0/S		CP 1543-1 (R0/	
Maximum number of res		10	10	246	246	128	128	48	48	118	118
	Max	Conf	Used	Configured	Used	Configured	Used	Configured	Used	Configured	Used
PG commur	4	-	1	-	0	-	0	-	0	-	0
HMI commur	4	0	0	0	0	0	0	0	0	0	0
S7 commur	0	-	-	3	2	0	1	0	0	3	0
Open user commur	0	-	-	0	0	0	0	0	0	0	0
Web commur	2	-	0	-	0	-	0	-	0	-	0
Other commur	0	-	-	-	0	-	0	-	0	-	0
Total resource		0	1	3	2	0	1	0	0	3	0
Available res		10	9	243	244	128	127	48	48	115	118

Figure 10-2 Connection resources - online

The online view of the "Connection resources" table also contains the reserved and configured connection resources of the offline view columns with the connection resources currently occupied on the CPU. In the online view, **all** occupied connection resources on the automation system are displayed regardless of whether they were set up automatically, programmed or configured. In the "Other communication" row, occupied connection resources for communication with third-party devices and communication via data record routing are displayed. The table is updated automatically.

Connection resources for HMI communication

You will find information about the availability and occupation of connection resources for HMI connections in the offline view in the context of the HMI device (in the Inspector window in the properties in the "Connection resources" area).

The following is displayed under "Offline used":

- the number of configured HMI connections

  If the maximum number of available connection resources for an HMI device is exceeded, a corresponding message is output by STEP 7.

- the maximum number of connection resources occupied by the configured HMI connections

  With HMI communication, the occupation of connection resources on the CPU depends on the HMI device you are using and the applications in which the HMI device is used; for example a Basic Panel requires up to 2 connection resources for an HMI connection whereas a Comfort Panel requires up to 3 connection resources on the CPU.

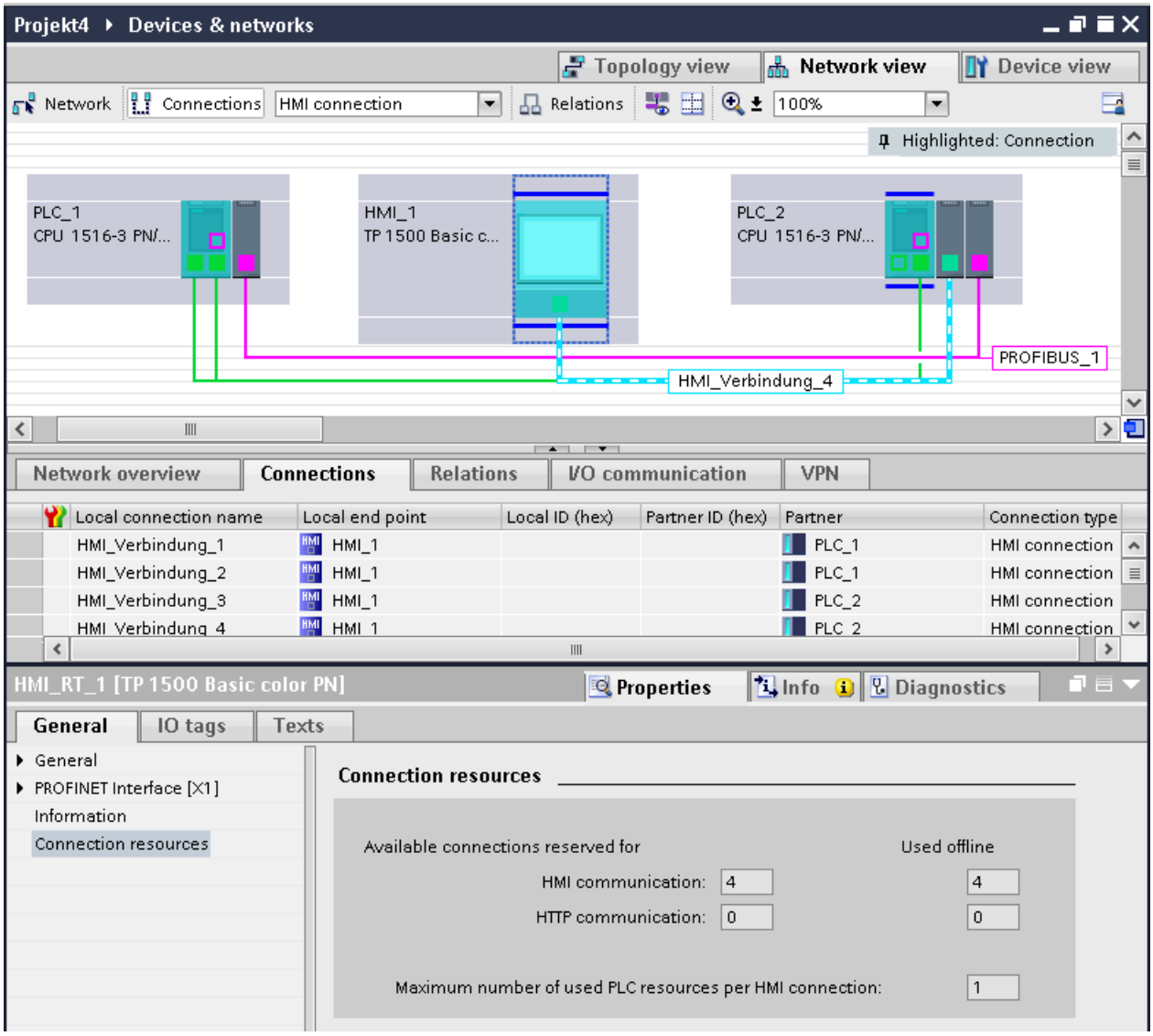


Figure 10-3 Connection resources - HMI communication

S7 connections beyond network boundaries (S7 routing)

To transfer data beyond network boundaries ("S7 routing"), an S7 connection is established between two CPUs over several subnets. The subnets are connected via gateways known as routers. The router is the crossing point of an S7 connection and can establish S7 connections. CPUs, CMs and CPs in S7-1500 can be routers.

In the endpoints of the communication (CPUs), the connection resources for S7 routing are taken into account and displayed in the "Connection resources" table for S7 communication in STEP 7. For S7 routing, 2 connection resources are also occupied on each router.

Data record routing

Data record routing also allows the transfer of data beyond network boundaries by an engineering station connected to PROFINET via PROFIBUS to various field devices.

2 connection resources are occupied for data record routing on each router. In the end point of the communication (CPU), connection resources for data record routing are displayed in the online view of the "Connection resources" table in the "Other communication" row.

Note

Connection resources for S7 routing and data record routing

With S7 routing or data record routing, corresponding connection resources are occupied on the routers. Configuration and monitoring of these connection resources is not possible in STEP 7. The routers need to monitor that the limits are kept to themselves.

Further information

- S7 routing is described in the section S7 routing (Page 57).
- Data record routing is described in the section Data record routing (Page 61).
- You will find the number of connection resources that an HMI device requires on the CPU in the documentation of the HMI device.

Connection diagnostics 11

11.1 Connection diagnostics

Connections table in the online view

After selecting a CPU in the Devices & networks editor of STEP 7, you will see the status of your connections displayed in the online view of the connections table.

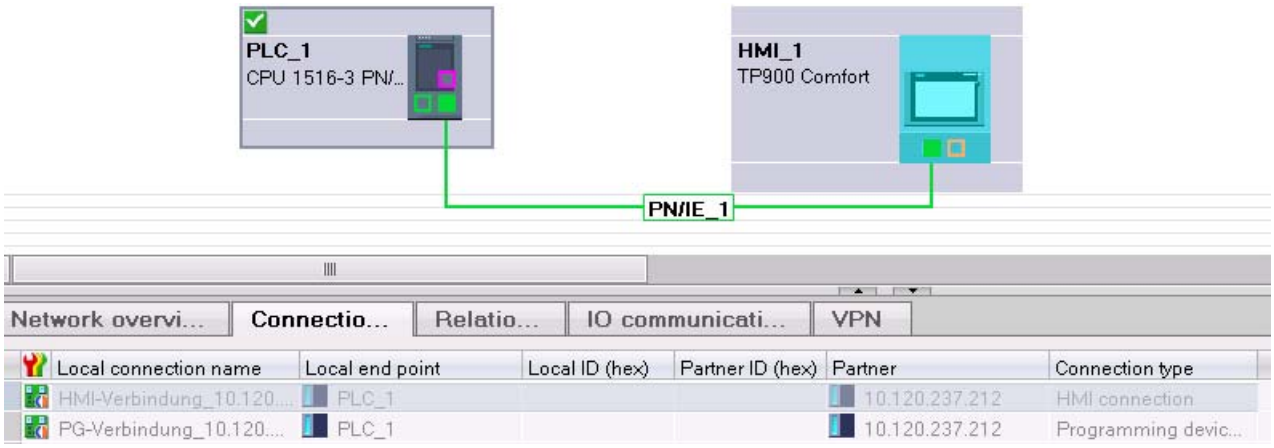


Figure 11-1 Online view of the connections table

After selecting the connection in the connections table, you obtain detailed diagnostics information in the "Connection information" tab.

"Connection information" tab: Connection details

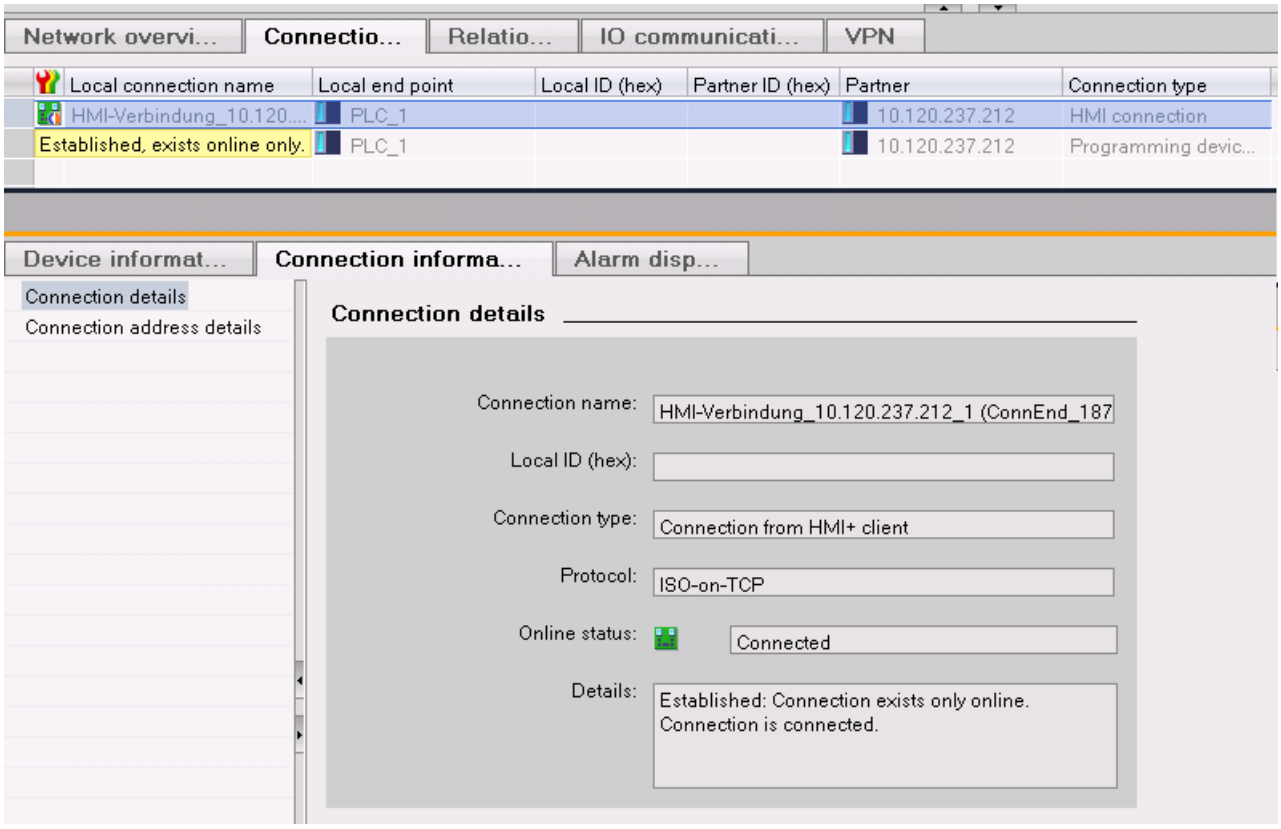


Figure 11-2 Diagnostics of connections - connection details

"Connection information" tab: Address details

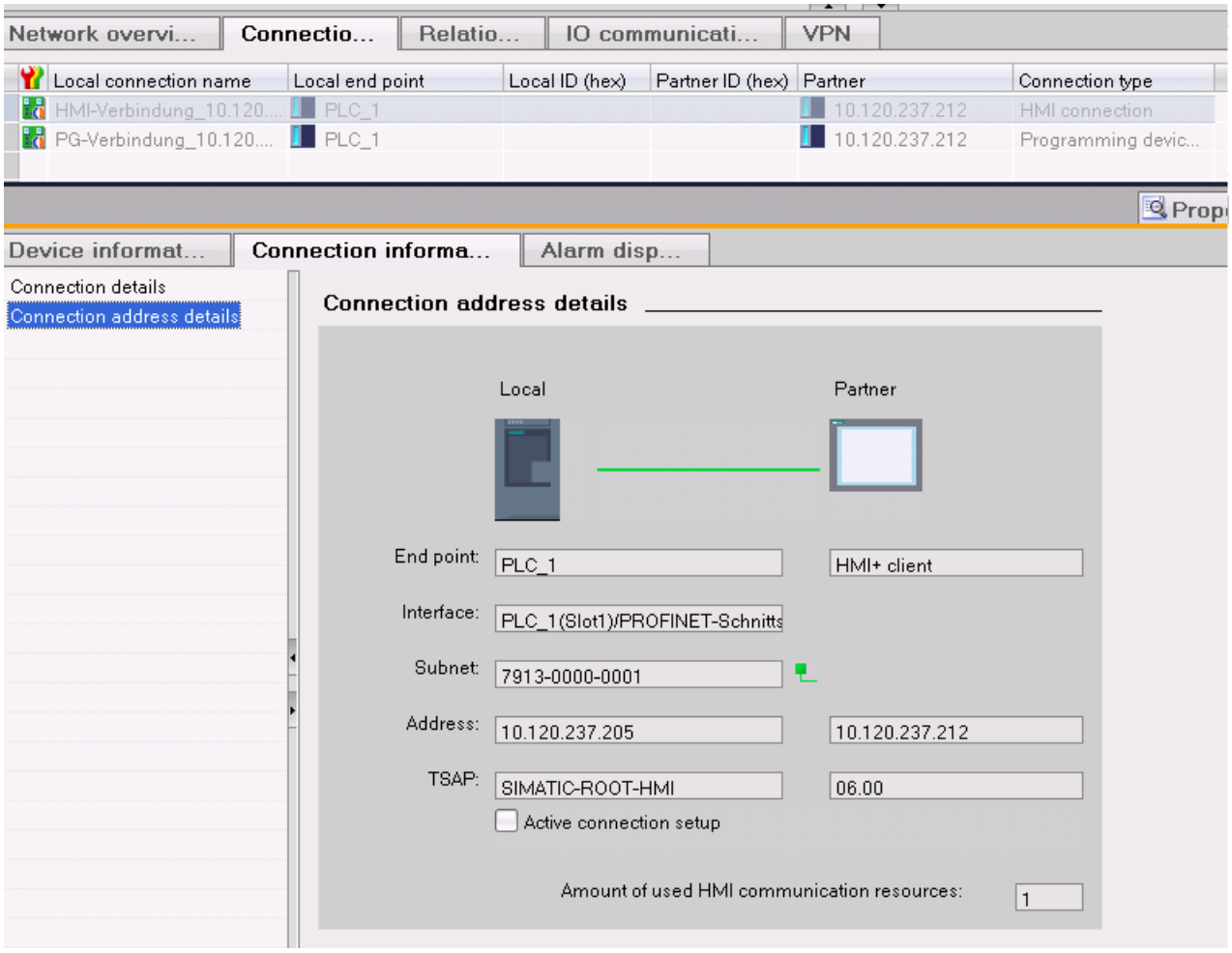


Figure 11-3 Diagnostics of connections - address details

Diagnostics via Web server

Via the integrated Web server of the S7-1500 CPUs, you can evaluate diagnostics information from the CPU using a Web browser.

On the "Communication" Web page, you will find the following information about communication via PROFINET in various tabs:

- Information on the PROFINET interfaces of the CPU
  (for example addresses, subnets, physical properties)
- Information on the quality of the data transfer
  (for example number of data packets sent/received error-free)
- Information about the occupation/availability of connection resources

Further information

You will find the description of the Web server functionality in the function manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).

Industrial Ethernet Security (CP 1543-1) 12

All-round protection - the task of Industrial Ethernet Security

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. Data transfer can also be protected by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

Security measures

- Firewall
  - IP firewall with stateful packet inspection (layer 3 and 4)
  - Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)
  - Bandwidth limitation
  - Global firewall rules

All network nodes located in the internal network segment of a CP 1543-1 are protected by its firewall.

- Logging

  To allow monitoring, events can be stored in log files that can be read out using the configuration tool or can be sent automatically to a Syslog server.
- HTTPS

  For encrypted transfer of Web pages, for example during process monitoring.
- FTPS (explicit mode)

  For encrypted transfer of files.
- Secure NTP

  For secure time-of-day synchronization and transmission.
- SNMPv3

  For secure transmission of network analysis information safe from eavesdropping.
- Protection for devices and network segments

  The firewall protective function can be applied to the operation of single devices, several devices, or entire network segments.

12.1 Firewall

Tasks of the firewall

The purpose of the firewall functionality is to protect networks and stations from outside influences and disturbances. This means that only certain previously specified communications relations are permitted.

To filter the data traffic, IP addresses, IP subnets, port numbers or MAC addresses among other things can be used.

The firewall functionality can be configured for the following protocol levels:

- IP firewall with stateful packet inspection (layer 3 and 4)
- Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)

Firewall rules

Firewall rules describe which packets are permitted or forbidden in which direction.

12.2 Logging

Functionality

For test and monitoring purposes, the security module has diagnostics and logging functions.

- Diagnostics functions

  These include various system and status functions that you can use in online mode.

- Logging functions

  This involves the recording of system and security events. Depending on the event type, the recording is made in volatile or non-volatile local buffer areas of the CP 1543-1. As an alternative, it is also possible to record on a network server.

  The parameter assignment and evaluation of these functions is only possible with a network connection.

Recording events with logging functions

You specify which events should be recorded with the log settings. Here you can configure the following recording variants:

- Local logging

  With this variant, you record the events in local buffers of the CP 1543-1. In the online dialog of the Security Configuration Tool, you can then access these recordings, visualize them and archive them on the service station.

- Network Syslog

  With the network Syslog, you use a Syslog server in the network. This records the events according to the configuration in the log settings.

12.3 NTP client

Functionality

To check whether the time for a certificate and for the time stamp and log entries is valid, the date and time are maintained on the CP 1543-1.

The CP 1543-1 as NTP client receives time-of-day frames from a Network Time Protocol server (NTP server). The automatic setting and periodic synchronization of the time is either via a secure or non-secure NTP server. A maximum of 4 NTP servers can be assigned to the CP 1543-1. A mixed configuration of non-secure and secure NTP servers is not possible.

12.4 SNMP

Functionality

The CP 1543-1 supports the transfer of management information using the Simple Network Management Protocol (SNMP). To achieve this, an "SNMP agent" is installed on the CP that receives and responds to the SNMP queries. Information about the properties of devices capable of SNMP is contained in so-called MIB files (Management Information Base) for which the user needs to have the appropriate rights.

With SNMPv1, the "community string" is also sent. The community string is like a password that is sent along with the SNMP query. If the community string is correct, the security module responds with the requested information. If the string is incorrect, the security module discards the query and does not respond.

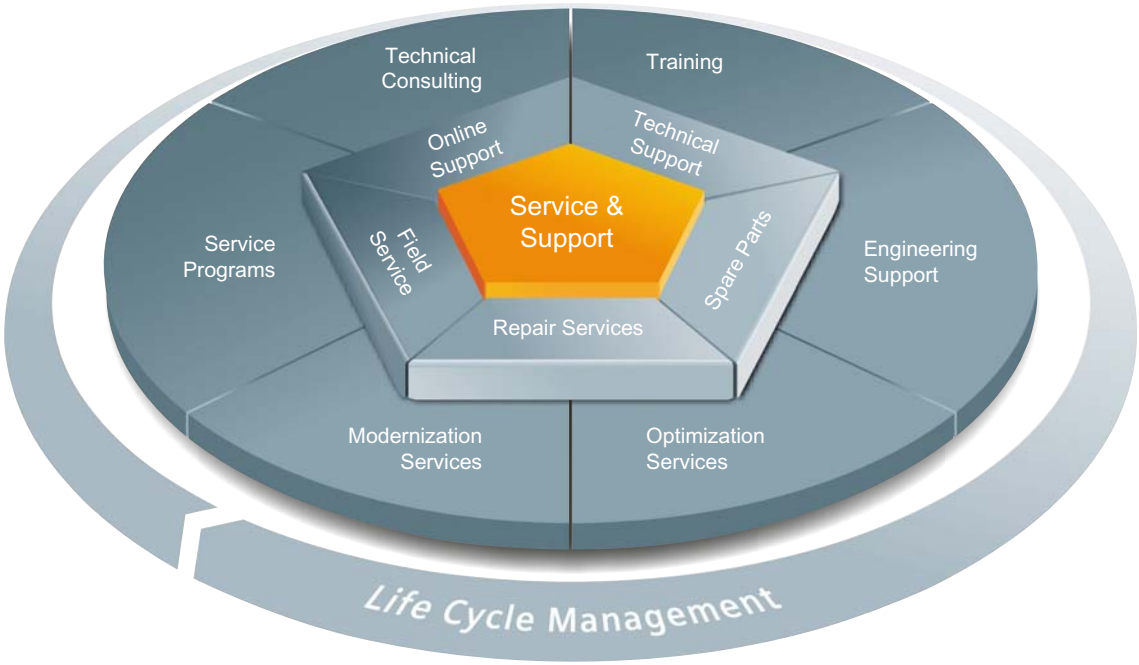
With SNMPv3, data can be transferred encrypted. To do this, select either an authentication method or an authentication and encryption method.

Possible selection:

- Authentication algorithm: none, MD5, SHA-1
- Encryption algorithm: none, AES-128, DES

Service & Support

A



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- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

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Glossary

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Bus

Transmission medium that connects several devices together. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

Client

Device in a network that requests a service from another device in the network (server).

CM

-> Communications module

Communications module

Module for communications tasks used in an automation system as an interface expansion of the CPU (for example PROFIBUS) and providing additional communications options (PtP).

Communications processor

Module for expanded communications tasks covering special applications, for example in the area of security.

Consistent data

Data that belongs together in terms of content and must not be separated when transferred.

CP

-> Communications processor

CPU

Central **P**rocessing **U**nit - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

Device

Generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices) and
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

DP master

Within PROFIBUS DP, a master in the distributed I/O that behaves according to the EN 50170 standard, Part 3.

See also Master

DP slave

Slave in the distributed I/O that is operated on PROFIBUS with the PROFIBUS DP protocol and behaves according to the EN 50170 standard, Part 3.

See also Slave

Duplex

Data transmission system; a distinction is made between full and half duplex.

Half duplex: One channel is available for alternate data exchange (sending or receiving alternately but not at the same time).

Full duplex: Two channels are available for simultaneous data exchange in both directions (simultaneous sending and reception in both directions).

Ethernet

International standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

Ethernet network adapter

Electronic circuitry for connecting a computer to an Ethernet network.
It allows the exchange of data / communication within the network.

FDL

Fieldbus **D**ata **L**ink; communications protocol for data transfer via PROFIBUS DP.

FETCH/WRITE

Server services using TCP/IP, ISO-on-TCP and ISO for access to system memory areas of S7 CPUs. Access (client function) is possible from a SIMATIC S5 or a third-party device/PC. FETCH: Read data directly; WRITE: Write data directly

Field device

-> Device

Freeport

Freely programmable ASCII protocol; here for data transfer via a point-to-point link.

FTP

File **T**ransfer **P**rotocol; a network protocol for transferring files via IP networks. It is used to download files from the server to the client or to upload files from the client to the server. FTP directories can also be created and read out and directories and files can be renamed or deleted.

HMI

Human **M**achine **I**nterface, device for visualization and control of automation processes.

IM

-> Interface module

Industrial Ethernet

Guideline for setting up an Ethernet network in an industrial environment. The essential difference compared with standard Ethernet is the mechanical ruggedness and immunity to noise of the individual components.

Instruction

The smallest self-contained unit of a user program characterized by its structure, function or purpose as a separate part of the user program. An instruction represents an operation procedure for the processor.

Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system via a fieldbus to the CPU (IO controller/DP master) and prepares the data for the I/O modules.

IO controller, PROFINET IO controller

Central device in a PROFINET system, usually a classic programmable logic controller or PC. The IO controller sets up connections to the IO devices, exchanges data with them, thus controls and monitors the system.

IO device, PROFINET IO device

Device in the distributed I/O of a PROFINET system that is monitored and controlled by an IO controller (for example distributed inputs/outputs, valve islands, frequency converters, switches).

IP address

Unique address in computer networks based on the Internet protocol (IP). It is assigned to devices connected to the network and makes these devices uniquely addressable and reachable. It is made up of the following: Address of the network and address of the device (generally called the host or network node). The IP address is made up, for example, of 4 decimal numbers with a range of values from 0 to 255. The decimal numbers are separated by dots.

ISO

Communications protocol for message or packet-oriented transfer of data in an Ethernet network. This protocol is hardware-oriented, very fast and allows dynamic data lengths. It is suitable for medium to large amounts of data.

ISO-on-TCP

Communications protocol capable of S7 routing for packet-oriented transfer of data in an Ethernet network; provides network addressing. It is suitable for medium and large amounts of data and allows dynamic data lengths.

Linear bus topology

Network topology characterized by the arrangement of the devices in a line (bus).

MAC address

Worldwide unique device identification for all Ethernet devices. It is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

Master

Higher-level, active participant in the communication/on a PROFIBUS subnet. It has rights to access the bus (token), sends data and requests it.

Modbus

Open communications protocol for serial interfaces based on a master/slave architecture.

Network

A network consists of one or more interconnected subnets with any number of devices. Several networks can exist alongside each other.

NTP

The **N**etwork **T**ime **P**rotocol (NTP) is a standard for synchronizing clocks in automation systems via Industrial Ethernet. NTP uses the UDP wireless network protocol.

Operating system

Software that allows the use and operation of a computer. The operating system manages resources such as memory, input and output devices and controls the execution of programs.

PNO

-> PROFIBUS Users Organization

Point-to-point link

Bidirectional data exchange via communications modules with a serial interface between two communications partners (and two only).

PORT

Physical connector to connect devices to PROFINET. PROFINET interfaces have one or more ports.

Process image

Address area of a programmable logic controller (PLC), in which the signal states of the inputs and the logical states of the outputs from the connected modules are stored digitally.

PROFIBUS

Process **Fi**eld **Bus** - European Fieldbus standard.

PROFIBUS address

Unique identifier of a device connected to PROFIBUS. The PROFIBUS address is sent in the frame to address a device.

PROFIBUS device

Device with at least one PROFIBUS interface either electrical (for example RS-485) or optical (for example Polymer Optical Fiber).

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O = fast, real-time capable, cyclic data exchange. From the perspective of the user program, the distributed IO is addressed in exactly the same way as the centralized IO.

PROFIBUS users organization

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINETstandard.

PROFINET

Open component-based industrial communications system based on Ethernet for distributed automation systems. Communications technology promoted by the PROFIBUS users organization.

PROFINET device

Device that always has a PROFINET interface (electrical, optical, wireless).

PROFINET interface

Interface of a module capable of communication (for example CPU, CP) with one or more ports. A MAC address is assigned to the interface in the factory. Along with the IP address and the device name (from the individual configuration), this interface address ensures that the PROFINET device is identified uniquely in the network. The interface can be electrical, optical or wireless.

PROFINET IO

IO stands for input/output (fast, cyclic data exchange with real-time capability). From the perspective of the user program, the distributed IO is addressed in exactly the same way as the centralized IO.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS and PROFINET International defines a cross-vendor communication, automation, and engineering model.

With PROFINET IO, a switching technology is used that allows all devices to access the network at any time. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. Simultaneous sending and receiving is enabled via the full-duplex operation of Switched Ethernet.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

PtP

Point-**t**o-**P**oint, interface and/or transmission protocol for bidirectional data exchange between two (and only two) communications partners.

Ring topology

All devices of a network are connected together in a ring. With the aid of media redundancy methods, the fault tolerance and availability in this network is increased.

Router

Network node with a unique identifier (name and address) that connects subnets together and allows transportation of data to uniquely identified communications nodes in the network.

RS-232, RS-422 and RS-485

Standardized data transmission method for serial data transmission.

RTU

Modbus RTU (RTU: **R**emote **T**erminal **U**nit, transfers the data in binary form; allows a good data throughput. The data must be converted to a readable format before it can be evaluated.

S7 routing

Communication between S7 automation systems, S7 applications or PC stations in different S7 subnets via one or more network nodes functioning as S7 routers.

SDA service

Send Data with Acknowledge. SDA is an elementary service with which an initiator (for example DP master) can send a message to other devices and then receives acknowledgment of receipt immediately afterwards.

SDN service

Send Data with No Acknowledge. This service is used primarily to send data to multiple stations and therefore remains unacknowledged. Suitable for synchronization tasks and status messages.

Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Server

A device or more generally an object that can provide certain services;
the service is performed at the request of a client.

Slave

Distributed device in a fieldbus system that can only exchange data with a master after the master has requested this.

SNMP

Simple **N**etwork **M**anagement **P**rotocol, uses the wireless UDP transport protocol. This works in much the same way as the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the MIB (**M**anagement **I**nformation **B**ase). This information allows a network management system to run detailed network diagnostics.

Subnet

Part of a network whose parameters must be matched up on the devices
(for example in PROFINET). It includes the bus components and all connected stations. Subnets can be linked together, for example using gateways or routers to form one network.

Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

TCP/IP

Transmission **C**ontrol **P**rotocol / **I**nternet **P**rotocol, connection-oriented network protocol, generally recognized standard for data exchange in heterogeneous networks.

Time-of-day synchronization

Capability of transferring a standard system time from a single source to all devices in the system so that their clocks can be set according to the standard time.

Tree topology

Network topology characterized by a branched structure: Two or more bus nodes are connected to each bus node.

Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ohms (22 AWG). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ-45 connector system.

UDP

User Datagram Protocol; communications protocol for fast and uncomplicated data transfer, without acknowledgement. There are no error checking mechanisms as found in TCP/IP.

User program

In SIMATIC, a distinction is made between the operating system of the CPU and user programs. The user program contains all instructions, declarations and data by which a system or process can be controlled. It is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

USS

Universal Serial Interface protocol (Universelles Serielles Schnittstellen-Protokoll); defines an access method according to the master-slave principle for communication via a serial bus.

Web server

Software/communications service for data exchange via the Internet. The Web server transfers the documents using standardized transmission protocols (HTTP, HTTPS) to a Web browser. Documents can be static or put together dynamically from different sources by the Web server on request from the Web browser.

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SIMATIC

PROFIBUS
PROFIBUS with STEP 7 V12

Function Manual

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01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the manual

This function manual provides an overview of the PROFIBUS communication in combination with SIMATIC STEP 7 V12.

STEP 7 V12 is integrated into the powerful graphic Totally Integrated Automation Portal (TIA Portal), the new integration platform for all automation software tools.

This function manual supports you in planning a PROFIBUS system.
The manual is structured into the following subject areas:

- PROFIBUS basics
- PROFIBUS diagnostics
- PROFIBUS functions

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Scope

This function manual is the basic documentation for all SIMATIC products from the PROFIBUS environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

Conventions

STEP 7: In this documentation we use "STEP 7" to refer to the configuration and programming software as synonym for "STEP 7 V12 (TIA Portal)" and later versions.

This documentation contains figures of the devices described. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

Additional support

Information on the offers of our Technical Support are available in the appendix Service & Support (Page 79).

The technical documentation for the individual SIMATIC products and systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

The online catalog and the online ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide 1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP and ET 200MP systems consists of the respective system manual, function manuals and device manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the additional documentation for PROFIBUS

The table below lists additional documents which supplement this description of PROFIBUS and which are available on the Internet.

Table 1- 1 Documentation for PROFIBUS

Subject	Documentation	Most important contents
PROFIBUS overview information	PROFIBUS (http://www.automation.siemens.com/w2/efiles/pcs7/pdf/76/prdbrief/kb_profibus_en.pdf) brochure	• Overview • Application examples • Hardware • Software
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	Configuring and programming with the engineering software
System diagnostics	System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual	• Overview • Diagnostic evaluation • Hardware/software
Description of the systems	S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning • I&M data

Subject	Documentation	Most important contents
Networks	PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591)	• Basics of PROFIBUS networks • Network configuration • Active and passive components • Technical product specifications • Installation instructions
	SIMATIC NET Manual: Twisted-pair and fiber-optic networks (http://support.automation.siemens.com/WW/view/en/8763736)	• Ethernet networks • Network configuration • Network components
Diagnostic repeater	Manual Diagnostic repeater for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/7915183)	• Configuration options • Installation • Wiring • Commissioning • Diagnostics
Modules of the S7-1500 automation system	Manuals for the S7-1500 product family (http://support.automation.siemens.com/WW/view/en/56926743)	• Interrupt, error and system messages • Technical specifications (including communication services)

Additional information on PROFIBUS is available on the Internet (http://www.profibus.com).

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Description 2

2.1 Introduction to PROFIBUS

What is PROFIBUS?

PROFIBUS is a bus system that networks automation systems and field devices that are compatible with PROFIBUS. As communication medium for the field level, PROFIBUS is an important part of Totally Integrated Automation (TIA).

The different communication networks can be used independent of one another or they can be combined with each other.

PROFIBUS protocols

PROFIBUS DP (distributed I/O) is a communication network for the field level according to IEC 61158-2 / EN 61158-2 with the hybrid access protocols token bus and master-slave. The networking takes place by means of two-wire lines or fiber-optic cables.
Data transmission rates of 9.6 kbps to 12 Mbps are possible.

PROFIBUS PA is the PROFIBUS for process automation (PA). It connects the PROFIBUS DP communication protocol with the MBP (Manchester Bus Powered) transmission technology to IEC 61158-2.

PROFIBUS PA networks can be designed based on shielded, twisted two-wire lines intrinsically safe and are therefore suitable for hazardous areas (Ex zones 0 and 1). The data transmission rate is 31.25 kbps.

2.1.1 Applications of PROFIBUS DP

Introduction

The efficiency of control systems is not determined by automation devices alone, but depends to a large extent on the overall configuration of an automation solution. This includes a powerful communication system in addition to plant visualization and operator control and monitoring.

The STEP 7 engineering tool supports you during the engineering and configuration of an automation solution.

Applications of PROFIBUS DP

The PROFIBUS network offers wireless connection of several controllers, components and subnets as electrical network, optical network or by using links. Sensors and actuators are controlled centrally by means of PROFIBUS DP.

The example shows connection options to PROFIBUS DP:

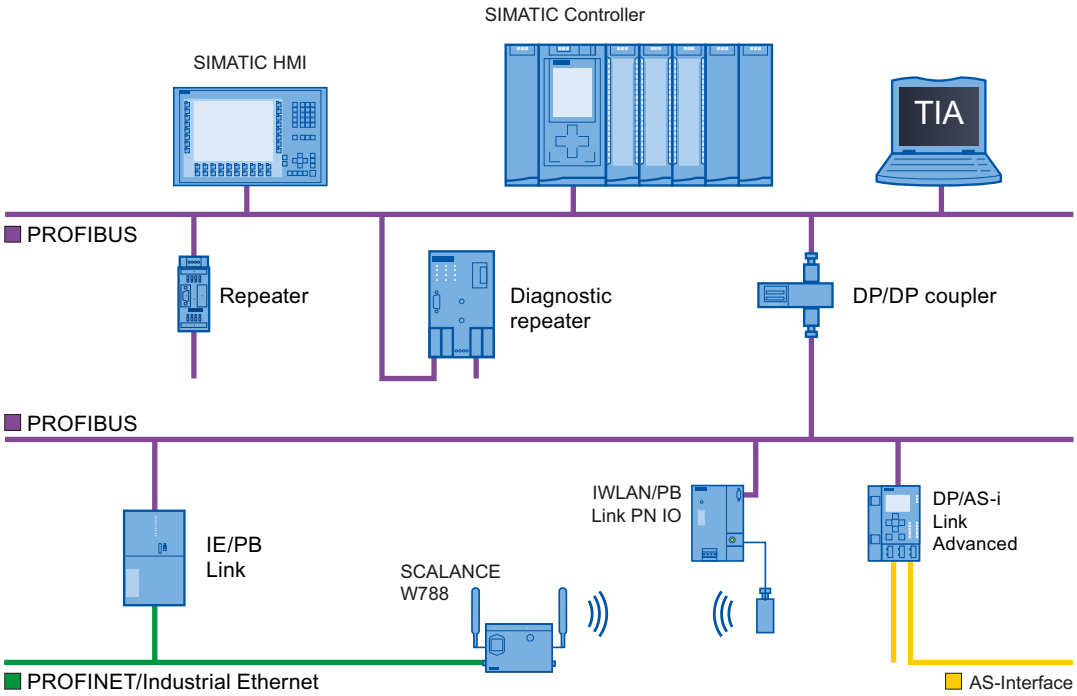


Figure 2-1 Connection options to PROFIBUS DP

Objectives of PROFIBUS DP

Distributed automation systems are increasingly used in production and process automation. This means a complex control task is divided up into smaller, more transparent subtasks with distributed control systems. This creates a high demand for communication between the distributed systems.

Distributed systems offer the following benefits:

- An independent and simultaneous commissioning of individual devices is possible.
- Small, manageable programs
- Parallel processing due to distributed automation systems
- Reduced response times
- Higher-level structures can take on additional diagnostic and logging functions.
- Increased plant availability because the rest of the overall system can continue to work when a subordinate station fails.

2.1.2 PROFIBUS terminology

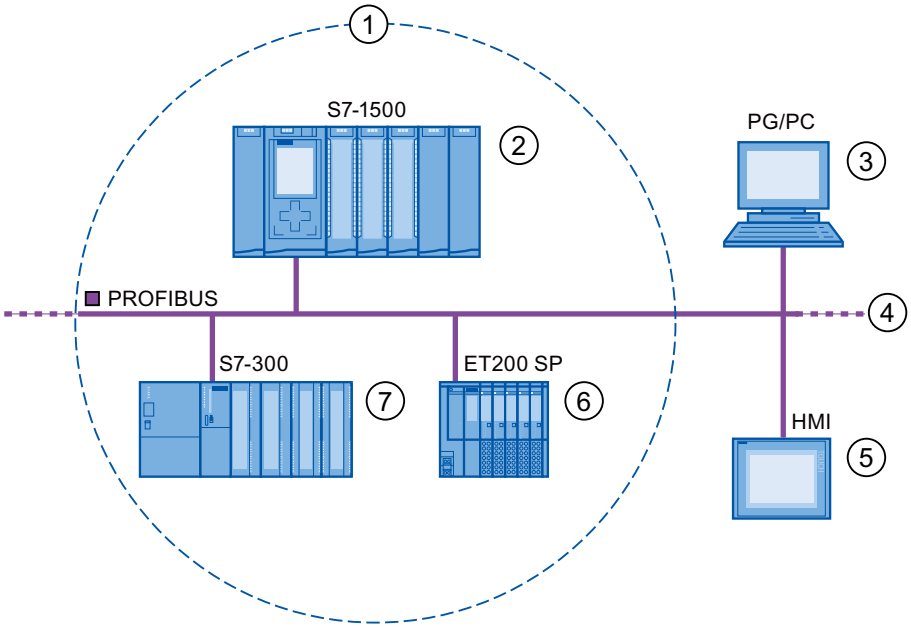
Definition: Devices in the PROFIBUS environment

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (e.g., diagnostic repeater, optical link module)
- Gateways to AS interface or other fieldbus systems

Devices with PROFIBUS DP

The figure below shows the most important components with PROFIBUS DP.
The table below lists the designations of the individual components.



Number	PROFIBUS	Note
①	DP master system	
②	DP master	Device used to address the connected DP slaves. The DP master exchanges input and output signals with field devices. The DP master is often the controller on which the automation program runs.
③	PG/PC	PG/PC/HMI device for commissioning and diagnostics DP master of class 2
④	PROFIBUS	Network infrastructure
⑤	HMI	Device for operating and monitoring functions
⑥	DP slave	Distributed field device assigned to the DP master, e.g., valve terminals, frequency converters.
⑦	I-slave	Intelligent DP slave

Figure 2-2 Devices with PROFIBUS

Overview of I/O communication

I/O communication is the reading or writing of inputs/outputs of the distributed I/O. The figure below gives you an overview of I/O communication using PROFIBUS DP:

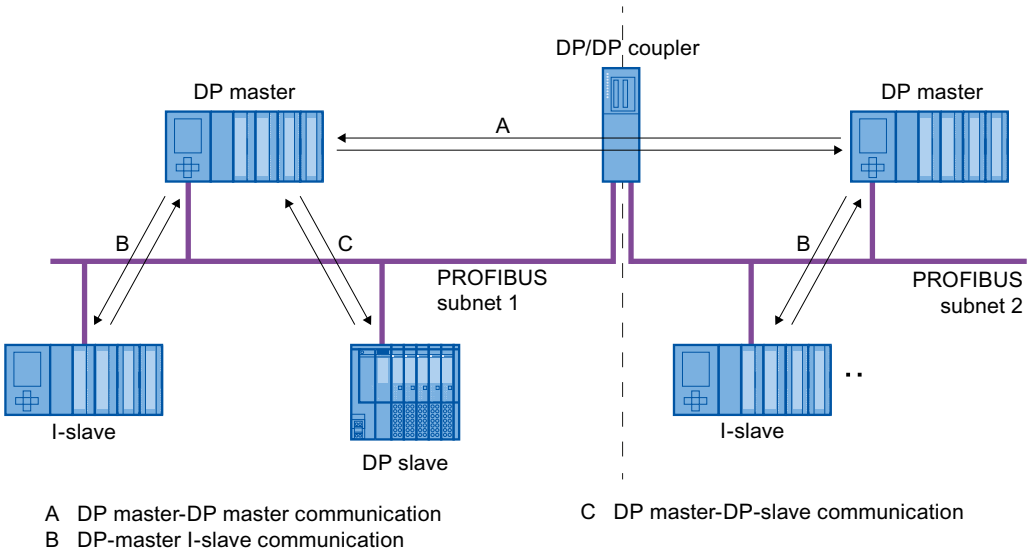


Figure 2-3 I/O communication using PROFIBUS DP

I/O communication is also available with the communication module (CM) or the interface module (IM) with integrated DP interface. These DP interfaces behave like integrated DP interfaces of the CPU.

I/O communication using PROFIBUS DP

Table 2- 1 I/O communication using PROFIBUS DP

Communication between …	Explanation
DP master and DP slave	The data exchange between a DP master and DP slaves with I/O modules takes place as follows: The DP master queries the DP slaves of its master system one after the other and receives input values from the DP slaves and transmits output data to the DP slaves (master-slave principle).
DP master and I-slave	A fixed number of data is transmitted cyclically between the user programs in CPUs of DP masters and I-slaves. The DP master does not access the I/O modules of the I-slave, but instead accesses configured address areas, called transfer areas, that can be inside or outside the process image of the I-slave CPU. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules. Data transmission takes place with load and transfer operations using the process image or by direct access.
DP master and DP master	A fixed number of data is transmitted cyclically between the user programs in CPUs of DP masters. A DP/DP coupler is required as additional hardware. The DP masters mutually access configured address areas, called transfer areas, inside or outside the process images of the CPUs. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules. Data transmission takes place with load and transfer operations using the process image or by direct access.

Additional information

You can find additional information on the hardware configuration in the STEP 7 online help.

2.1.3 PROFIBUS DP interface

Properties

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS 485) interface or optical (Polymer Optical Fiber, POF) interface.

Table 2- 2 Properties of the PROFIBUS DP interface

Standard	PROFIBUS: IEC 61158/61784
Bus configuration / media	PROFIBUS cables (twisted two-wire lines RS 485 or fiber-optic cables)
Transmission rate	9.6 kbps to 12 Mbps

Representation of the PROFIBUS DP interface in STEP 7

In the device view of STEP 7, the PROFIBUS DP interfaces for a DP master and a DP slave are highlighted by a purple rectangle:

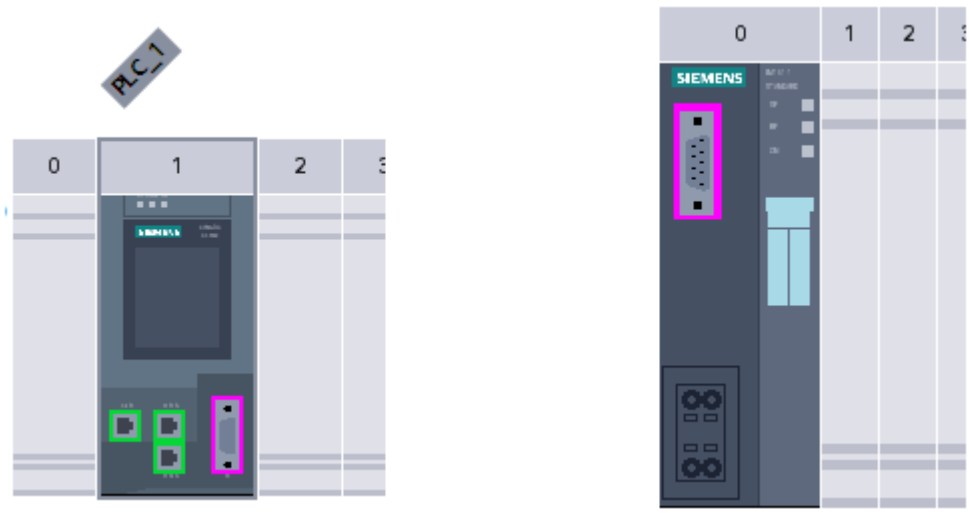


Figure 2-4 PROFIBUS DP interfaces

2.2 Structure of PROFIBUS networks

Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors.
- Overview of the most important active network components: These are network components that actively affect a signal, for example, repeaters, diagnostic repeaters.
- Overview of the most common network structures (topologies)

Physical connections of industrial networks

PROFIBUS devices can be networked in industrial plants in two different physical ways:

- By means of electrical signals via copper cables
- By means of optical signals via fiber-optic cables

Selection criteria for networking

The table below includes selection criteria for electrical and optical networking of PROFIBUS devices:

Table 2- 3 Selection criteria for electrical and optical networking

Criteria		Electrical PROFIBUS	Optical network with OLM	Optical network with OBT
Transmission medium	Shielded two-wire line	●	–	–
	POF	–	●	●
	PCF	–	●	●
	Glass	–	●	–
Distances	Max. network span	PROFIBUS DP: 9.6 km PROFIBUS PA: 1.9 km	90 km	9.6 km
	Between two devices	up to 1 km [1)]	up to 15 km [2)]	up to 300 m [2)]
Topology	Bus	●	–	–
	Linear	–	●	●
	Tree	●	●	●
	Ring	–	●	●
Transmission protocols		DP, PA	DP, PA	DP

Criteria		Electrical PROFIBUS	Optical network with OLM	Optical network with OBT
Connection of devices by means of	OLM	–	●	–
	Integrated interfaces	●	–	●
	Bus terminal	●	–	●
	Bus connector	●	–	–
Electrical network segments can be connected		●	●	–

● Suitable

– Not relevant for this application

1) Depending on data rate and type of service used

2) Depending on cable type used

Installation guideline for PROFIBUS networks

A PROFIBUS segment must be terminated at the start and end;
passively with a connector or actively with a bus terminating resistor.

The same principles apply to the installation of a PROFIBUS network as described in the SIMATIC NET PROFIBUS networks (http://support.automation.siemens.com/WW/view/en/35222591) manual.

2.2.1 Passive network components for RS 485 networks

2.2.1.1 RS 485 cables

Introduction

The following applies to all RS 485 cables for PROFIBUS from Siemens:

- Their double shielding makes them especially suited for laying in industrial environments with electromagnetic interference.
- A continuous grounding concept can be implemented by means of the outer shield of the bus cable and the ground terminals of the bus terminals.
- The imprinted meter marking makes it easier to determine the length (accuracy ±5 %).

RS 485 cables for PROFIBUS

SIMATIC NET PROFIBUS cables are available in different versions which makes for an optimum adaptation to different areas of application:

- FC Standard Cable GP (bus cable for fixed laying inside buildings)
- FC Standard Cable IS GP (bus cable for hazardous area)
- FC-FRNC Cable GP (bus cable with halogen-free protective jacket for use inside buildings)
- FC Food Cable (bus cable with PE jacket for use in the food and beverage industry)
- FC Robust Cable (bus cable with PUR jacket for environments subject to chemical and mechanical stress)
- FC Ground Cable (ground cable with PE jacket)
- PROFIBUS FC Trailing Cable (trailing cable for tow chains)
- PROFIBUS Festoon Cable (bus cable for festoon mounting)
- PROFIBUS Torsion Cable (torsion-free bus cable for networking movable plant parts, for example, robots)
- PROFIBUS FC Flexible Cable (bus cable for machine parts that are moved infrequently or cabinet doors)
- SIENOPYR-FR ship cable (for permanent laying on ships and off-shore units in all rooms and on open deck)
- PROFIBUS Hybrid Standard Cable (hybrid cable with 2 power wires (1.5 mm^2) for data and power supply of the ET 200pro)
- PROFIBUS Hybrid Robust Cable (trailable hybrid cable with 2 power wires (1.5 mm^2) for data and power supply of the ET 200pro)

Maximum cable lengths

When using copper cables, the maximum size of a PROFIBUS segment depends on the transmission rate.

If these lengths are not sufficient for your application, you can expand the network by using repeaters. You can achieve a maximum size by cascading up to nine repeaters.

Table 2- 4 Maximum cable lengths

Transmission rate	Maximum cable length of a bus segment	Maximum distance between two stations
9.6 to 187.5 kbps	1000 m	10000 m
500 kbps	400 m	4000 m
1.5 Mbps	200 m	2000 m
3 to 12 Mbps	100 m	1000 m

2.2.1.2 PROFIBUS FastConnect system

PROFIBUS FastConnect (FC)

PROFIBUS FastConnect is a system for fast and easy fabrication of PROFIBUS copper cables.

The system consists of three components:

- FastConnect bus cables for quick mounting
- FastConnect stripping tool
- FastConnect bus connector for PROFIBUS with insulation displacement method

FastConnect bus cables and stripping tool

The special design of the FastConnect bus cables allows for the use of the FastConnect stripping tool to accurately strip away the outer jacket and the braided shield in one step. The connection of the prepared cables takes place in the FastConnect bus connectors using the insulation displacement method.

All PROFIBUS FastConnect bus cables can also be connected to the conventional bus connectors with screw-type terminals.

Area of application

You need FastConnect bus connectors for PROFIBUS for the following applications:

- Connect devices with an electrical 9-pin D-Sub interface to IEC 61158-2 directly with SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

Versions

The FastConnect bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for hazardous area of zone 2

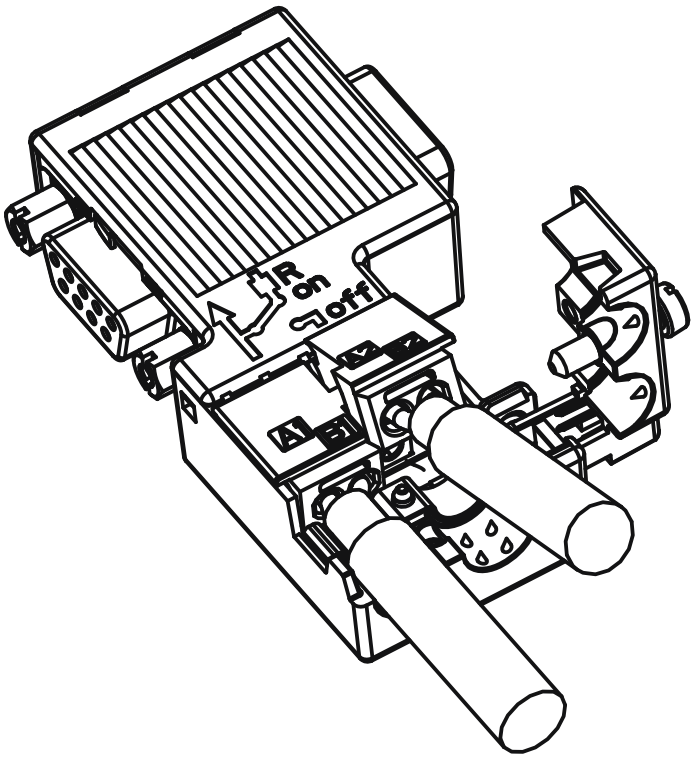


Figure 2-5 Example for PROFIBUS FastConnect bus connector with PG socket, cable outlet 90°

Additional information

For additional information on the available components visit the Siemens Mall (http://mall.automation.siemens.com).

2.2.1.3 PROFIBUS bus connector

Area of application

You need PROFIBUS bus connectors for the following applications:

- Connect devices with a 9-pin D-Sub interface to IEC 61158-2 directly with the SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

Versions

The PROFIBUS bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for hazardous area of zone 2

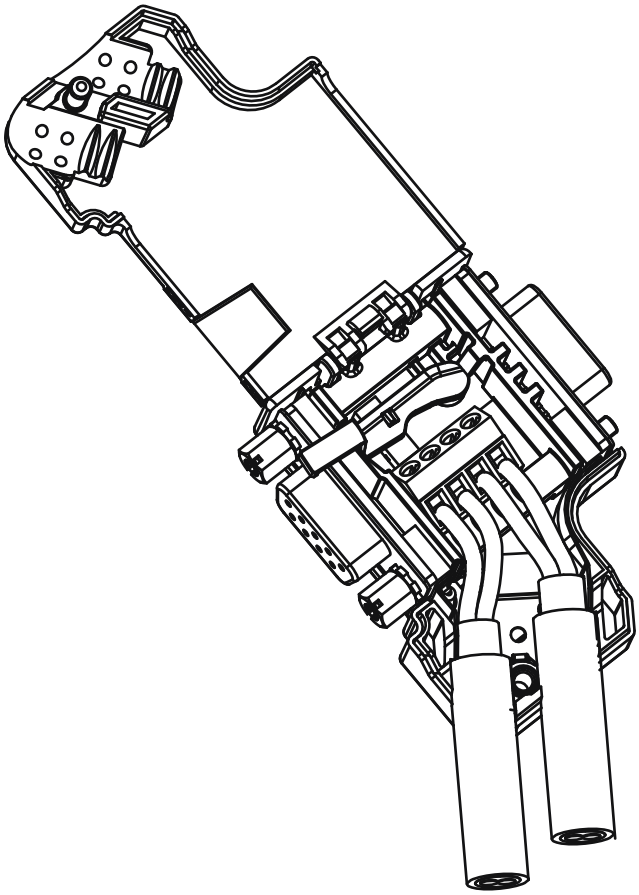


Figure 2-6 Example for PROFIBUS bus connector with PG socket, cable outlet 35°

Additional information

For additional information on the available components visit the Siemens Mall (http://mall.automation.siemens.com).

2.2.1.4 M12 bus connector

Area of application

Devices with an electrical M12 interface can use the M12 bus connector for SIMATIC NET PROFIBUS for direct connection with the SIMATIC NET PROFIBUS cables.

The M12 bus connector in degree of protection IP65 is available in the following versions:

- with screw-type terminals
- with insulation displacement termination
- with a cable outlet of 180°

2.2.1.5 Bus terminals for RS 485 networks

Bus terminal RS 485 and bus terminal M12

A bus terminal is used for the connection of an individual PROFIBUS station with RS485 interface to the PROFIBUS bus cable.

Bus terminals in degree of protection IP20 are available in the following versions:

- Bus terminal RS 485 with or without PG interface, transmission rate 9.6 kbps to 1.5 Mbps, integrated terminating resistor combination (connectible), with 1.5 m and 3 m connecting cable
- Bus terminal M12, transmission rate 9.6 kbps to 12 Mbps, integrated terminating resistor combination with isolating function, with 1.5 m connecting cable

2.2.1.6 M12 bus terminating resistor

Terminating segment with terminating resistor

If there is a station with M12 connection system at the beginning or end of a PROFIBUS segment, you need an M12 bus terminating resistor.

The M12 PROFIBUS connection of a device consists of an M12 socket for the infeed and an M12 male connector to loop-through the bus signal.

This means you need one bus terminating resistor with male contacts (6GK1905-0EC00) and with female contacts (6GK1905-0ED00) for each M12 bus cable.

2.2.2 Passive components for optical networks

2.2.2.1 Fiber-optic cables

Types of fiber-optic cables

Data transmission with fiber-optic cables takes place through modulation of electromagnetic waves in the range of visible and invisible light. These cables are made of high-quality plastic fibers and glass fibers:

- Plastic and PCF fiber-optic cables (Page 25)
- Glass fiber-optic cables (Page 26)

The different types of fiber-optic cables provide solutions matched to the operating and environmental conditions for the connection of components with each other.

Benefits

Fiber-optic cables offer the following benefits when compared with electrical cables:

- Galvanic isolation of the devices and segments
- No potential equalization currents
- No impact on transmission path through external electromagnetic interference
- No lightning protection elements required
- No noise radiation along the transmission route
- Low weight
- Depending on the type of fiber you can implement cable lengths up to few kilometers at even higher transmission rates.
- No dependency of the maximum permitted distances on the transmission rate

Additional information

Additional information of the properties and technical specifications of the passive components and connectors for fiber-optic cables is available in the PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591).

2.2.2.2 Plastic and PCF fiber-optic cables

Plastic and PCF fiber-optic cables

Plastic (POF) and PCF fiber-optic cables are used for the connection of Optical Link modules with connections for plastic fiber-optic cables (OLM/P), Optical Bus Terminal (OBT) and devices with integrated optical interfaces. Under certain conditions, they are an inexpensive alternative to conventional glass fiber-optic cables.

Plastic Fiber Optic duplex core

The plastic fiber-optic duplex core is a flat dual core with PVC inner jacket without protective jacket. The cable can be easily assembled on-site.

The cable is intended for indoor applications with low mechanical loads or inside cabinets. For OLM connections and with integrated optical interfaces you cover a length of up to 50 m between two devices with this cable.

Plastic Fiber Optic standard cable

The plastic fiber optic standard cable consists of two plastic fibers with robust polyamide inner jacket surrounded by Kevlar tensile elements and a purple PVC protective jacket. The cable can be easily assembled on-site.

The robust round cable is suited for indoor applications. The maximum distance that can be covered is 80 m for OLM/P connections and 50 m with integrated optical interfaces and OBT.

PCF Standard Cable

The pre-assembled PCF Standard Cable consists of two PCF fibers surrounded by Kevlar tensile elements and a purple PVC protective jacket. It is always supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Standard Cable GP

The PCF Standard Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Trailing Cable

The PCF Trailing Cable consists of two PCF fibers surrounded by Aramid tensile elements and a green PUR protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Trailing Cable GP

The PCF Trailing Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

2.2.2.3 Glass fiber-optic cables

Glass fiber-optic cables

Glass fiber-optic cables are suitable for connection of optical interfaces that work in the wavelength range around 850 nm and around 1300 nm. They include two graded-index multimode fibers of the type 62.5/125 µm.

The glass fiber-optic cables are available in different versions which makes for an optimum adaptation to different areas of application:

- Fiber Optic standard cable
- INDOOR Fiber Optic indoor cable
- Flexible Fiber Optic trailing cable

Fiber Optic standard cable

The standard cable is the universal cable for indoor and outdoor use.

INDOOR Fiber Optic indoor cable

The indoor cable is intended for weather-proof indoor use. It is halogen-free, non-crush and flame-retardant.

Flexible Fiber Optic trailing cable

The trailing cable was designed for the special application of forced movement, for example, for constantly moved machine parts such as trailing chains. It is mechanically designed for 100,000 bending cycles by ±90° (with the specified minimum radius). Integrated dummy elements ensure a round cross-section of the cable. The trailing cable can be used indoors and outdoors.

Maximum distances between two optical link modules

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

Additional information

All operating instructions (http://support.automation.siemens.com/WW/view/en/10805951/133300) of the SIMATIC NET bus components include information on distances that can be covered with the SIMATIC NET glass fiber-optic cables. You can configure your optical network without any calculations using simple limits.

2.2.3 Active network components

2.2.3.1 Network components in electrical networks

Active network components

The following active network components are available for PROFIBUS in electrical networks:

- Repeater RS485
- Diagnostic repeater
- PROFIBUS Terminator
- DP/DP coupler
- IE/PB Link PN IO
- IWLAN/PB Link PN IO
- Active components for the connection of CAN
- Active components for the gateway between PROFIBUS and AS-Interface
  - DP/AS-i LINK Advanced
  - DP/AS-Interface Link 20E
  - DP/AS-i F-Link

RS485 repeater

The RS485 IP20 repeater connects two PROFIBUS bus segments in RS485 technology with up to 32 devices. It provides transmission rates from 9.6 kbps to 12 Mbps.

The RS485 repeater refreshes a signal regarding amplitude, signal width and edge steepness between two segments. It is used when more than 32 stations are connected to the bus or the maximum cable length of a segment is exceeded.

Bus segments can be operated ungrounded (galvanic isolation of segments) with a RS485 repeater.

Diagnostic repeater

The diagnostic repeater connects three PROFIBUS segments in RS485 technology, two of which are diagnostics-capable segments with 31 devices each. It is designed as DP slave to send diagnostic messages to the DP master.

The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is indicated relative to the existing devices.

The diagnostic repeater refreshes a signal regarding amplitude, signal width and edge steepness between two segments. The cascading depth between any two PROFIBUS devices is limited to nine diagnostic repeaters.

PROFIBUS Terminator

The PROFIBUS Terminator forms an active bus termination. Bus devices can be switched off, removed or replaced without affecting data transmission. This is particularly true for bus devices on both ends of the bus cable at which terminating resistors must be connected or supplied. The PROFIBUS Terminator can be mounted on a standard mounting rail.

IE/PB Link PN for the connection of a PROFIBUS segment to an Industrial Ethernet network

The IE/PB Link PN IO as independent component provides the seamless transition between Industrial Ethernet and PROFIBUS. By using the IE/PB Link PN IO as substitutes on the Ethernet, the existing PROFIBUS devices can still be used and integrated into a PROFINET application.

A PROFINET IO controller is required for this configuration. The IE/PB Link PN acts as master on the PROFIBUS end.

IWLAN/PB Link PN IO as gateway between LAN and PROFIBUS

PROFIBUS devices can be coupled to PROFINET IO by means of IWLAN/PB Link PN IO. This means you can integrate existing PROFIBUS configurations into PROFINET.

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission, for example, in suspended monorail systems or conveyor systems. By supporting PROFINET, the numerous PROFIBUS system services, for example, diagnostic by bus, can still be used.

A PROFINET IO controller is required for this configuration. The IWLAN/PB Link PN IO acts as master on the PROFIBUS end.

CANopen module for connection to CAN

You can use the CANopen module to easily connect CANopen applications to PROFIBUS.

Typical areas of application:

- Control of hydraulic valves / hydraulic axles in vehicles
- Control of motors in packaging machines and on conveyor belts
- Use in wind turbines for detection of angular encoders
- Detection of HMI devices on machines, e.g., joysticks
- Detection of measured data from displacement transducers, inclination sensors or angle encoders on tower cranes or gantry cranes

DP/DP coupler for connection of two PROFIBUS networks

The PROFIBUS DP/DP coupler is used to connect two PROFIBUS DP networks. Data (0 to 244 bytes) is transmitted from the DP master of the first network to the DP master of another network and vice versa.

The DP/DP coupler comes equipped with two independent DP interfaces that establish the connection to the two DP networks. There is always one slave at the DP networks. The data exchange between the two DP networks takes place by internal copying in the coupler.

DP/PA bus link for connection of PROFIBUS PA

The DP/PA bus link is the connection between PROFIBUS DP and PROFIBUS PA. This means it connects the process control systems with the field devices of the process automation.

The following components are available for a DP/PA bus link:

- DP/PA coupler Ex [ia]
- DP/PA coupler FDC 157-0
- Interface module IM 153-2 for establishing a DP/PA link.
- Active field distributor AFDiS for hazardous areas

Active components for the gateway between PROFIBUS and AS-Interface

- DP/AS-i LINK Advanced

  The DP/AS-i LINK Advanced is PROFIBUS DPV1 slave (to IEC 61158-2 / EN 61158-2) and AS-Interface master (to AS-Interface-specification V3.0 to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP.

  PROFIBUS DP masters can cyclically exchange I/O data with the AS-Interface; DP masters with acyclical services can also make AS-Interface master calls. The DP/AS-i LINK Advanced is particularly suited for distributed configurations and for the connection of a subordinate AS-Interface network.

  The DP/AS-i LINK Advanced in the version as AS-Interface single master is completely sufficient for applications with typical quantity structures.

  For applications with high quantity structures, the DP/AS-i LINK Advanced is used as AS-Interface double master. In this case, the duplicate quantity structures can be used on two independently running AS-Interface strands.

- DP/AS-Interface Link 20E

  The DP/AS-Interface Link 20E is PROFIBUS DP slave (in accordance with EN 61158) and AS interface master (in accordance with AS interface specification V3.0 according to EN 50295) and supports operation of the AS-Interface on PROFIBUS DP.

  Single PROFIBUS masters can cyclically exchange I/O data with the AS interface; masters with acyclical services can exchange I/O data and make master calls.

- DP/AS-i F-Link

  The DP/AS-i F-Link is PROFIBUS DP-V1 slave (to EN 61158) and AS-i master (to AS-Interface-specification V3.0 to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP. The DP/AS-i F-Link is also the only AS-i master that can forward safety-oriented input data of ASIsafe slaves to a fail-safe CPU with PROFIBUS DP master by means of the PROFIsafe protocol. An additional safety cabling or monitoring is not required (especially no AS-Interface safety monitor). Depending on the slave type, you can transmit binary values or analog values. All slaves to AS-Interface specification V2.0, V2.1 or V3.0AIs can be operated as AS-i slaves.

  As fully adequate AS-i master to specification V3.0, you can use higher quantity structures on the AS-i network (496 inputs and outputs each, up to 62 digital or analog slaves).

Additional information

Information on the components is available in the Siemens Mall (http://mall.automation.siemens.com).

Additional information is available in these manuals:

- PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591)
- Diagnostic repeater (http://support.automation.siemens.com/WW/view/en/7915183)
- DP/DP coupler (http://support.automation.siemens.com/WW/view/en/1179382)
- SIMATC NET Twisted-Pair and Fiber-Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)
- Basics for installation of an Industrial Wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764)
- SIMATIC bus links, DP/PA coupler, active field distributors, DP/PA Link and Y Link (http://support.automation.siemens.com/WW/view/en/1142696)
- Information on the CANopen module is available on the Internet (http://www.hms-networks.com/can-for-et200s).
- DP/AS-INTERFACE LINK Advanced (http://support.automation.siemens.com/WW/view/en/22502958/133300) manual
- DP/AS-i F-Link (http://support.automation.siemens.com/WW/view/en/24196041) manual

See also

Topology with RS485 repeater (Page 34)

OLM topology (Page 39)

WLAN topology (Page 39)

Connecting PROFIBUS to PROFINET (Page 40)

2.2.3.2 Network components in optical networks

Active network components

The following active network components are available for PROFIBUS in optical networks:

- Optical Link Module OLM
- Optical Bus Terminal OBT

Optical Link Module OLM

You can use the PROFIBUS Optical Link Modul OLM to install PROFIBUS networks in line, star structure and redundant ring structure.

The transmission rate of a fiber-optic cable line does not depend on the distance and can be 9.6 kbps to 12 Mbps.

Applications for OLM include, for example, plant buses on PROFIBUS base, networking across buildings using glass fiber-optic cables, mixed networks with electrical and optical segments, large networks (road tunnels, traffic guidance systems) and networks with high demands on availability (redundant ring networks).

Optical Link modules can be combined by means of an RS485 interface and individual devices or entire electrical segments can be integrated into the optical PROFIBUS network.

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

Optical Bus Terminal OBT (optical bus terminal)

The Optical Bus Terminal connects an individual PROFIBUS device without integrated optical interface or a PROFIBUS RS 485 segment with up to 31 devices to an optical PROFIBUS.

An individual PROFIBUS DP device is connected with its RS 485 interface by means of a PROFIBUS cable with integrated terminating resistor, for example, connecting cable 830-1T, to the RS 485 interface of the OBT. The OBT is integrated into the optical line by means of two optical interfaces.

The following optical transmission media can be connected to the OBT:

- Plastic fiber-optic cable up to 50 m single distance length.
  They can be assembled on-site with two 2x2 Simplex connectors.
- PCF fiber-optic cable up to 300 m single distance length.
  The cables are delivered pre-assembled.

Additional information

Information on the components is available in the Siemens Mall (http://mall.automation.siemens.com).

Additional information is available in these manuals:

- PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591)
- SIMATIC NET PROFIBUS, Optical Link Module (http://support.automation.siemens.com/WW/view/de/56606534/0/en)
- SIMATC NET Twisted-Pair and Fiber-Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)

2.2.4 Examples for topology

2.2.4.1 Topology with RS485 repeater

Configuration options with the RS485 repeater

You can operate the RS485 repeater in the following configurations:

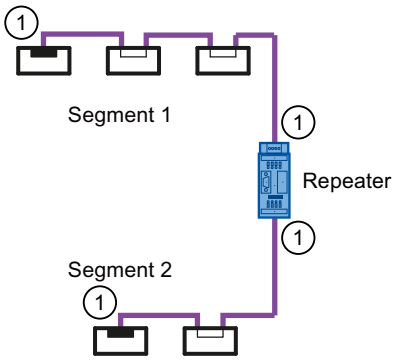


Figure 2-7 Segment 1 and segment 2 connected to RS485 repeater

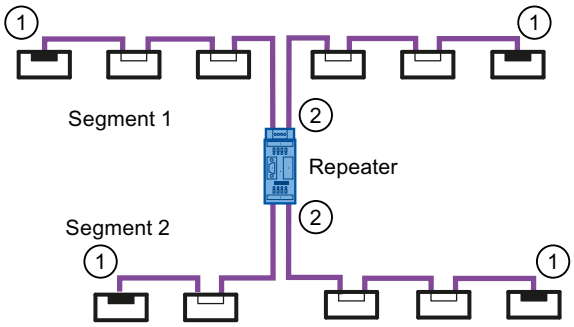


Figure 2-8 Segment 1 and segment 2 looped-through to RS485 repeater

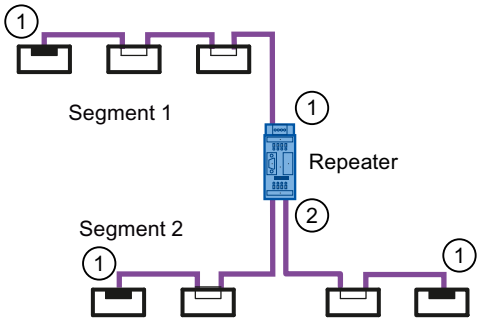


Figure 2-9 Segment 1 connected to RS485 repeater and segment 2 looped-through to RS485 repeater

① Connect terminating resistor

② Do not connect terminating resistor

Configuration example

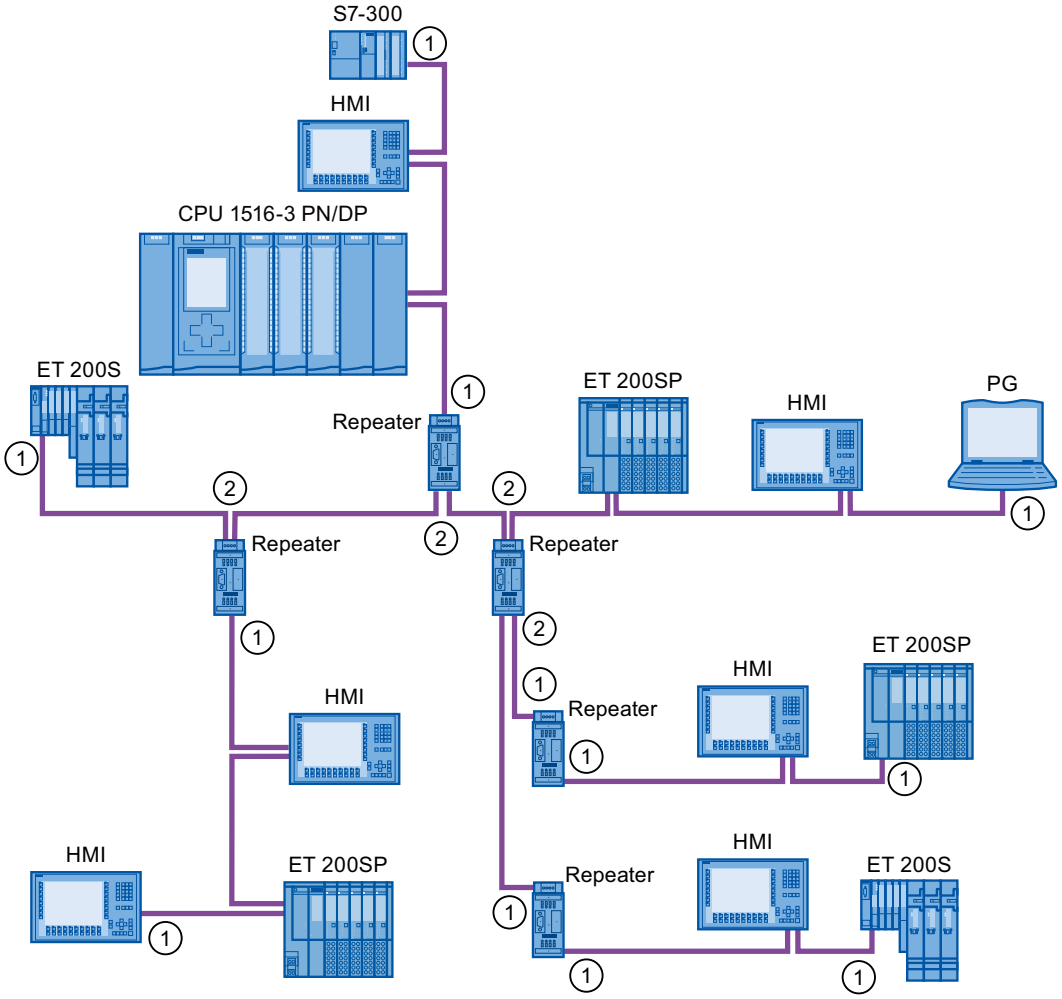


Figure 2-10 Configuration example with five RS485 repeaters

① Connect terminating resistor

② Do not connect terminating resistor

Maximum configuration

If you install a PROFIBUS network with RS485 repeaters, you may not connect more than nine RS485 repeaters in series.

2.2.4.2 Topology with diagnostic repeater

Diagnostic repeater with three segments

You may not exceed the maximum permitted cable length of 100 m per segment that can be monitored for the diagnostic repeater. The segments connected to DP2 and DP3 are diagnostics-capable. The cable length that can be monitored is limited for some cable types.

Maximum cascade depth

You can connect up to nine diagnostic repeaters in series between any two PROFIBUS stations.

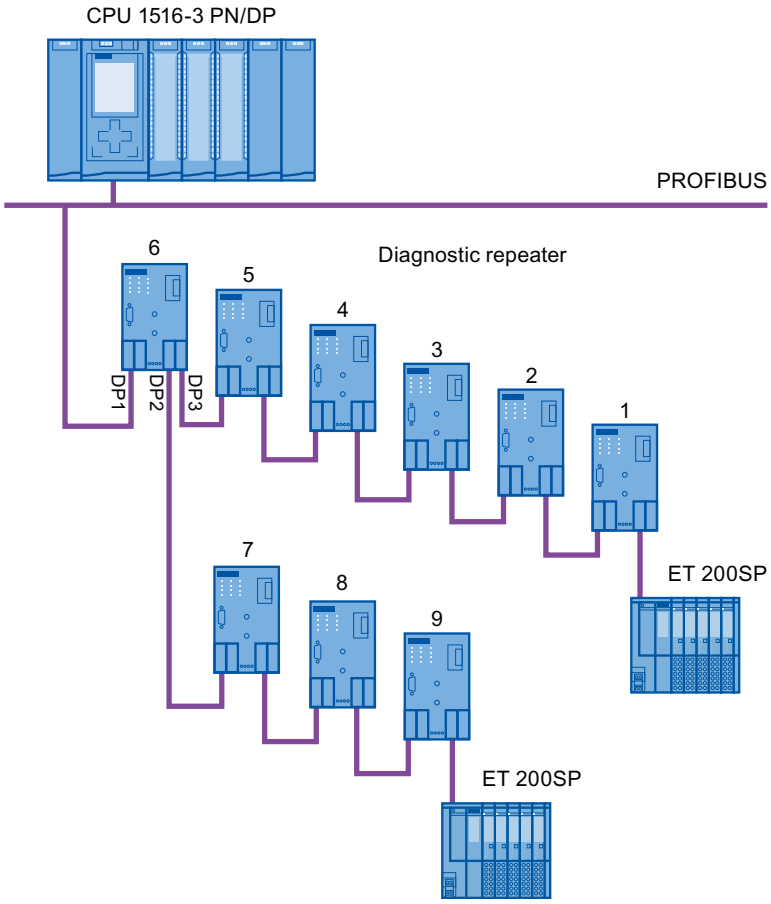


Figure 2-11 Schematic layout of a PROFIBUS network with maximum possible cascade depth at diagnostic repeaters

Example: Maximum cascade depth exceeded

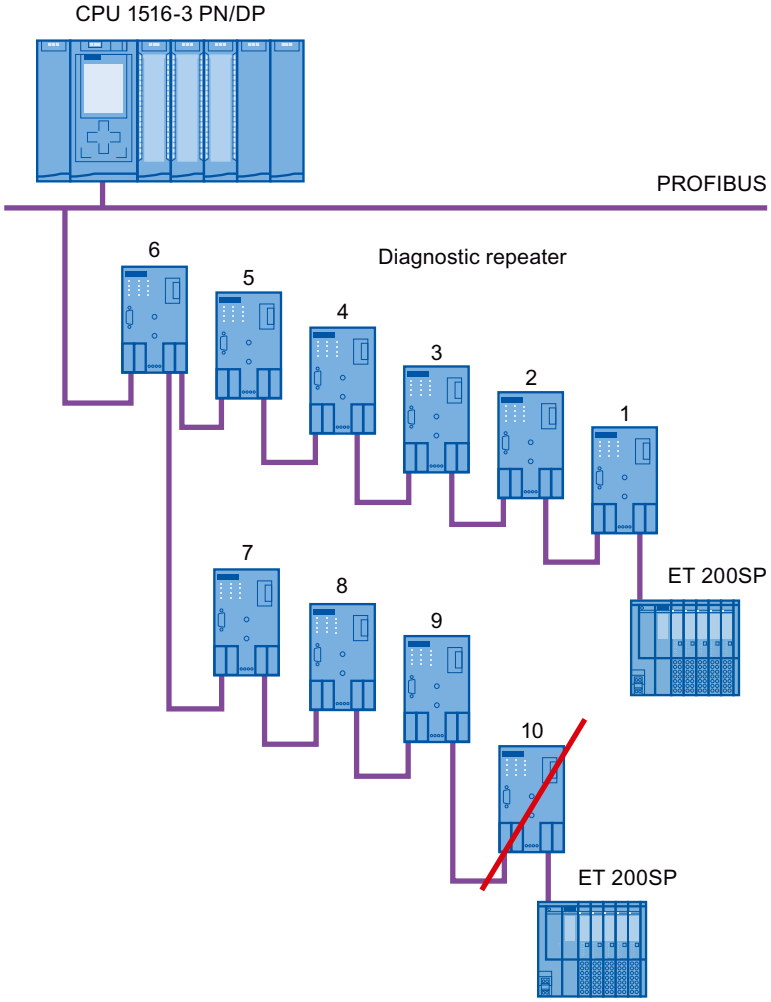


Figure 2-12 Maximum cascade depth exceeded

Layout with several segments

You can increase the number of used diagnostic repeaters by using several segments. The example shows a layout in which the maximum cascade depth is exceeded at two segments.

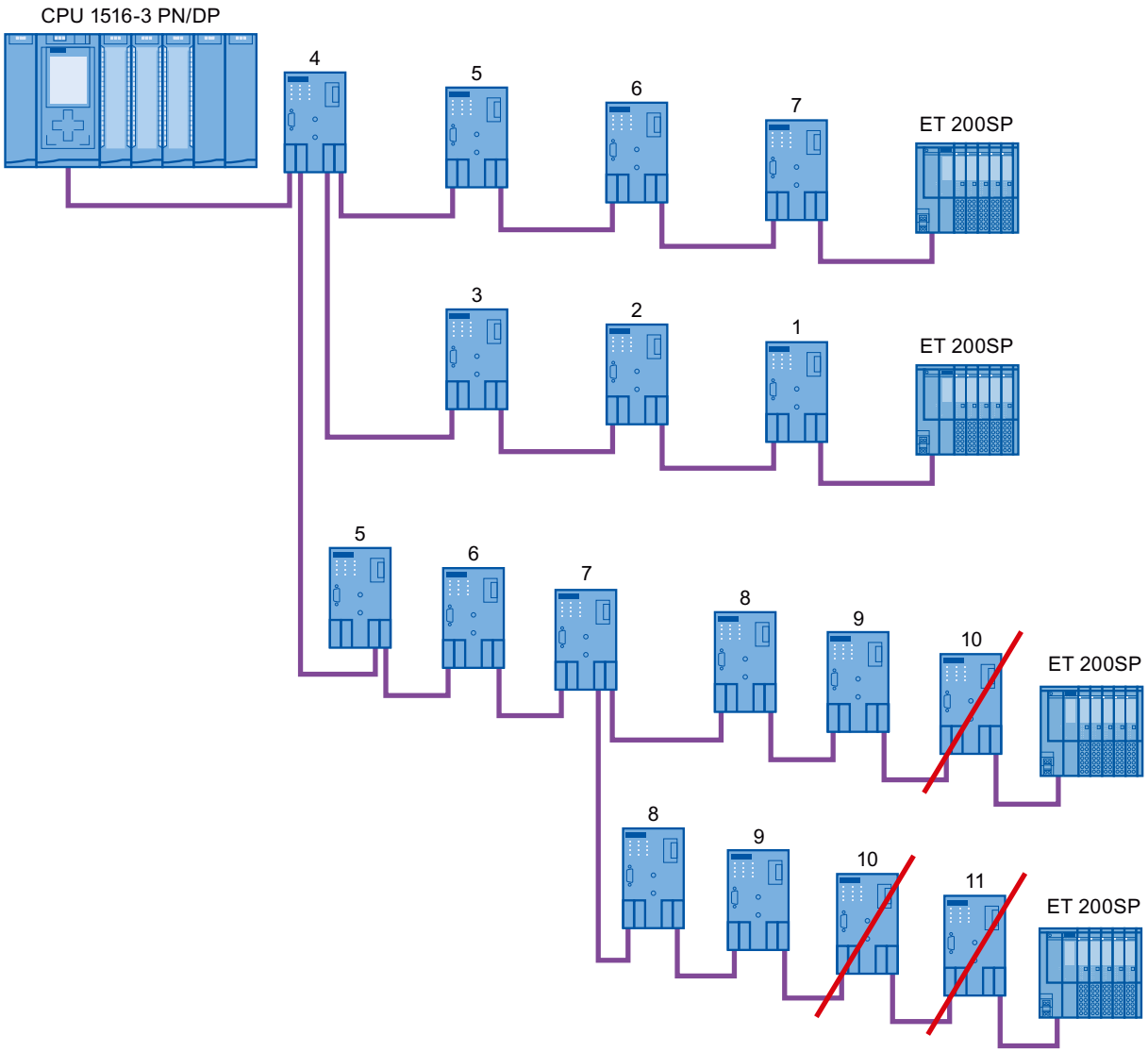


Figure 2-13 Layout with several segments, maximum cascade depth exceeded

Additional information

Additional information is available in the Diagnostic Repeater (http://support.automation.siemens.com/WW/view/en/7915183) manual.

2.2.4.3 OLM topology

Combination of electrical and optical networks with OLM

Additional distances can be covered by means of the Optical Link Module.

Because bus cables across several buildings are particularly vulnerable to damage caused by overvoltage (effect of lightning), the devices in the connected bus segment must be protected against overvoltage.

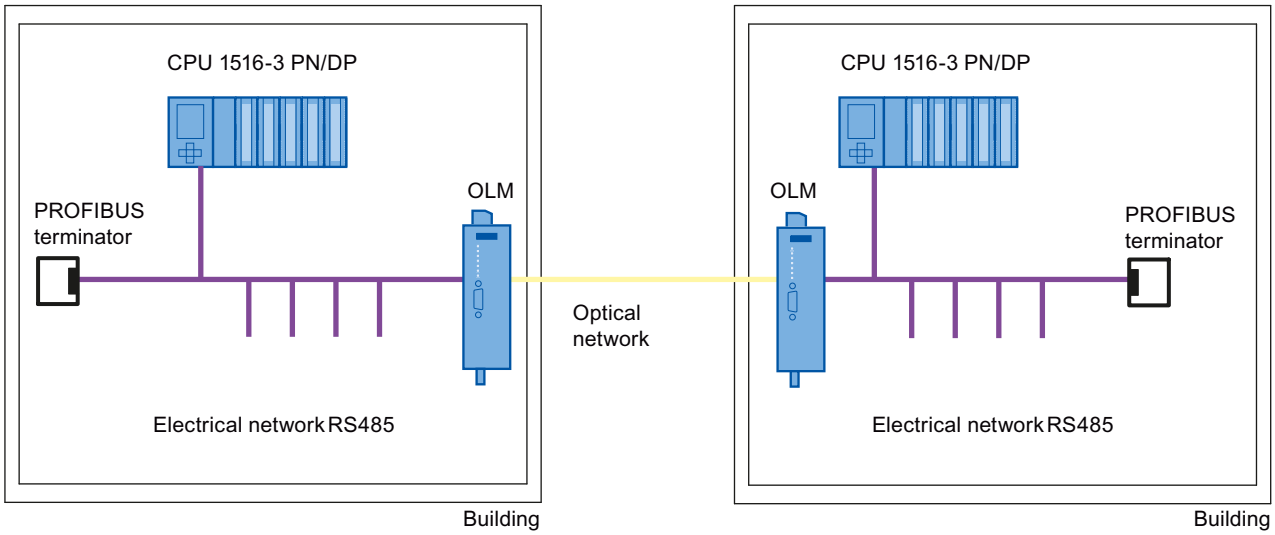


Figure 2-14 Combination of electrical and optical networks

2.2.4.4 WLAN topology

IWLAN/PB Link PN IO as gateway between Industrial Wireless LAN and PROFIBUS

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission. This means the numerous PROFIBUS system services, for example, diagnostic by bus, can be used throughout.

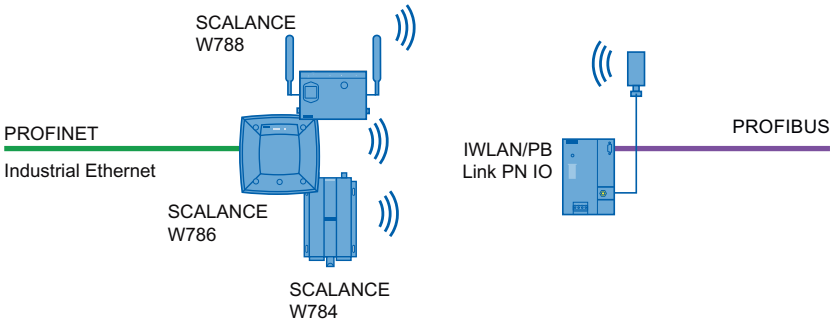


Figure 2-15 PROFIBUS and WLAN

2.2.4.5 Connecting PROFIBUS to PROFINET

PROFIBUS can be integrated in PROFINET. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This provides a continuous data exchange.

Coupling of PROFIBUS and PROFINET

With a proxy-capable PROFINET device that is equipped with a PROFIBUS interface in addition to a PROFINET interface, you can integrate existing PROFIBUS configurations into the PROFINET configuration.

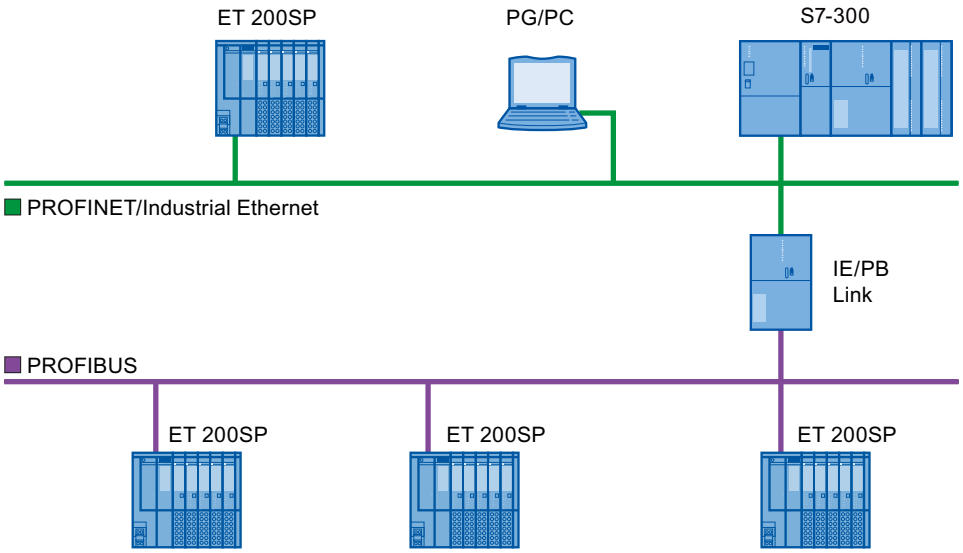


Figure 2-16 Connection of PROFIBUS and PROFINET with IE/PB link

PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link. The IE/PB link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

Parameter assignment/addressing 3

To set up an automation system, you will need to configure, assign parameters and link the individual hardware components. The work needed for this is undertaken in the STEP 7 device, topology and network view.

Configuration

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device or network view.

A PROFIBUS address is automatically assigned to each module. The addresses can be subsequently modified.

The CPU compares the preset configuration created in STEP 7 with the actual configuration of the plant. Errors can be detected and signaled immediately this way.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

Parameter assignment

"Parameter assignment" is understood to mean setting the properties of the components used. The settings for the hardware components and for data exchange are assigned, for example, activating diagnostics, input delay with DI.

The parameters are downloaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules can be replaced with ease because with SIMATIC CPUs the set parameters are automatically downloaded into the new module during each startup.

Adjusting the hardware to the project requirements

You need to adapt the hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your layout, link them with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset so that in many cases you do not have to assign parameters again.

But parameter assignment is required in the following cases:

- You want to change the preset parameters of a module.
- You want to use special functions.
- You want to configure communication connections.

Basic procedure for creating a PROFIBUS DP system

- Configuration
  - Creating PROFIBUS devices and modules in STEP 7
  - Assigning the DP slave to a DP master (Page 42)
- Optional: Parameter assignment
  - Assigning the PROFIBUS address (Page 44)
  - Making network settings (Page 45)
  - Considering cable configuration (Page 48)
  - Considering additional network devices (Page 50)
  - Bus parameters – creating a user-defined profile (Page 51)
  - Configuring constant bus cycle time (Page 54)

3.1 Assigning the DP slave to a DP master

PROFIBUS DP system

A PROFIBUS DP system consists of a PROFIBUS DP master and its assigned PROFIBUS DP slaves. Once the devices have been placed in the network view or device view, STEP 7 assigns default parameter values to them. Initially, you only have to assign the DP slaves to one DP master.

Requirement

- The network view of STEP 7 is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- A DP slave has been placed (e.g., IM151-1 HF).

Procedure

To assign DP slaves to a DP master, follow these steps:

1. On the DP slave, use the left mouse button to click on the "Not assigned" link.
   The "Select DP master" menu opens.
2. Select the DP master in the menu to which you want to assign the DP slave.

   Result: A subnet with a DP system is created on the CPU. The CPU is now the PROFIBUS DP master. The DP slave is assigned to the DP master.
3. Repeat steps 1 and 2 for all other DP slaves that you want to assign to the DP master.

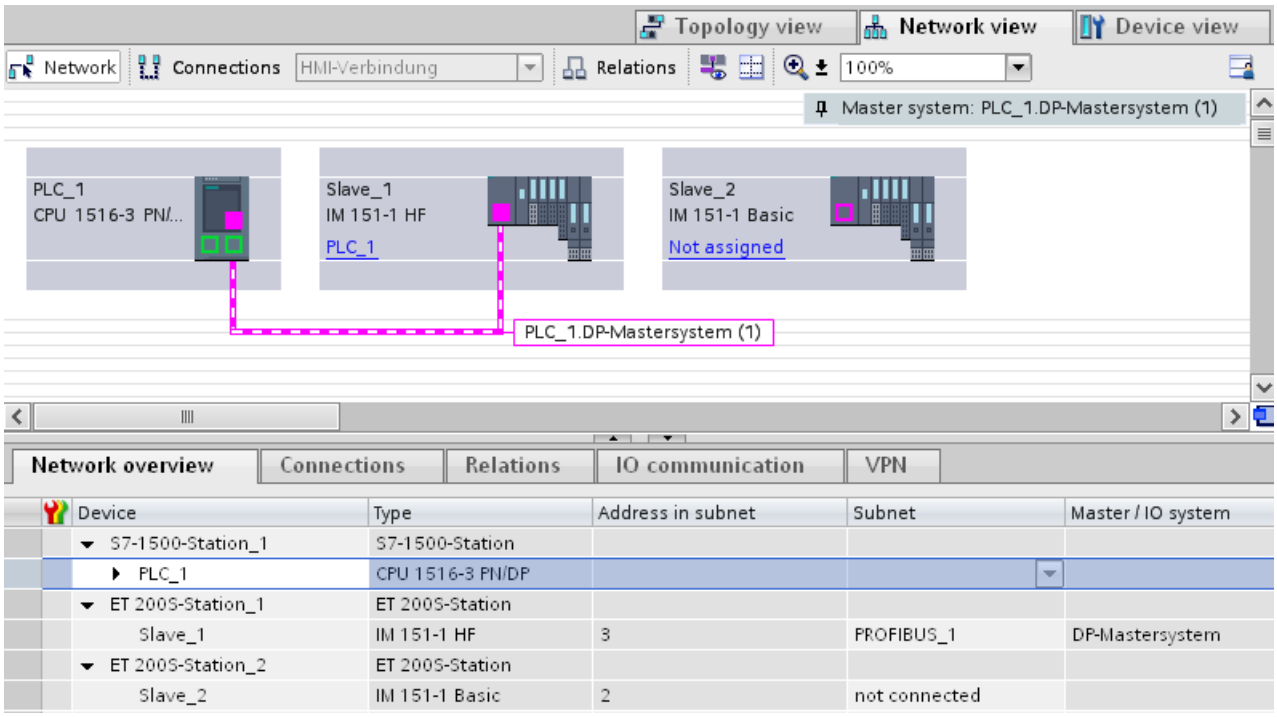


Figure 3-1 Assigning the DP slave to a DP master

Network overview

You can check the communication relationships of the activated interface in the network overview. The network overview is context-sensitive for selection in the network view:

- The selection of the CPU shows the DP communication of the CPU.
- The selection of the station shows the communication of the entire station.
- The selection of the interface shows the DP communication of the interface.

3.2 PROFIBUS address

Devices can be connected to the PROFIBUS subnet that communicate by means of configured connections or that are part of a PROFIBUS DP master system.

If the DP slave has already been assigned to a DP master, the PROFIBUS subnet to which the device is connected is automatically displayed under "Interface linked with".

In the Inspector window under "PROFIBUS", select the subnet to which the interface is linked or add a new subnet.

All devices of a subnet must have different PROFIBUS addresses.

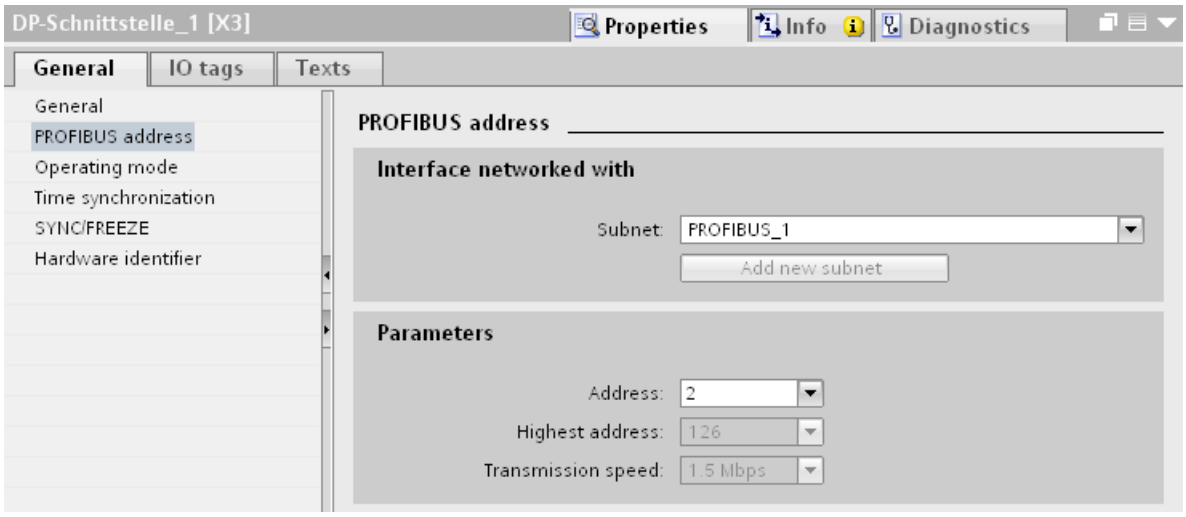


Figure 3-2 PROFIBUS address

Rules for address assignment

STEP 7 automatically assigns device addresses.

You can change the addresses if you observe the following points:

- Assign a unique PROFIBUS address to each device in the PROFIBUS network, each DP master and each DP slave in the PROFIBUS network.
- Depending on the DP slave, not all permitted PROFIBUS addresses are supported. For devices with BCD switches, it is often the case that only the PROFIBUS addresses 1 to 99 are supported.

Changing the PROFIBUS address

You change the PROFIBUS address under "Parameter".

3.3 Network settings

Highest PROFIBUS address (HSA)

Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, but only up to 126.

Profile

Depending on the connected device types and the protocols used, different profiles are available on the PROFIBUS. The profiles differ with respect to their setting options and calculation of the bus parameters.

The PROFIBUS subnet will only work properly if the bus parameters of all devices have the same values.

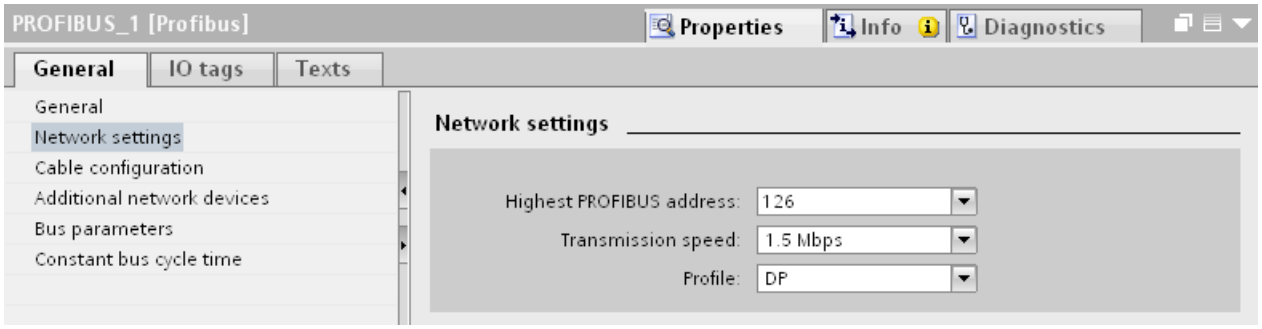


Figure 3-3 Network settings

Profiles and transmission rates

Table 3- 1 Profiles and transmission rates

Profiles	Supported transmission rates
DP	9.6 kbps to 12 Mbps
Standard	9.6 kbps to 12 Mbps
Universal (DP/FMS) (FMS is not supported)	9.6 kbps to 1.5 Mbps
User-defined	9.6 kbps to 12 Mbps

DP (recommended profile)

Select the "DP" profile if only devices meeting the requirements of the standard EN 61158-6-3 are connected to the PROFIBUS subnet. The setting of the bus parameters has been optimized for these devices. These include devices with DP master and DP slave interfaces of SIMATIC S7 as well as distributed I/O devices from third parties.

Note

Profile for constant bus cycle time and isochronous mode

DP is the recommended profile for the configuration of constant bus cycle time and isochronous mode.

Standard

Compared with the "DP" profile, the "Standard" profile gives you the option to take into consideration devices of another project or devices that have not been configured here for calculation of the bus parameters. The bus parameters are then calculated with a simple algorithm that was not optimized.

Universal (DP/FMS) (FMS is not supported)

Select the "Universal (DP/FMS)" profile if individual devices in the PROFIBUS subnet use the FMS service (e.g., CP 343-5, PROFIBUS FMS devices).

As with the "Standard" profile, here, too, you have the option to take additional devices into consideration for calculation of the bus parameters.

User-defined

The PROFIBUS subnet will only work properly if the parameters for the profile have been synchronized. Select the "User-defined" profile if none of the other profiles "match" for operation of a PROFIBUS device and if you have to adapt the bus parameters for your special layout.

You cannot configure all theoretically possible combinations with the user-defined profile either. The PROFIBUS standard prescribes some parameter limits depending on other parameters. It is, for example, not permitted that a responder responds (Min Tsdr) before the initiator is able to receive the frame (Trdy). These standard specifications are also checked in the "User-defined" profile.

Note

User-defined settings

Use user-defined settings only if you are familiar with the PROFIBUS parameters.
It is usually better to work with the "DP" profile.

Contact Customer Support (Page 79) if you have any questions.

The bus parameters that were last valid on the PROFIBUS subnet are automatically set as user-defined. If the "DP" bus profile was valid for the subnet, for example, the bus parameters for "DP" are set in the "User-defined" bus profile. You can modify the parameters based on these settings.

The monitoring times are not automatically recalculated in the "User-defined settings" setting so that the uniformity of the set values is not changed without your knowledge, for example, to configure other configuration tools.

You can calculate the monitoring times Ttr and watchdog based on the parameters you have set. To do so, click on the "Recalculate" button.

See also

Additional network stations (Page 50)

3.4 Cable configuration

Considering cable configuration

Information on the cable configuration can be taken into consideration for calculation of the bus parameters. To do so, select the check box "Consider following cable configuration" in the properties of the PROFIBUS subnet.

The other information depends on the type of cable used.

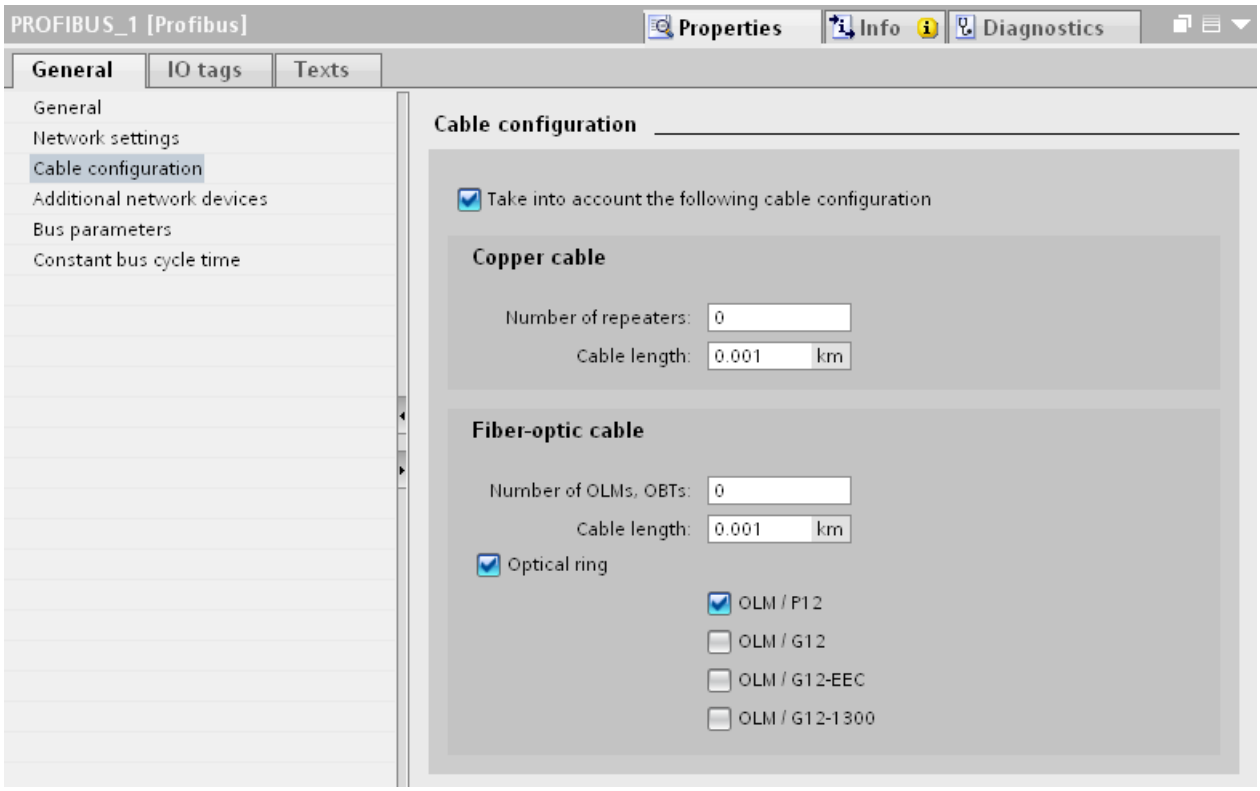


Figure 3-4 Cable configuration

Cable configuration: Fiber-optic cables / optical ring

The calculation depends on the used OLM types. Select the corresponding check box. Multiple selections are possible.

Adapt bus parameters in the optical ring

With the layout as ring, there is a kind of redundancy because you have the option to address all devices using the ring structure even if the connection to other devices is interrupted.

The following configuration conditions must be met in the optical ring:

- A free address below HSA (Highest Station Address)
- Increasing the retry value to at least 3

  (Network settings: user-defined profile)
- Checking and adapting the slot time

  (Network settings: user-defined profile; bus parameters: Tslot parameter:

  You need short slot time values for OLM / P12, median slot time values for OLM / G12 and OLM / G12-EEC and high slot time values for OLM / G12-1300. This results in a high performance for small networks and a medium to low performance with medium to large networks.

Additional information

Additional information on adaptation of the retry value and the slot time is available in the PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591).

3.5 Additional network stations

Communication load - considering additional network stations

The bus parameters depend on the communication volume of the active network stations. There are differences between cyclical communication (DP) and connection-oriented, acyclical communication (S7 communication, Send/Receive (FDL)). Contrary to DP, the number and size of the communication jobs (communication load) depends on the user program. This means the communication load cannot always be determined automatically.

If you select the check box "Consider the following network stations", you can consider network stations in the calculation of the bus times that were not configured in the project.

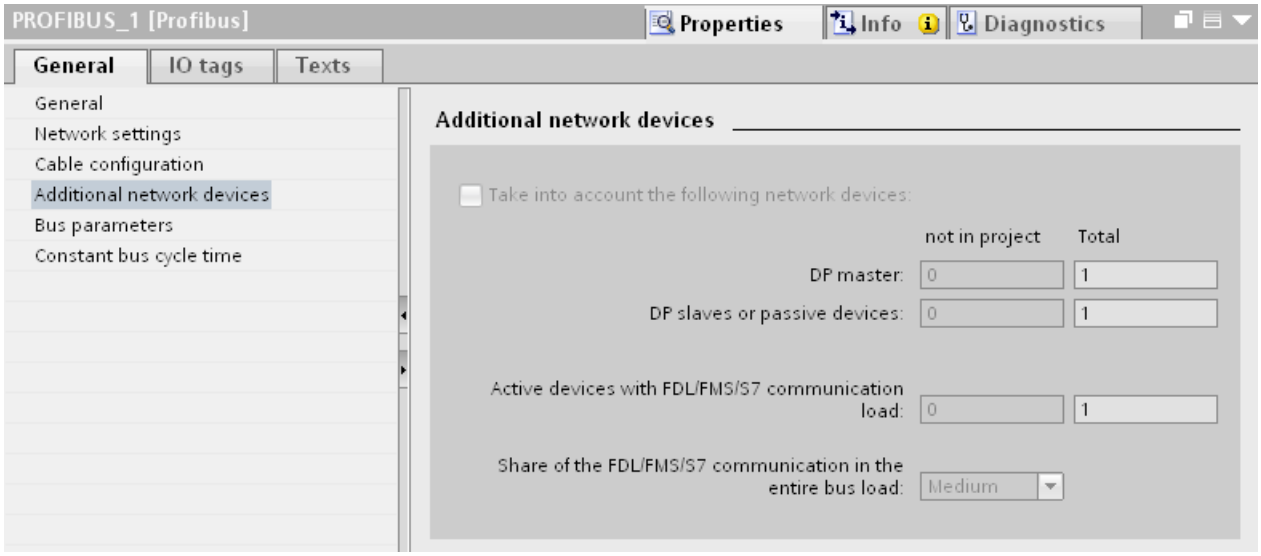


Figure 3-5 Additional network stations

Calculating the bus times

You can specify a network configuration in the parameter group "Additional network stations" for calculation of the bus times that deviates from the configured network configuration.

The network configuration is available for the following profiles:

- Standard
- Universal (DP/FMS)
- User-defined

Quantification of the communication load

The following settings are possible to take the communication load into consideration:

- Number of network stations that are not configured
- Information on the communication load from the user programs for FDL or S7 communication. You can choose from the following levels:
  - Low: Typical for DP, no larger data communication except DP.
  - Medium: Typical for mixed operation of DP and other communication services (e.g., S7 communication), if DP has high time requirements and with medium, acyclical communication volume.
  - High: For mixed operation of DP and other communication services (e.g., S7 communication), if DP has low time requirements and with high, acyclical communication volume.

3.6 Bus parameters

Introduction

Bus parameters control the transmission behavior on the bus.
Each device on the bus must correspond with the bus parameters of other devices.

Note

The PROFIBUS subnet will only work properly if the parameters for the bus profile have been synchronized. Change the preset values only if you are familiar with the parameter assignment of the bus profile for PROFIBUS.

Cyclical distribution of the bus parameters

If the check box "Activate cyclical distribution of bus parameters" is selected under "Bus parameters" with the selected PROFIBUS subnet in the Inspector window, the bus parameters are sent cyclically during operation by the modules that support this function. This way you can, for example, connect a programming device to the PROFIBUS during operation.

Disable this function in the following cases:

- In constant bus cycle time mode to minimize the bus cycle.
- If third-party devices are connected in the PROFIBUS subnet whose protocol uses the DSAP 63 (Destination Service Access Point) for multicast.

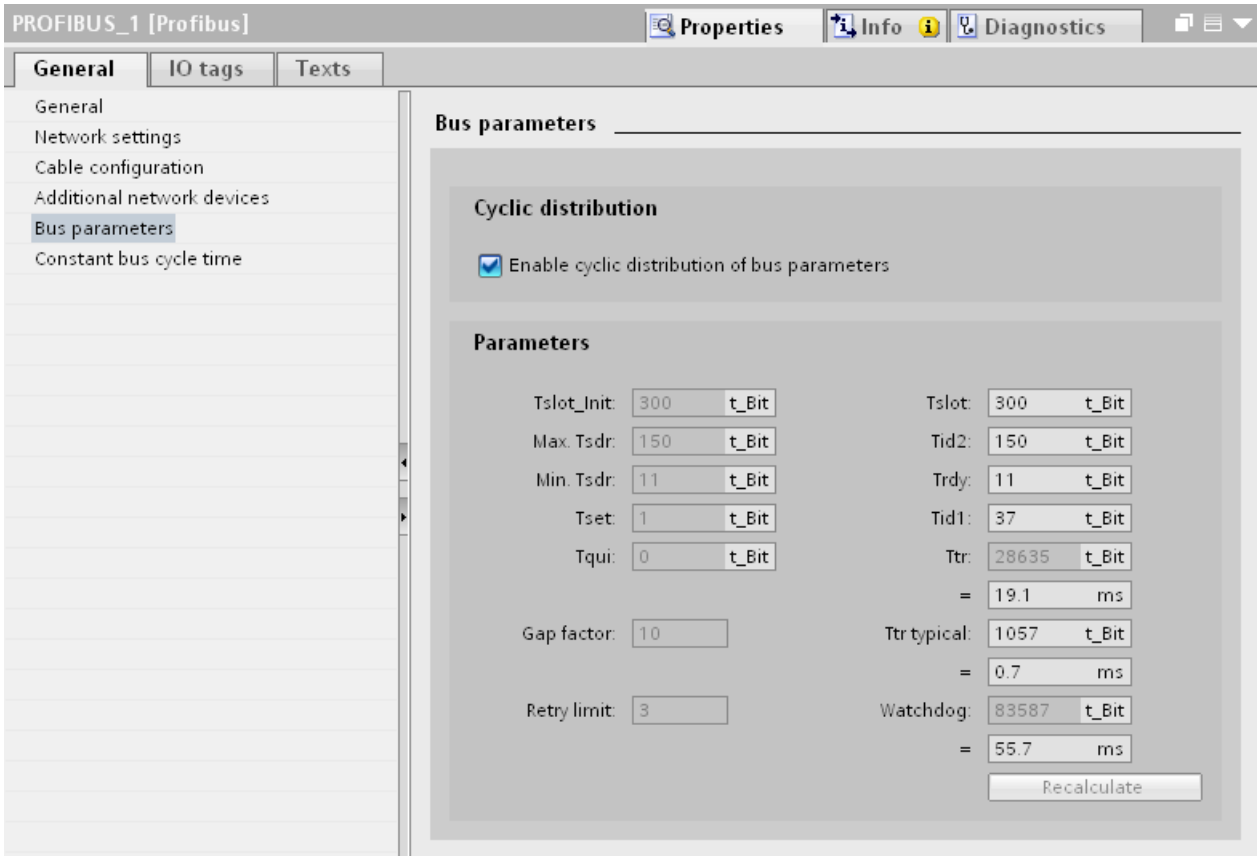


Figure 3-6 Bus parameters

Bus parameters for the bus profile of PROFIBUS subnets

Note

Display of offline values

The offline values of the bus parameters are always displayed even if they are connected online with the target system.

Table 3- 2 Bus parameters - value ranges

Bus parameters	Adjustable [1]	Limit values
Tslot_Init	Yes	Max. Tsdr + 15 <= Tslot_Init <= 16.383 t_Bit
Max. Tsdr	Yes	35 + 2*Tset + Tqui <= Max. Tsdr <= 1,023 t_Bit
Min. Tsdr	Yes	11 t_Bit <= Min. Tsdr <= MIN(255 t_Bit, ... Max. Tsdr - 1, 34 + 2*Tset + Tqui)
Tset	Yes	1 t_bit <= Tset <= 494 t_bit
Tqui	Yes	0 t_bit <= Tqui <= MIN(31 t_bit, Min. Tsdr - 1)
GAP factor	Yes	1 <= GAP factor <= 100
Retry limit	Yes	1 <= Retry limit <= 15
Tslot (slot time)	No	-
Tid2	No	Tid2 = Max. Tsdr
Trdy	No	Trdy = Min. Tsdr
Tid1	No	Tid1 = 35 + 2*Tset + Tqui
Ttr (Target Rotation Time)	Yes	256 t_Bit <= Ttr <= 16,777,960 t_bit
Ttr typical	No	This time is for information only and is not transmitted to the devices.
Watchdog		10 ms <= Watchdog <= 650 s

[1] depending on bus profile

User-defined bus profile

Use the following settings to create a user-defined bus profile:

- minimum Target Rotation Time (Ttr) = 5000x HSA
  (highest PROFIBUS address of an active device)
- minimum watchdog (Watchdog) = 6250x HSA

Recalculate

Use the button "Recalculate" to recalculate the parameters.

3.7 Constant bus cycle time

Constant bus cycle time

The DP master addresses its assigned DP slaves cyclically. S7 communication may cause the intervals to vary. You can enable a "bus cycle with constant bus cycle time" to achieve identical intervals. This ensures data transmission at the same (constant bus cycle time) intervals.

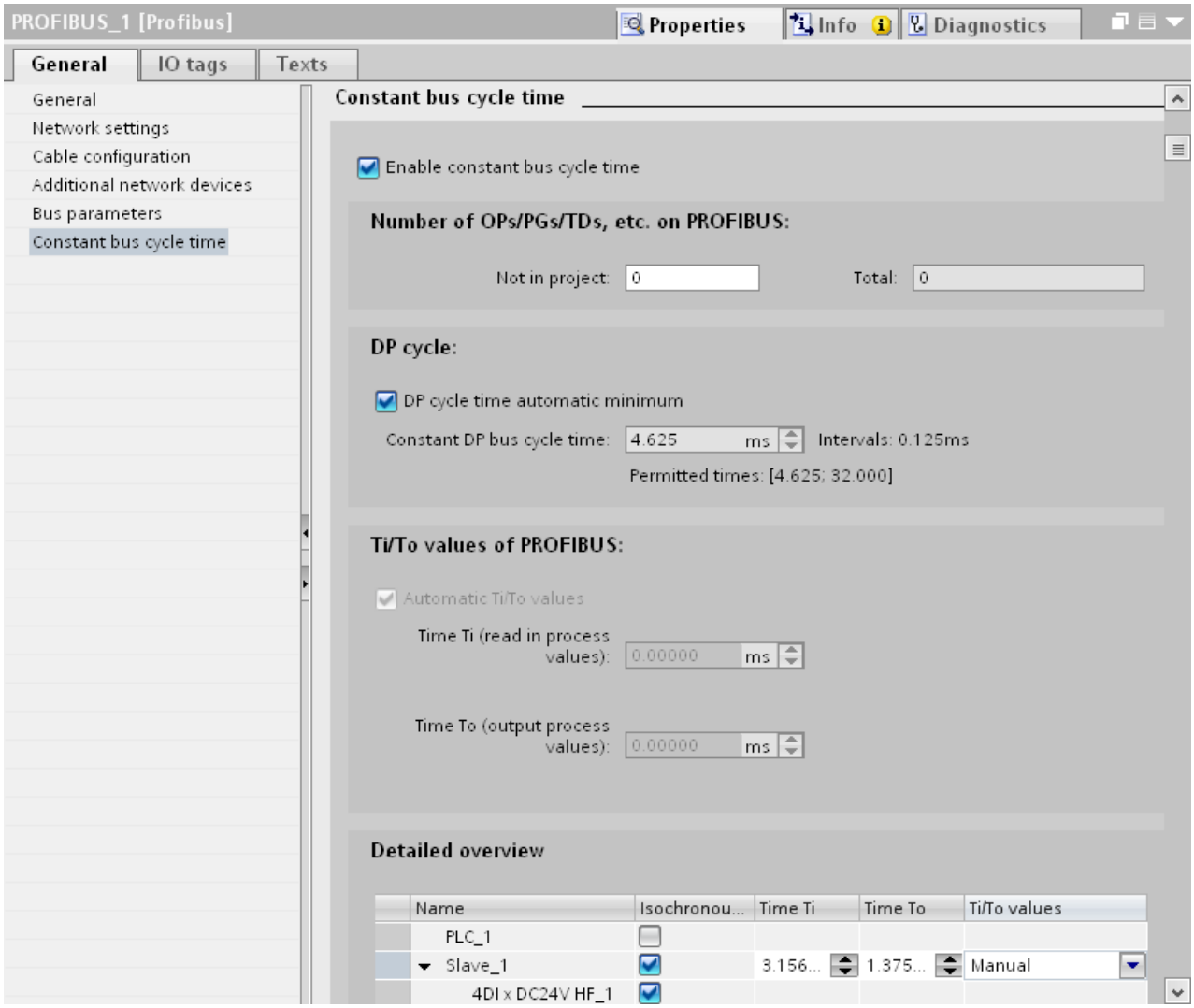


Figure 3-7 Enabling a bus cycle with constant bus cycle time

Number of OPs/PGs/TDs at the PROFIBUS

Here you enter the number of devices that are not configured.

Increasing DP cycle time manually

The following situation can occur especially with very short DP cycle times:
The runtime of the user program is greater than the shortest cycle
(see Technical specifications of the CPU, section "Isochronous mode").
You have to manually increase the automatically calculated DP cycle time in this case.

See also

Configuring isochronous mode (Page 66)

Diagnostics 4

4.1 Overview

Diagnostic options

In case of an error you can determine the current status of your automation system and react specifically by using the event-related diagnostics and the evaluation of interrupts.

You can use the following options for diagnostics of the PROFIBUS components:

- Determine the status of the system using the Lifelist in STEP 7.
- Evaluate the module status, error and message texts by using the display of the S7-1500 CPU.
- Run cable diagnostics during operation by means of the diagnostic repeater.
- Evaluate the diagnostics and interrupt behavior in isochronous mode. (Page 69)
- Determine status information for fault localization and fault rectification by using the DP/PA coupler FDC 157-0 configured as PROFIBUS diagnostic slave.

Additional information

Additional information on diagnostics is available in these manuals:

- In the Diagnostic repeater for PROFIBUS-DP (http://support.automation.siemens.com/WW/view/en/7915183) manual for diagnostics with STEP 7, diagnostics in the user program, monitoring function isochronous PROFIBUS, topology display in STEP 7.
- In the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) system manual for diagnostic options that are available for the automation systems S7-1500, ET 200MP and ET 200SP.
- In the PROFIBUS (http://support.automation.siemens.com/WW/view/en/35222591) network manual for diagnostics of fiber-optic cables.
- In the DP/PA coupler, active field distributors, DP/PA Link and Y Link (http://support.automation.siemens.com/WW/view/en/1142696) manual.
- In the Web server (http://support.automation.siemens.com/WW/view/en/59193560) manual for diagnostic options (depending on the functionality of the CPU).

4.2 Diagnostics using the display of the S7-1500

Displays

Each CPU in the S7-1500 automation system has a front cover with a display and operating buttons. Control and status information is displayed in different menus on the display.
You use the operating buttons to navigate through the menus.

The following states can be evaluated on the display:

- Module status for central and distributed modules
- Error and alarm texts (system diagnostics, user-defined alarms)

Module status

From the station overview you go to the module status for a distributed module via the module overview.

Figure 4-1 Example: Station overview, module overview, module status

Error and alarm texts

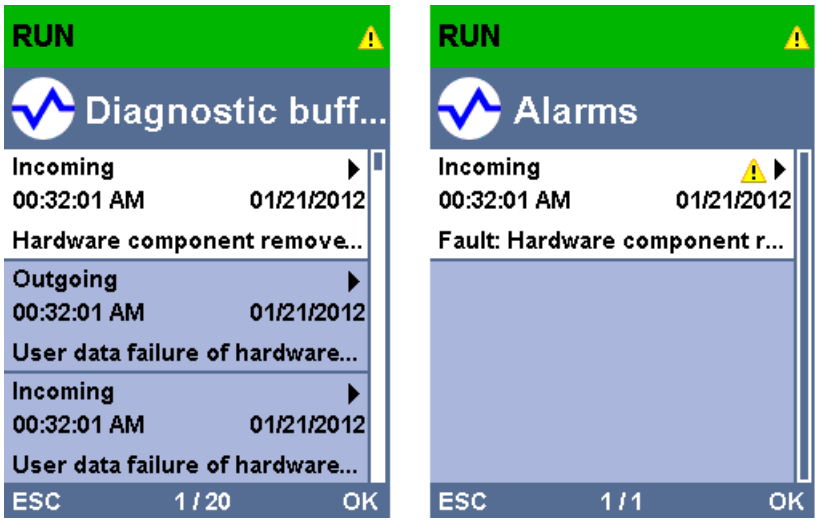


Figure 4-2 Example: Diagnostic buffer, alarms

Additional information

Additional information on the topic "Functions and operation of the display" is available in the documentation for the S7-1500 automation system on the Internet (http://support.automation.siemens.com/WW/view/en/59191792).

4.3 Diagnostics with the diagnostic repeater

Introduction

The diagnostic repeater is a repeater that can monitor two segments of a RS485-PROFIBUS subnet (copper cable) during operation and signal cable faults to the DP master by sending a diagnostic frame. Fault location and the cause of the fault can be displayed in plain text by means of STEP 7 as well as operator control and monitoring devices (SIMATIC HMI).

With its cable diagnostics during operation, the diagnostic repeater allows you to detect and localize cable faults early on. This means plant faults are detected early and plant downtimes can be prevented.

Diagnostic functions

- The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is specified relative to the devices present, for example "Break on signal line A and/or B".
- Reading out the saved diagnostic and statistical information.
- Monitoring of the isochronous PROFIBUS, e.g., violation of cycle time.
- Providing identification data.

Additional information

Additional information on diagnostics with STEP 7 and for reading out the diagnostics with the user program is available in the Diagnostic repeater for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/7915183) manual.

4.4 I&M data (Identification and Maintenance)

Definition and properties

Identification and maintenance data (I&M) is information saved in a module to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only, vendor-specific module information.

Maintenance data (M data) is system-specific information such as the installation location and date. M data is generated in the course of configuration and is written to the module memory.

The modules can be uniquely identified in online mode by means of the I&M data.

Additional information

Information if and to what extent a DP device supports I&M data is available in the respective device manual of the device.

Functions

5

5.1 Isochronous mode

5.1.1 What is isochronous mode?

Why isochronous mode?

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

Just-In-Time

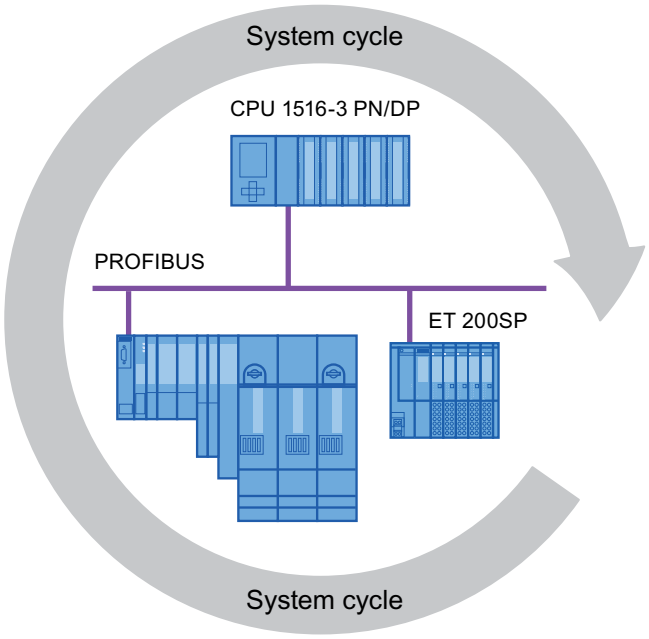


Figure 5-1 System cycle

The high speed and reliable reaction time of a system operating in isochronous mode is based on the fact that all data is provided just-in-time. The constant bus cycle time PROFIBUS DP cycle beats the time here.

Advantages of isochronous mode

The use of isochronous mode provides:

- Optimized controls
- Determinism
- Consistent (simultaneous) reading of input data
- Consistent (simultaneous) output of output data

5.1.2 Use of isochronous mode

The system property "isochronous mode" enables recording of measured values and process data in a defined system cycle. Signal processing takes place in the same system cycle all the way to switching to the "output terminal". This means isochronous mode improves the control quality and provides greater manufacturing precision. Isochronous mode drastically reduces the possible fluctuations of process response times. The time-assured processing can be used for a higher machine cycle.

Isochronous mode is basically always the choice when acquisition of measured values needs to be synchronized, movements need to be coordinated and process reactions need to be defined and take place simultaneously. This means the areas of applications for isochronous mode are manifold.

5.1.3 Isochronous applications

Example: Isochronous measurement at several measuring points

QC requires precise measurement of dimensions within a camshaft production process.

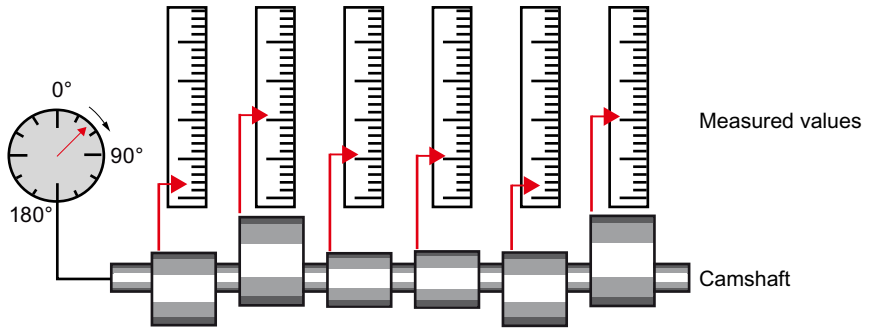


Figure 5-2 Measuring of camshafts

Isochronous workflow

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously and the time required for measurement is reduced. Resultant workflow:

- Continuous turning of the camshaft.
- During the continuous turning, measure the positions and cam excursion synchronously.
- Process the next camshaft.

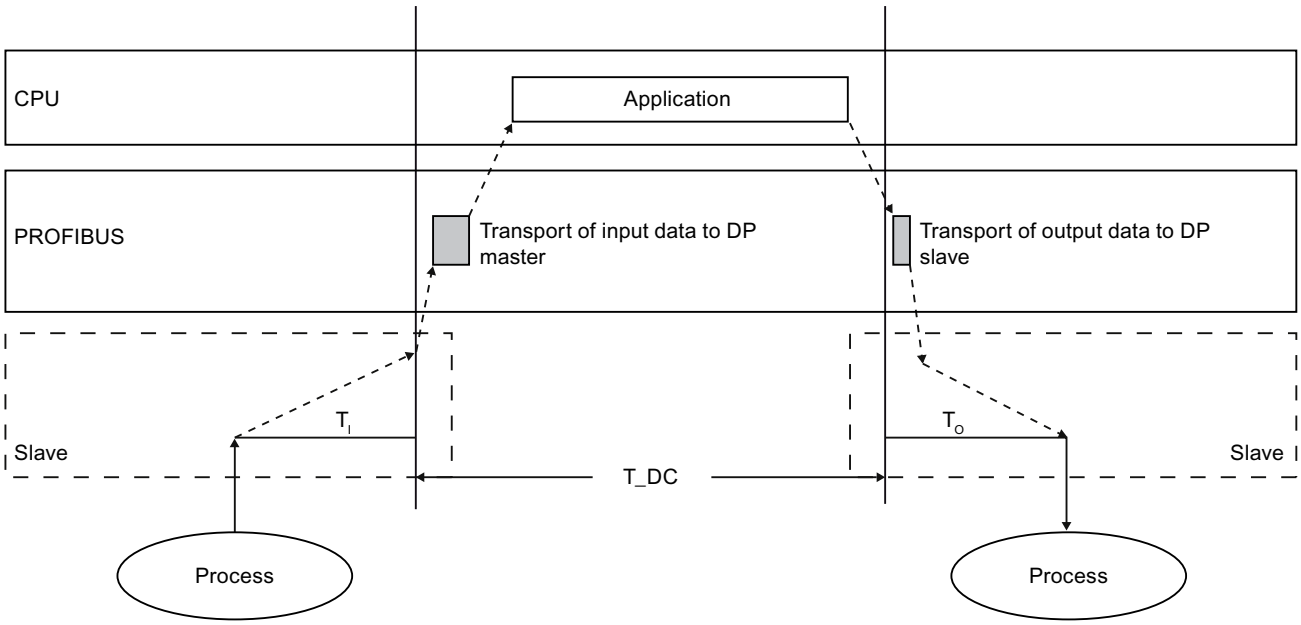
All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

5.1.4 Sequence of synchronization

From reading of input data to output of output data

The sequence of all components involved in the synchronization is explained in the paragraphs below:

- Isochronous reading of input data
- Transport of input data by means of the PROFIBUS subnet to the DP master (CPU)
- Further processing in the isochronous application of the CPU
- Transport of output data by means of the PROFIBUS subnet to the output DP slave
- Isochronous output of output data



T_DC Date cycle

T_I Time for reading the input data

T_O Time for output of output data

Figure 5-3 Time sequence of synchronization

To ensure that all input data is ready for transportation via the PROFIBUS DP line when the next PROFIBUS DP cycle begins, the I/O read cycle has a lead time T_I so that it starts earlier. The T_I is the "flash gun" for all inputs. This T_I is necessary to compensate for analog to digital conversion, backplane bus times, etc. The lead time T_I can be configured by STEP 7 or by the user. We recommend that you have T_I assigned automatically by STEP 7.

The PROFIBUS DP line transports the input data to the DP master. The synchronous cycle interrupt OB SynchronousCycle is called. The user program in the synchronous cycle interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

T_o is the compensation from the backplane bus and the digital to analog conversion within the slave. The T_o is the "flash gun" for all outputs. The time T_o can be configured by STEP 7 or by the user. We recommend that you have T_o assigned automatically by STEP 7.

Without isochronous mode, application, data transmission and field devices have their own, unsynchronized processing cycles; these result in a higher total cycle time with high jitter. With isochronous mode, application, data transmission and field device are synchronized resulting in a minimum total cycle with minimum jitter.

Isochronous mode and non isochronous mode distributed I/O

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one DP master.

5.1.5 Requirements for configuration

Note the following requirements for configuration of isochronous mode:

- Isochronous mode cannot be used in optical PROFIBUS networks.
- Constant bus cycle time and isochronous mode are only possible with the bus profiles "DP" and "User-defined".
- Isochronous mode is only possible with the DP interfaces integrated in the CPU. Isochronous mode with CPs for PROFIBUS is not possible.
- Only the constant bus cycle time master is permitted as active station on the isochronous PROFIBUS DP. OPs and PGs (for example, PCs with PG functionality) influence the time behavior of the isochronous DP cycle and are therefore not permitted.
- Isochronous mode is not permitted across lines.
- Isochronous I/O can only be processed in process image partitions. Isochronous consistent data transmission is not possible without the use of process image partitions. The adherence to quantity structures is monitored because the number of slaves and bytes on the DP master system is limited for each process image partition.
- The addresses of isochronous modules must be located in a process image partition.
- Full isochronous mode from "terminal" to "terminal" is only possible if all components involved in the chain support the system property "isochronous mode".

  Make sure you look for the entry "Isochronous mode" or "Isochronous processing" in the information box of the module when you select it in the catalog.
- When you configure isochronous mode, you may not assign a SYNC/FREEZE group to the slave.

5.1.6 Configuring isochronous mode

Introduction

A SIMATIC automation solution can be connected to the isochronous PROFIBUS with the isochronous mode function. Isochronous mode guarantees the synchronous reading of input data, the processing and output of output data at the same (isochronous) intervals.

Basic procedure for configuration of isochronous mode

1. Setting the properties for isochronous mode on the DP slave:
   - Isochronous DP cycle
   - Isochronous mode of the modules
2. Setting the properties for isochronous mode on the modules:
   - Synchronous cycle interrupt (SynchronousCycle)
   - Process image partition
   - Input delay
3. Create user program with access to isochronous I/O

Requirement

- The network view in STEP 7 is open.
- A S7-1500 CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An interface module has been placed and networked with the CPU (e.g., IM 151-1 HF).
- I/O modules have been placed (e.g., 2DI x DC24V HF and 2DO x DC24V/0,5A HF).

Configuring isochronous mode on the DP slave

1. Select the DP slave in the network view and navigate to the "isochronous mode" area in the Inspector window.
2. Enable the option for synchronization to the DP cycle for the DP slave.

   Default: The DP slaves get the Ti/To values from the subnet which means the values are automatically the same for all DP slaves of the DP master system.
3. Enable the "Isochronous mode" option the the "Detail view" for all I/O modules you want to operate in isochronous mode.
4. Repeat steps 1 and 3 for all DP slaves that you want to operate in isochronous mode.

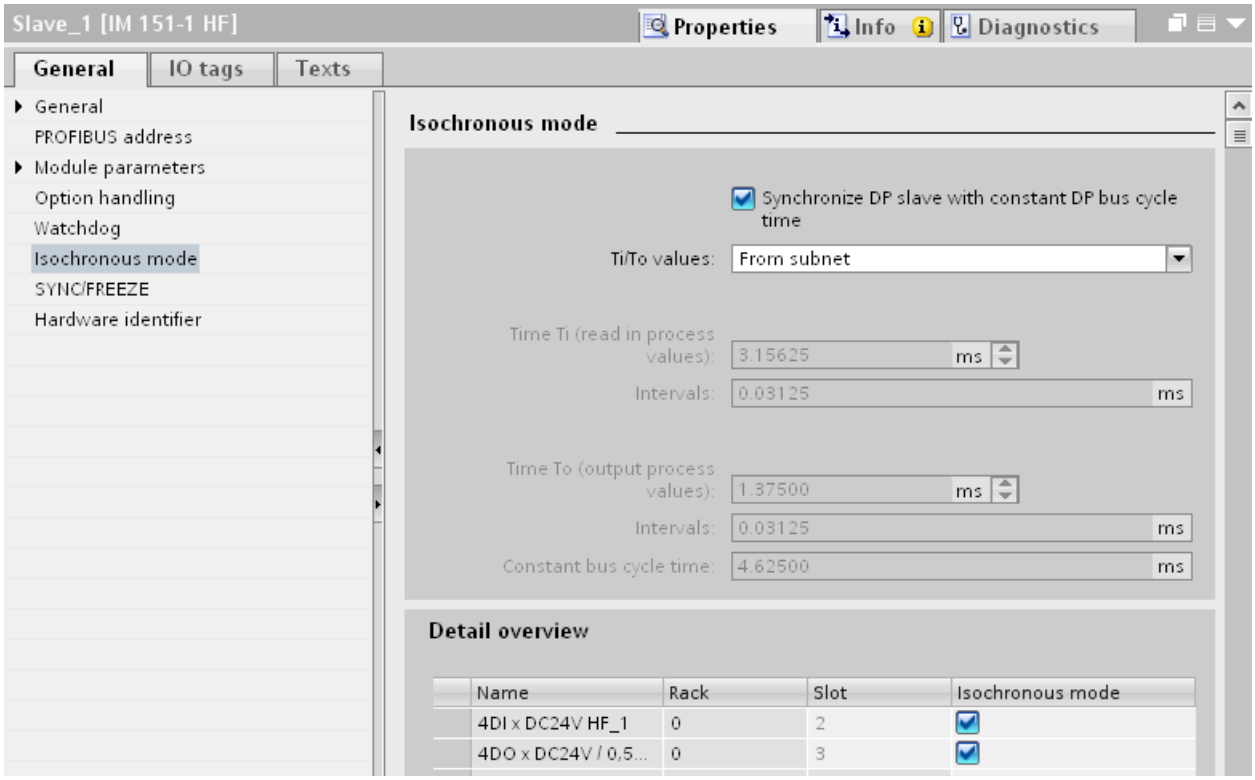


Figure 5-4 Configuring isochronous mode on the DP slave

Configuring synchronous cycle interrupt on the I/O module

1. Select an I/O module in the device view and navigate to the "I/O addresses" area in the Inspector window.
   – The option for isochronous mode is selected.
2. Select the synchronous cycle interrupt in the drop-down list.

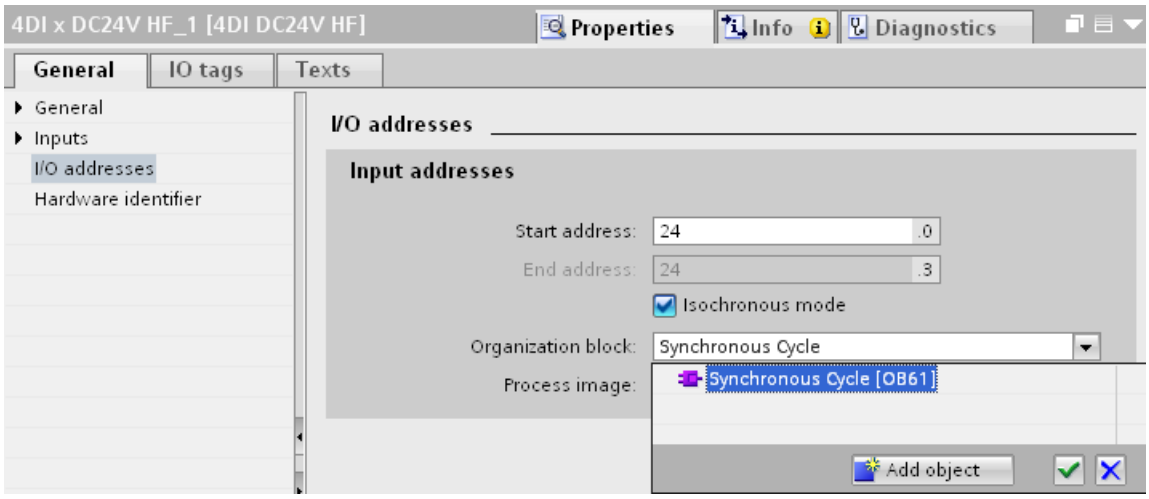


Figure 5-5 I/O addresses - creating the synchronous cycle interrupt OB

3. Assign the process image partition configured in the CPU.

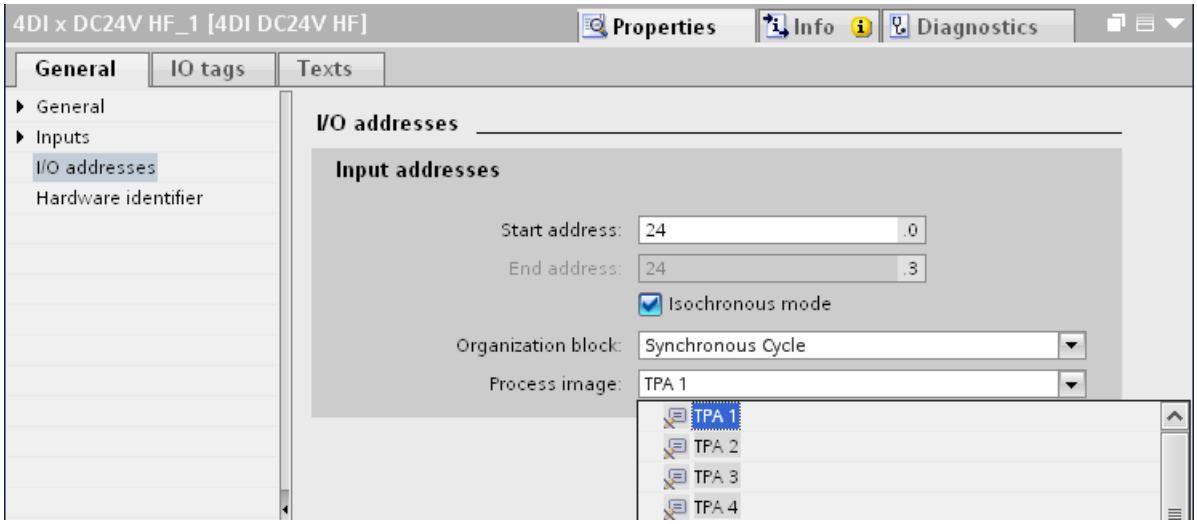


Figure 5-6 I/O addresses - assigning process image partitions

4. Repeat steps 1 and 3 for all I/O modules that you want to operate in isochronous mode.

Programming isochronous mode

To operate your plant in isochronous mode, the user program must be structured accordingly. This means you have to add a synchronous cycle interrupt in the STEP 7 project tree.

You access the isochronous I/O by means of a process image partition, which means the addresses of the isochronous modules must be located in a process image partition. You program access to isochronous I/O with the SYNC_PI instructions (updating the process image partitions of the inputs) and SYNC_PO (updating the process image partition of the outputs) in the synchronous cycle interrupt OB.

You call the SYNC_PI instruction at the start of the synchronous cycle interrupt OB, provided you have selected the automatic setting for the delay time. You call the SYNC_PO instruction at the end of the synchronous cycle interrupt OB.

5.1.7 Diagnostics and interrupt functions

The diagnostic and interrupt functions of STEP 7 are available for isochronous mode. These reduce downtimes and simplify localization and elimination of faults.

Events, causes of errors and remedies

Below, you will find the events for diagnostic and interrupt functions and remedies for the problem.

Table 5- 1 Events, causes of errors and remedies

Event	Cause of the error	Remedy
• Synchronous cycle interrupt OB is started with the input parameter EventCount > 0 (number of lost OB calls since last OB call) If configured: • Call of the time error OB • Diagnostic buffer entry "Buffer overflow for OB6x events"	The synchronous cycle interrupt OB takes too long.	• Shorten the synchronous cycle interrupt OB. • Increase the DP cycle. • Reduce the delay time setting (setting with isochronous mode at synchronous cycle interrupt OB).
Error (negative RetVals) when updating the isochronous process image partition with SYNC_PI / SYNC_PO: • Consistency warning • Update time is after / before the permitted access window.	SYNC_PI / SYNC_PO are not called in the permitted access window in the synchronous cycle interrupt OB, which means they are called or processed during the I/O data transfer on PROFIBUS.	• Increase the delay time. • Increase the DP cycle. • Adapt the program.
Error when updating the isochronous process image partition with SYNC_PI / SYNC_PO: • Access error	DP slave / module does not respond / is not available.	

5.1.8 Parameter settings for isochronous mode

Parameter changes as task of the field service technician

The task of a field service technician is to maintain the production process.

In this context the technician has to detect, localize and eliminate errors and performance losses of isochronous mode.

All parameters which influence isochronous mode can be checked and configured using the "Isochronous mode" dialog box.

Parameters should only be changed by experienced users or service technicians.

5.1.8.1 Viewing isochronous mode parameters

"Isochronous mode" dialog box

1. Select "Properties > Isochronous mode" in the Inspector window.

   The "isochronous mode" dialog box opens with an overview of parameters which influence isochronous mode.
   Information on the individual parameters is available under "Detail overview".

2. Compare the values shown with the values in the documentation, or with the value specified by a technician.

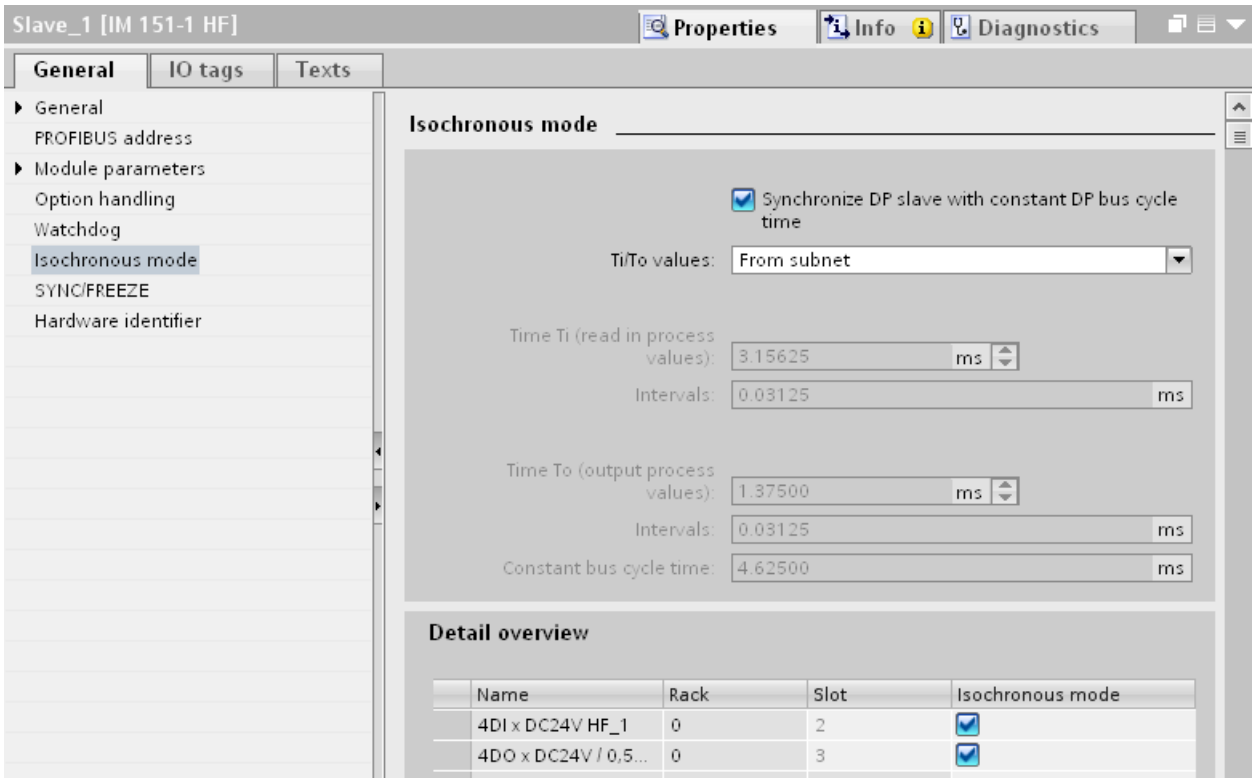


Figure 5-7 Viewing parameters for isochronous mode

5.1.8.2 Change parameters

Changing parameters for the DP master system

You can change the parameters for isochronous mode in the "Constant bus cycle time" dialog box.

1. Select the DP master system in the network view.
2. Select the section "Constant bus cycle time" in the Inspector window.
3. Change the parameters according to the received instructions.

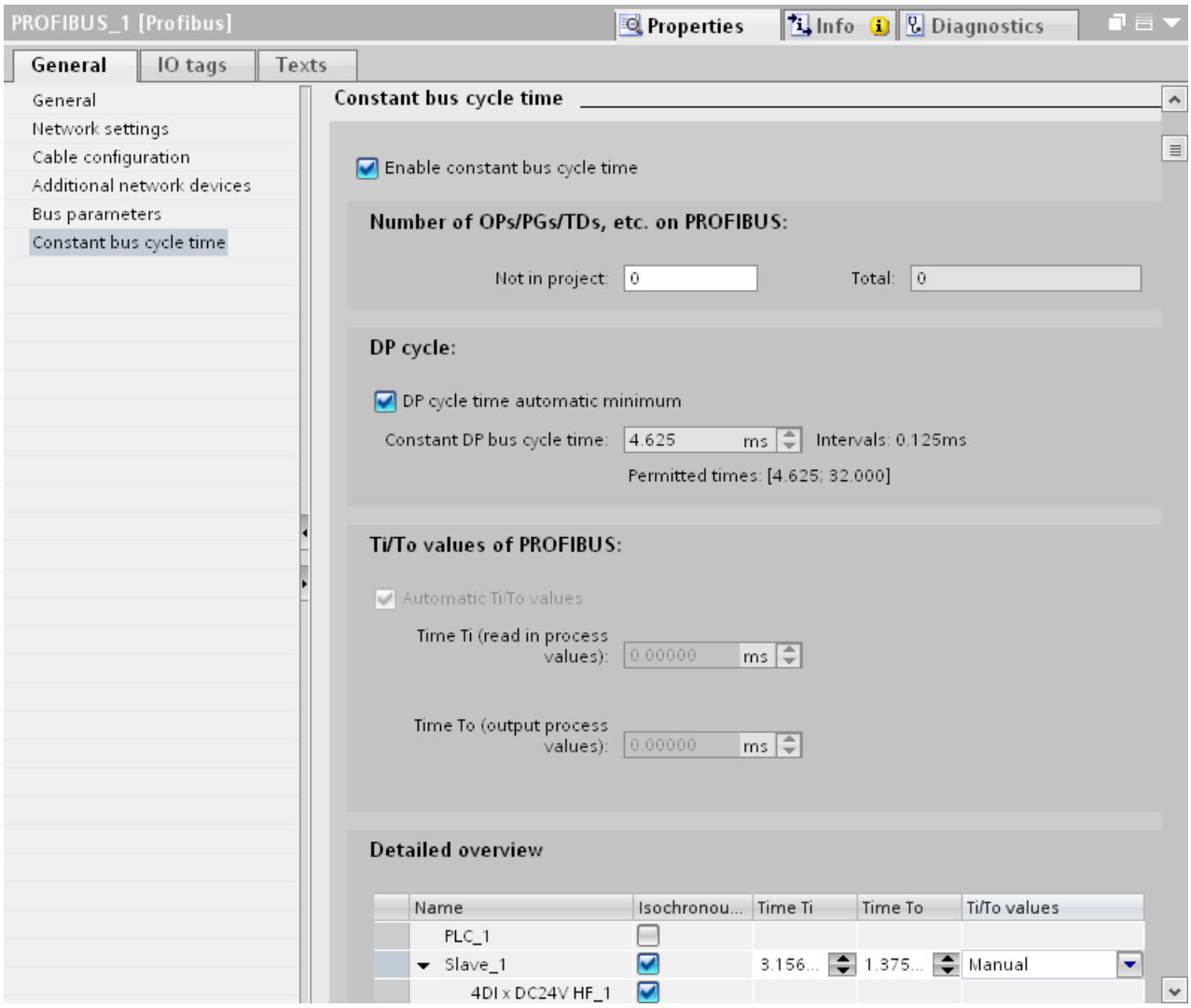


Figure 5-8 Changing parameters for the DP master system

Adapting the input delay

1. Select the input module in the device view.
2. Select the section "Inputs" in the Inspector window.
3. Adapt the input delay.

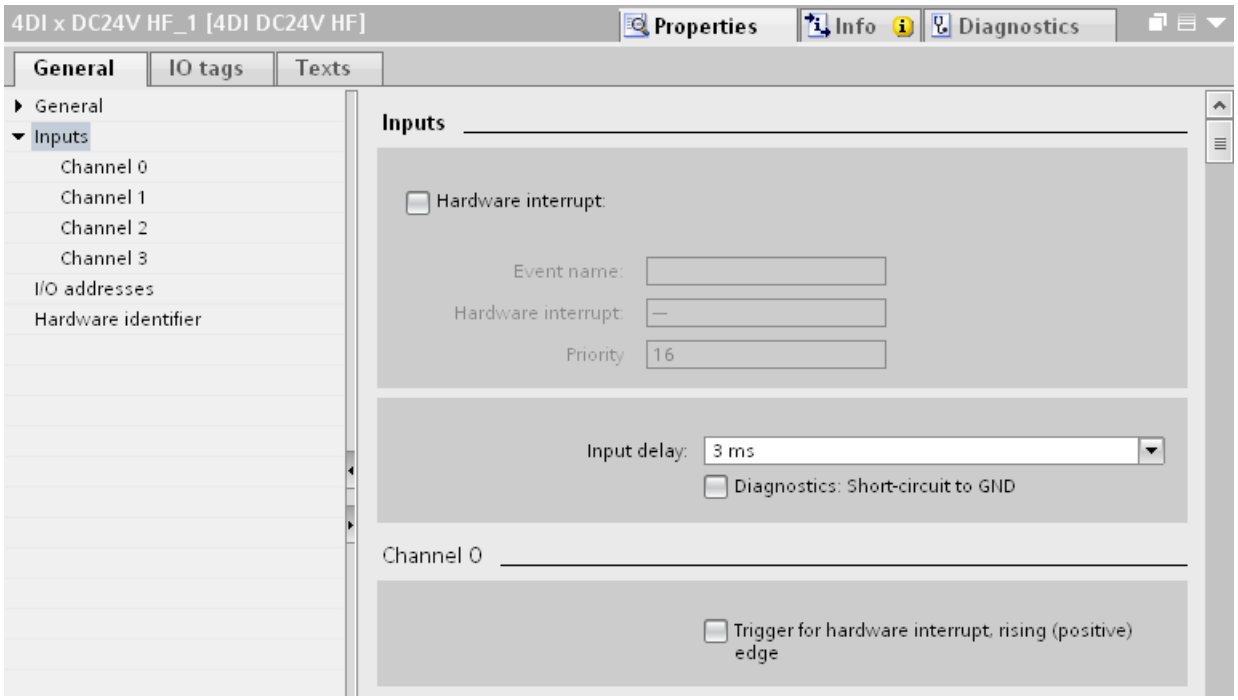


Figure 5-9 Adapting the input delay

Compile, load and save the changed configuration

1. Put the plant out of operation.
2. Select the CPU in the project navigator.
3. Select "Compile > Hardware" in the shortcut menu.
4. Select "Download to device" in the shortcut menu.
5. Save the project.

5.2 Acyclical data exchange

Additional functionality with DPV1 devices (DP master / DP slaves)

DP masters and DP slaves that support DPV1 have the following additional functions compared to the devices that support only DPV0:

- The acyclical data exchange between master and slave is supported.
- Interrupts can be set by a DPV1 slave which ensures treatment of the interrupt-triggering event in the master CPU.

Acyclical data exchange

Read/write data record, for example, to change the parameters of a slave during operation. The data records of a module and the structure of these data records is available in the documentation for the respective module.

The table below includes the instructions with their functions for access to DPV1 slaves. Detailed information is available in the STEP 7 online help.

Table 5- 2 Instructions for access to DPV1 slaves

Instructions	Function (DPV1)
RDREC	Read data record
WRREC	Write data record
RALRM	Receive interrupt from a DP slave. (The instruction must be called in the OB that triggers the interrupt.)

5.3 SYNC/FREEZE groups

Assigning the SYNC/FREEZE group to the DP slave

A DP master with the corresponding functionality can send the control commands SYNC and/or FREEZE for synchronization of the DP slaves simultaneously to a group of DP slaves. You must assign SYNC/FREEZE groups to the DP slaves for this purpose.

Requirement: A DP master system has been created in the project.

Procedure

To assign a DP slave to a SYNC/FREEZE group, follow these steps:

1. Select the DP interface of the DP slave you want to assign to a group in the device view or network view.
2. Select the check boxes for the required SYNC/FREEZE groups under the group "SYNC/FREEZE" in the Inspector window.

   You can assign each DP slave to only one SYNC/FREEZE group.

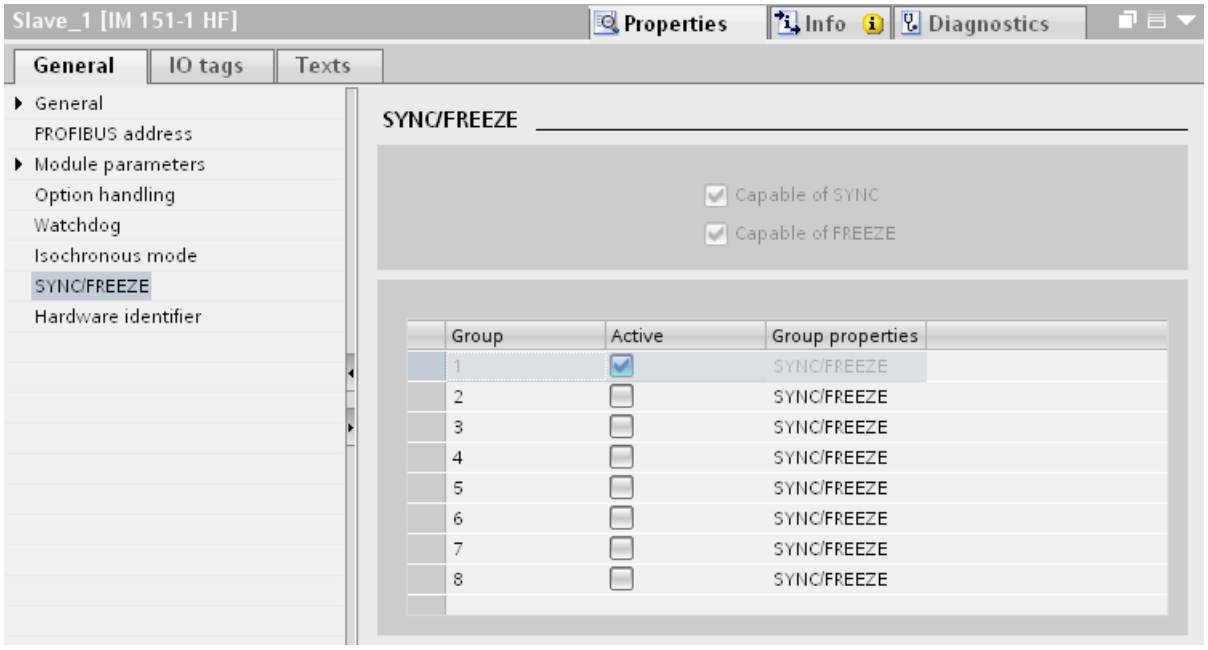


Figure 5-10 Assigning the DP slave to a SYNC/FREEZE group

Important information on the control commands SYNC and FREEZE

You can use the control commands SYNC and FREEZE in the DP master to synchronize the DP slaves event-controlled. The DP master sends the control commands simultaneously to a group of DP slaves in its master system. It does not take into consideration DP slaves that have failed or are currently sending diagnostic information.

Requirement for synchronization using control commands is that you have assigned the DP slaves to SYNC/FREEZE groups.

For a S7 CPU use the instruction DPSYC_FR (SFC 11) to synchronize the DP slaves.

When you select the DP master, you see a list of the eight SYNC/FREEZE groups under "Properties > DP interface > SYNC/FREEZE" in the Inspector window.

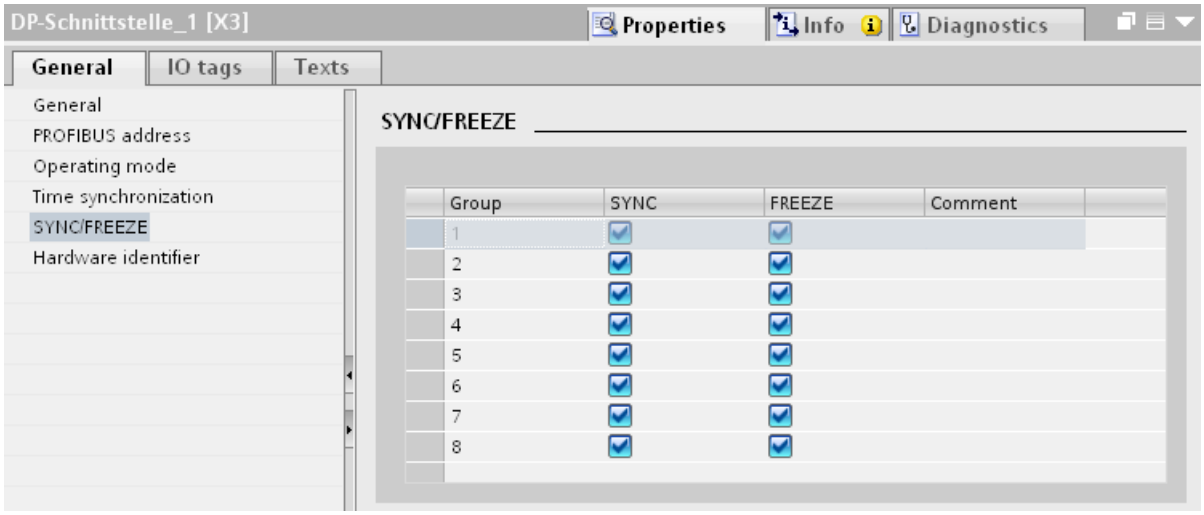


Figure 5-11 SYNC/FREEZE groups on DP master

SYNC control command

The DP master uses the SYNC control command to cause a group of DP slaves to freeze the states of their outputs to the current value.

The DP slaves save the output data of the DP master for the following frames. But the states of the DP slave outputs remain unchanged.

Only after each new SYNC control command does the DP slave set its outputs to the values that it has saved as the output data of the DP master.

The outputs are not updated cyclically again until the DP master has sent a UNSYNC control command.

FREEZE control command

After receiving the FREEZE control command from the DP master, the DP slaves of a group freeze the current status of their inputs. The DP slaves send these frozen input data to the DP master with the following cyclical frames.

The DP slaves freeze the current state of their inputs again after each new FREEZE control command.

The state of the DP slave inputs is only send to the DP master cyclically again when the DP master sends the UNFREEZE control command.

5.4 Interrupts

Interrupts and interrupt OBs for DPV1

Interrupts can be set by a DPV1 slave which ensures treatment of the interrupt-triggering event in the master CPU. The interrupt data is evaluated in the CPU even in the "STOP" operating mode and the diagnostic buffer and the module state are updated.
The OB is not processed in STOP.

The following DPV1 interrupts are supported:

- Status interrupt
- Update interrupt
- Vendor-specific interrupt

Detailed information is available in the descriptions on the OBs. You can use the corresponding OBs for diagnostic interrupts, process interrupts, pull/insert interrupts that are provided by the operating system of the S7-CPUs.

OB 55 interrupt - Status interrupt

The status interrupt can be triggered when the operating mode of a device or module changes, for example, from RUN to STOP.

OB 56 interrupt - Update interrupt

An update interrupt can be triggered if the parameters of a slot were changed.
This may be caused by local access or partner access to the parameters.

OB 57 interrupt - Vendor-specific interrupt

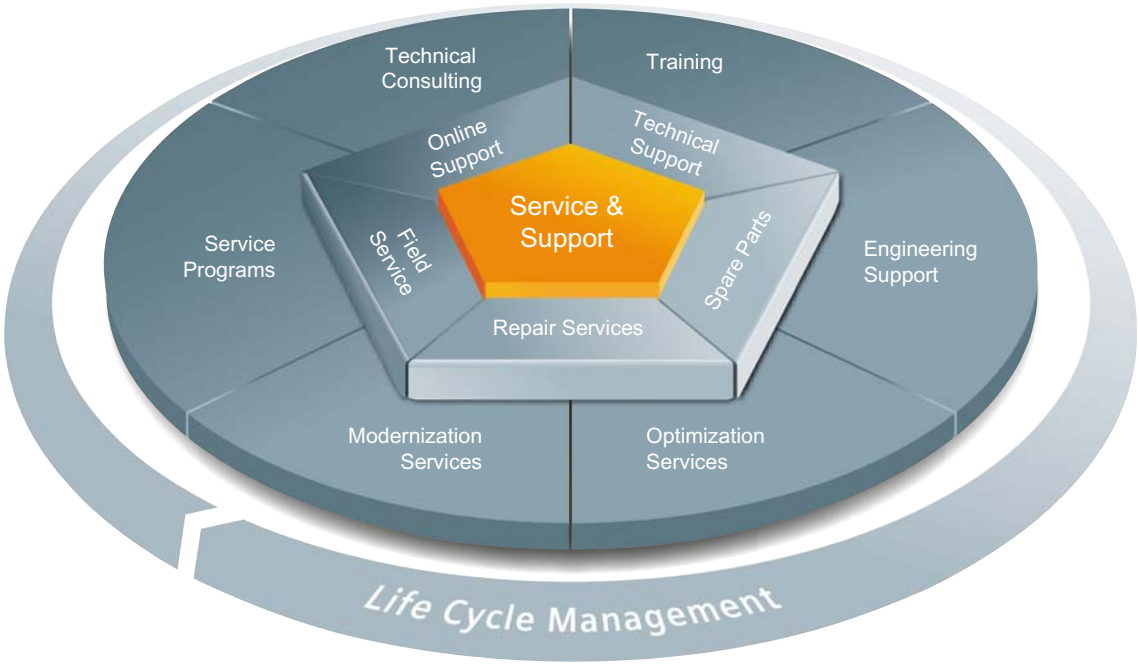
The event that triggers the vendor-specific interrupt can be specified by the manufacturer of a DPV1 slave.

Additional information

A detailed description of the events at which interrupts are triggered is available in the documentation of the respective manufacturer of the DPV1 slave.

Service & Support

A



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Glossary

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Bus

A common transfer route to which all nodes are connected; it has two defined ends.

In the case of PROFIBUS, the bus is a two-wire line or a fiber-optic cable.

Bus connector

Physical connection between the node and bus cable.

Bus system

All stations physically connected to a bus cable form a bus system.

Device

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus, for example, a DP slave by means of PROFIBUS DP.

Device

In the PROFIBUS environment, "device" is the generic term for:

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- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus,
for example, a DP slave by means of PROFIBUS DP.

Diagnostics

Monitoring functions for the recognition, localization, classification, display and further evaluation of errors, faults and alarms. They run automatically during plant operation. This increases the availability of plants because commissioning times and downtimes are reduced.

DP master

CPU or device that conducts the communication with the DP slaves according to a defined algorithm. To do this, the DP master uses the functions for communication with the DP slaves which are defined by PROFIBUS DP. It acts according to standard EN 50170, part 3.

See also Master

DP slave

Slave in the distributed I/O that is operated on the PROFIBUS with PROFIBUS DP protocol and acts according to standard EN 50170, part 3. It is addressed by the DP master and provides it with specified functions (I/O data, diagnostics, etc.).

See also Slave

DPV1

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality is integrated in IEC 61158/EN 50170, volume 2, PROFIBUS.

FDL

Fieldbus Data Link (bus access protocol). Step 2 with PROFIBUS.

HMI device

Human Machine Interface, device for visualization and control of automation processes

HSA

Highest Station Address. A bus parameter for PROFIBUS. Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, up to 126.

Industrial Ethernet

Guideline for establishing an Ethernet in an industrial environment. The major difference to the standard Ethernet is the mechanical loading capacity and noise immunity of the individual components.

I-slave

The "I-slave" functionality of a CPU supports the exchange of data with a DP master and can thus be used, for example, as intelligent preprocessing unit of partial processes. The I-slave is connected in its role as DP slave to a "higher-level" DP master.

Master

A master device that is in possession of the token can send data to other devices and request data from them (= active device).

PCF

Polymer Cladded Fiber (plastic-covered glass fiber)

POF

Polymer Optical Fiber (plastic fiber-optic cable made of light-conducting plastics)

Process image

Address area in the system memory of the DP master. At the start of cyclic program execution, the signal states of the input modules are transmitted to the process image of the inputs. And the end of cyclic program execution, the process image of the outputs is transmitted to the DP slave as signal state.

PROFIBUS

PROcess Field BUS, in IEC 61158-2 as "Type 3" standardized, bit-serial fieldbus system. The standard specifies functional, electrical and mechanical properties.

PROFIBUS is a bus system that networks automation systems and field devices compatible with PROFIBUS at the cell and field level. PROFIBUS is available with the protocols DP (= distributed periphery), FMS (= fieldbus message specification) or PA (process automation).

PROFIBUS address

Unique identification of a device connected to PROFIBUS. The PROFIBUS address is transmitted in the frame for addressing a device. A PC or programming device has the PROFIBUS address "0". DP masters and DP slaves have a PROFIBUS address in the range from 1 to 125.

PROFIBUS device

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485) or optical (Polymer Optical Fiber, POF) interface.

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O (fast, real-time capable, cyclic data exchange). From the perspective of the user program, the distributed I/O is addressed in exactly the same way as the centralized I/O.

PROFINET

Open, component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology supported by the PROFIBUS User Organization.

RS 485

Asynchronous data transmission process for PROFIBUS DP to ANSI TIA/EIA-RS485-A.

RS 485 repeater

Equipment for amplifying bus signals and for coupling segments over long distances.

Segment

The bus line between two terminating resistors forms a bus segment.

A bus segment can contain up to 32 bus nodes. Segments can be coupled, for example, by means of RS 485 repeaters or diagnostic repeaters.

Slave

Distributed device in a fieldbus system that may exchange data with a master after being requested to do so by the master. Slaves are all DP slaves, for example, such as ET 200SP, ET 200MP.

Standard mounting rail

Standardized metal profile to EN 50022.

The standard mounting rail is used for quick snap-on installation of network components, such as OLM, repeaters, etc.

Subnet

Part of a network whose parameters must be synchronized with the devices (e.g., with PROFIBUS). It includes the bus components and all connected stations.

SynchronousCycle

Name for synchronous cycle interrupt OB in STEP 7.

Target-Rotation-Time (Ttr)

Bus parameter for PROFIBUS. The token is the send permission for a device on PROFIBUS. A device compares a token rotation time it has measured with the Target-Rotation-Time and controls the sending of frames with high priority or low priority based on this comparison.

Terminating resistor

Component that terminates the ends of a data transmission line to prevent reflections in the transmission medium.

Terminator

Terminating resistor of bus segments with transmission rates of 9.6 kbps to 12 Mbps. The power supply is separate from the bus nodes.

TIA Portal

Totally Integrated Automation Portal

Topology

Structure of a network. Common structures are line topology, ring topology, star topology and tree topology.

Transmission rate

Specifies the number of bits transmitted per second.

Watchdog

Mechanism for monitoring the readiness for operation.

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PROFINET with STEP 7 V12

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01/2013

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This function manual provides an overview of the PROFINET communication system with SIMATIC STEP 7 V12.

STEP 7 V12 is integrated into the powerful graphical framework, Totally Integrated Automation Portal (TIA), the new development environment for all automation software tools.

This function manual supports you in planning a PROFINET system. The manual is structured into the following subject areas:

- PROFINET basics
- PROFINET diagnostics
- PROFINET functions

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Experience of working with STEP 7 (TIA Portal)

Scope

This documentation is the basic documentation for all SIMATIC products from the PROFINET environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

Conventions

STEP 7: In this documentation "STEP 7" is used as a synonym for "STEP 7 V12 (TIA portal)" and subsequent versions of the configuration and programming software.

This documentation contains pictures of the devices described.
The pictures may differ slightly from the device supplied.

Please also observe notes marked as follows:

Note

The notes contain important information on the product, handling the product or on part of the documentation to which particular attention should be paid.

Additional support

You will find information about available technical support in the appendix Service & Support (Page 157).

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers all aspects of your automation system.

The complete documentation for the S7-1500, ET 200SP and ET 200MP systems consists of the system manuals, function manuals and manuals of the products.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Overview of the documentation for PROFINET

The following table lists additional documents which supplement this description of PROFINET and are available on the Internet.

Subject	Documentation	Most important contents
General information on PROFINET	Brochure (http://www.automation.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_8097497&InfoType=brochures) PROFINET	• Application examples • Hardware • Software
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	Configuring and programming with the engineering software
System diagnostics	System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual	For S7-1500, ET 200MP, ET 200SP: • Overview • Output media • Configuration options
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925) function manual	For S7-1500, ET 200MP, ET 200SP: • Interfaces for communication • Communications services
Description of the Systems	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning • I&M data

Subject	Documentation	Most important contents
Networks	Manual SIMATIC NET: Twisted Pair- und Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)	• Ethernet networks • Network configuration • Network components
Security	Industrial Ethernet Security manual (http://support.automation.siemens.com/WW/view/en/56577508)	Overview and description of the security functions in Industrial Ethernet

Additional information on PROFINET can be found on the Internet (http://www.profibus.com).

SIMATIC Manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Description 2

2.1 Introduction to PROFINET

What is PROFINET IO?

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the logical further development of:

- PROFIBUS DP, the established fieldbus and
- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of Ethernet technology. This ensures the integration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS/PROFINET International defines a cross-vendor communication, automation, and engineering model.

Objectives of PROFINET

The objectives of PROFINET:

- Industrial networking, based on Industrial Ethernet (open Ethernet standard)
- Compatibility of Industrial Ethernet and standard Ethernet components
- High robustness due to Industrial Ethernet devices. Industrial Ethernet devices are suited to the industrial environment (temperature, noise immunity, etc.).
- Use of IT standards such as TCP/IP, http.
- Real-time capability
- Seamless integration of other fieldbus systems

Implementation of PROFINET in SIMATIC

PROFINET is implemented in SIMATIC as follows:

- We have implemented communication between field devices in SIMATIC with **PROFINET IO**.
- Installation technology and network components are available as SIMATIC NET products.
- Ethernet standard protocol and procedures (e.g., SNMP = Simple Network Management Protocol for network parameter assignment and diagnostics) are used for remote maintenance and network diagnostics.

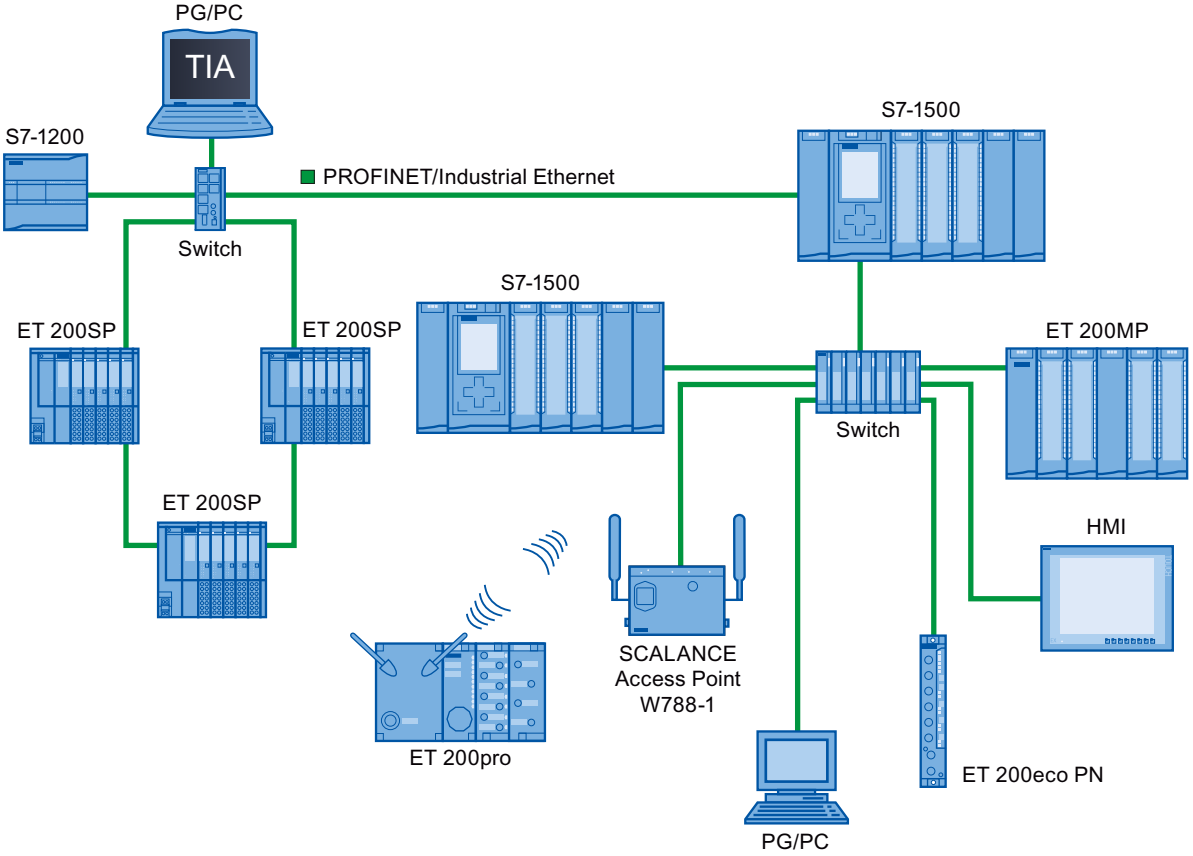


Figure 2-1 PROFINET overview configuration

STEP 7

The STEP 7 engineering tool supports you in setting up and configuring an automation solution. STEP 7 provides a uniform application view over all bus systems.

Documentation from PROFIBUS & PROFINET International on the Internet

You will find numerous documents on the topic of PROFINET at the Internet address (http://www.profibus.com) of the "PROFIBUS & PROFINET International" PROFIBUS user organization, which is also responsible for PROFINET.

Additional information can be found on the Internet (http://www.siemens.com/profinet).

2.1.1 PROFINET terms

Definition: Devices in the PROFINET environment

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

Functional differences of the PROFINET interfaces

A PROFINET device features at least one PROFINET interface.

PROFINET interfaces can provide different functions. PROFINET interface functions include identification, configuration, diagnostics and communication services (e.g., open communication). PROFINET interfaces that provide PROFINET IO functions and network security functions are also available.

The following table illustrates the differences using the example of the CPU 1516-3 PN/DP, which features two PROFINET interfaces with different functionality.

Table 2- 1 Functionality of the PROFINET interfaces of the CPU 1516-3 PN/DP

PROFINET interface (X1)	PROFINET interface (X2)
2 ports with PROFINET IO functionality:	1 port with PROFINET functionality:
• Identification, configuration and diagnostics	
• PG communication	
• HMI communication	
• S7 communication	
• Time synchronization	
• Web server	
• Open communication	
• IO controller	-
• I-device	-
• RT/IRT	-
• Isochronous mode	-
• Media redundancy	-
• Prioritized startup	-

Additional Information on the Functionality of PROFINET interfaces

You can find information on the number and functionality of the interfaces of a PROFINET device in the documentation for the specificPROFINET device.

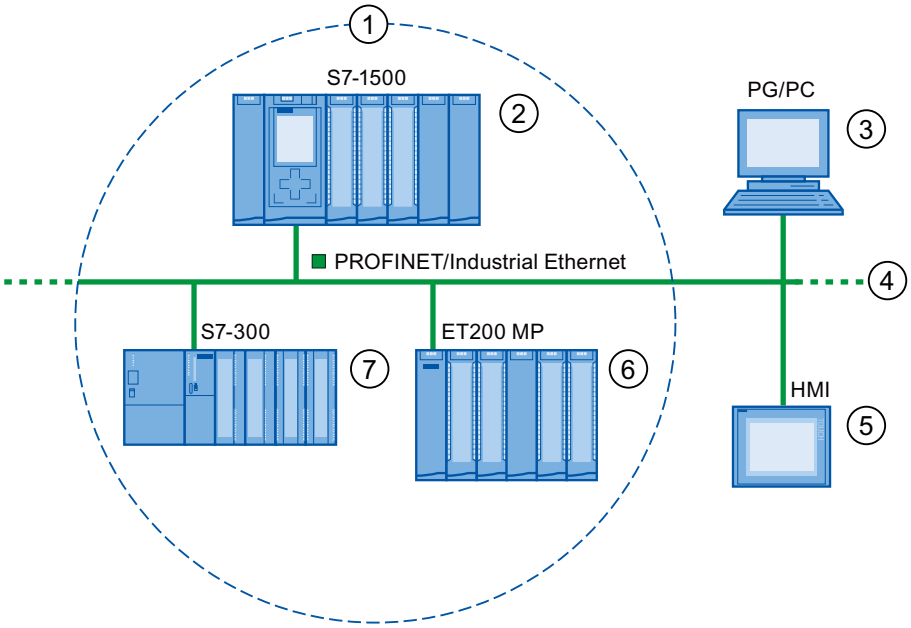
PROFINET communication services are described in the Communication function manual (http://support.automation.siemens.com/WW/view/en/59192925).

In the Network security (Page 35) section you can find components that are used to protect networks against hazards.

The Functions (Page 93) section describes the PROFINET IO functions.

PROFINET IO Devices

The following graphic shows the general names used for the most important devices in PROFINET. In the table below the graphic you can find the names of the individual components in the PROFINET IO context.

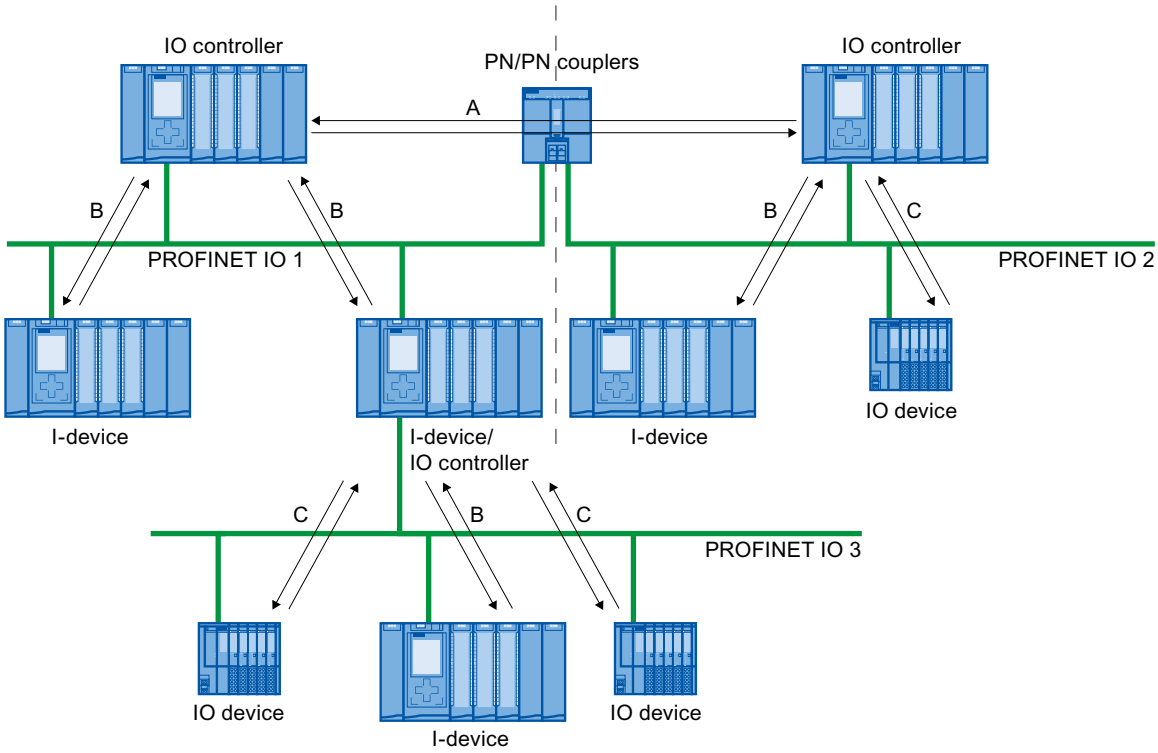


Number	PROFINET	Explanation
①	PROFINET IO System	
②	IO controller	Device used to address the connected IO devices. This means that: The IO controller exchanges input and output signals with field devices.
③	Programming device / PC (PROFINET IO supervisor)	PG/PC/HMI device used for commissioning and for diagnostics
④	PROFINET / Industrial Ethernet	Network infrastructure
⑤	HMI (Human Machine Interface)	Device for operating and monitoring functions.
⑥	IO device	A distributed field device that is assigned to one of the IO controllers (e.g., Distributed IO, valve terminals, frequency converters, switches with integrated PROFINET IO functionality)
⑦	I-device	Intelligent IO device

Figure 2-2 PROFINET devices

I/O communication via PROFINET IO

The inputs and outputs of distributed I/O devices are read and written by means of PROFINET IO using what is referred to as I/O communication. The following figure provides an overview of I/O communication by means of PROFINET IO



A IO controller - IO controller communication
B IO controller - I-device communication
C IO controller - IO device communication

Figure 2-3 I/O communication via PROFINET IO

I/O communication via PROFINET IO

Table 2- 2 I/O communication via PROFINET IO

Communication between ...	Explanation
IO controllers and IO devices	The IO controller sends data to the IO device of its PROFINET IO system and receives data from this within a time interval.
IO controller and I-device	A fixed quantity of data is transferred cyclically between the user programs in CPUs of IO controllers and I-devices. The IO controller does not access the I/O module of the I-device, but instead accesses configured address ranges, i.e. transfer ranges, which may be located inside our outside the process image of the CPU of the I-device. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access.
IO controller and IO controller	A fixed quantity of data is cyclically transferred between the user programs in CPUs of IO controllers. A PN/PN coupler is required as additional hardware. The IO controllers mutually access configured address ranges, i.e. transfer ranges, which may be located inside or outside the process image of the CPU. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access.

2.1.2 Basic terminology of communication

PROFINET communication

PROFINET communication takes place via Industrial Ethernet.
The following transmission types are supported:

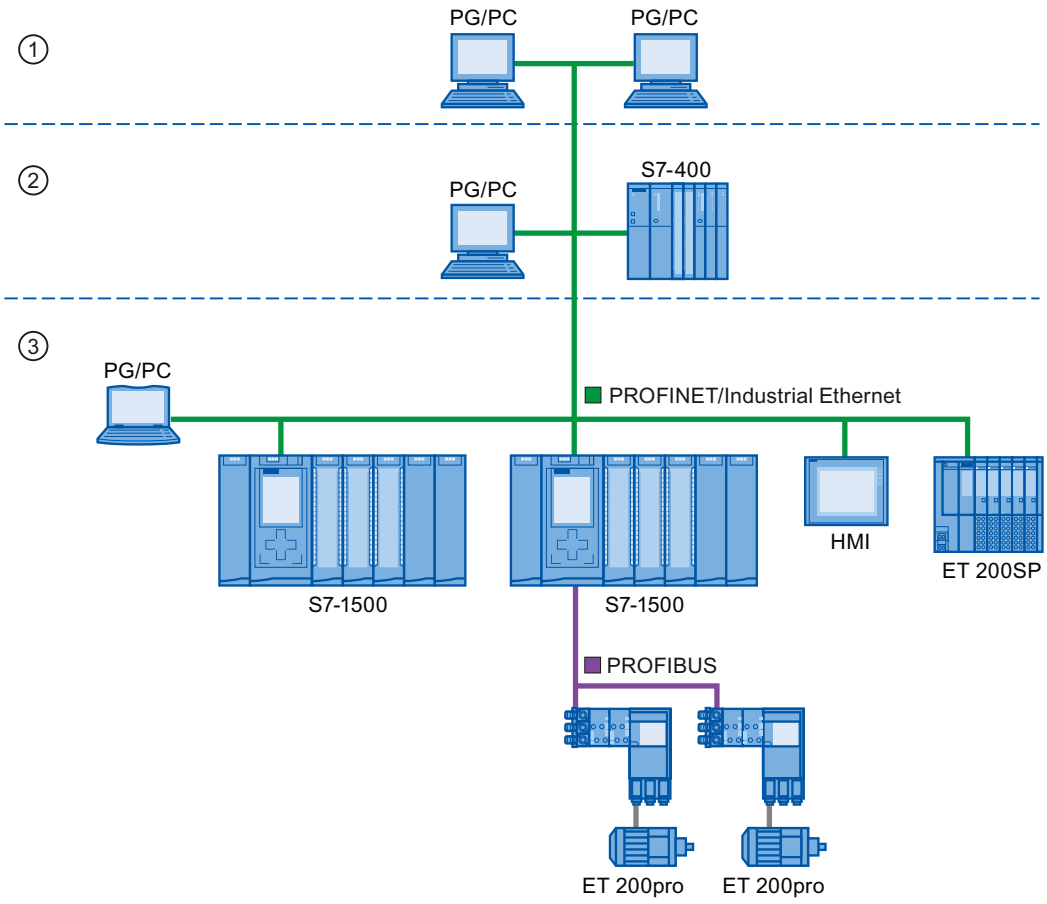
- Acyclic transmission of engineering and diagnostic data and interrupts
- Cyclic transmission of user data

The PROFINET-IO communication takes place in real-time.

For additional information on the real-time communication,
refer to chapter Real-time communication. (Page 120).

Transparent data access

Access to process data from different levels of the factory is supported by PROFINET communication. By using Industrial Ethernet, standard mechanisms of communication and information technology such as OPC/XML can now be used along with standard protocols such as UDP/TCP/IP and HTTP in automation engineering. This allows transparent access from company management level directly to the data from the automation systems at the control level and production level.



① Management level
② Control level
③ Production level

Figure 2-4 Access to process data

Update time

The update time is a time interval. An IO device / I-device in the PROFINET IO system is supplied cyclically with new data from the IO controller within this time interval. The update time can be configured separately for each IO device and determines the interval at which data is sent from the IO controller to the IO device (output module/submodule) as well as from the IO device to the IO controller (input module/submodule).

STEP 7 calculates the update time automatically in the default setting for each IO device of the PROFINET IO system, taking into account the volume of data to be exchanged as well as the set send clock.

For additional information on the update time, refer to section Real-time communication. (Page 120).

Watchdog time

The watchdog time is the time interval that an IO controller or IO device permits, without receiving IO data. If the IO device is not supplied by the IO controller with data within the watchdog time, the device detects the missing frames and outputs substitute values. This is reported in the IO controller as a station failure.

In STEP 7, the watchdog time is made up from an integral multiple of the update time and can be set by the user.

Send clock

The period of time between two consecutive communication cycles.
The send clock is the shortest possible interval in data exchange.

Relationship between the update time and send clock

The calculated update times are step-downs (1, 2, 4, 8, ..., 512) of the send clock. The minimum possible update time thus depends on the minimum send clock of the IO controller that can be set and the efficiency of the IO controller and IO device. Depending on the send clock, only a part of the step-downs can be available (STEP 7 guarantees this through a pre-selection).

The following tables illustrate the dependency of the update time that can be set on the send clock, using an example of the CPU 1516-3 PN/DP. The update times satisfy the requirements of the PROFINET standard IEC 61158

Table 2- 3 With real-time communication the following applies:

Send clock	Update time	Step-downs
250 µs	250 µs to 128 ms	1,2, ..., 512
500 µs	500 µs to 256 ms	1,2, ..., 512
1 ms	1 ms to 512 ms	1,2, ..., 512
2 ms	2 ms to 512 ms	1,2, ..., 256
4 ms	4 ms to 512 ms	1,2, ..., 128

Further information

For information on real-time communication, refer to the section Real-Time Communication (RT) (Page 121).

2.1.3 PROFINET interface

Overview

PROFINET devices of the SIMATIC product family have one or more PROFINET interfaces (Ethernet controller/interface). The PROFINET interfaces have one or more ports (physical connection options).

In the case of PROFINET interfaces with multiple ports, the devices have an integrated switch.

PROFINET devices with two ports on one interface allow you to configure the system in line or ring topology. PROFINET devices with three and more ports on one interface are also ideal for setting up tree topologies.

Properties and rules for naming the PROFINET interface and its representation in STEP 7 are explained in the following.

Properties

Every PROFINET device on the network is uniquely identified via its PROFINET interface. For this purpose, each PROFINET interface has:

- A MAC address (factory default)
- An IP address
- A device name

Identification and numbering of the interfaces and ports

Interfaces and ports for all modules and devices in the PROFINET system are identified with the following characters:

Table 2- 4 Identification for interfaces and ports of PROFINET devices

Element	Symbol	Interface number
Interface	X	In ascending order starting from number 1
Port	P	In ascending order starting from number 1 (for each interface)
Ring port	R	

Examples of identification

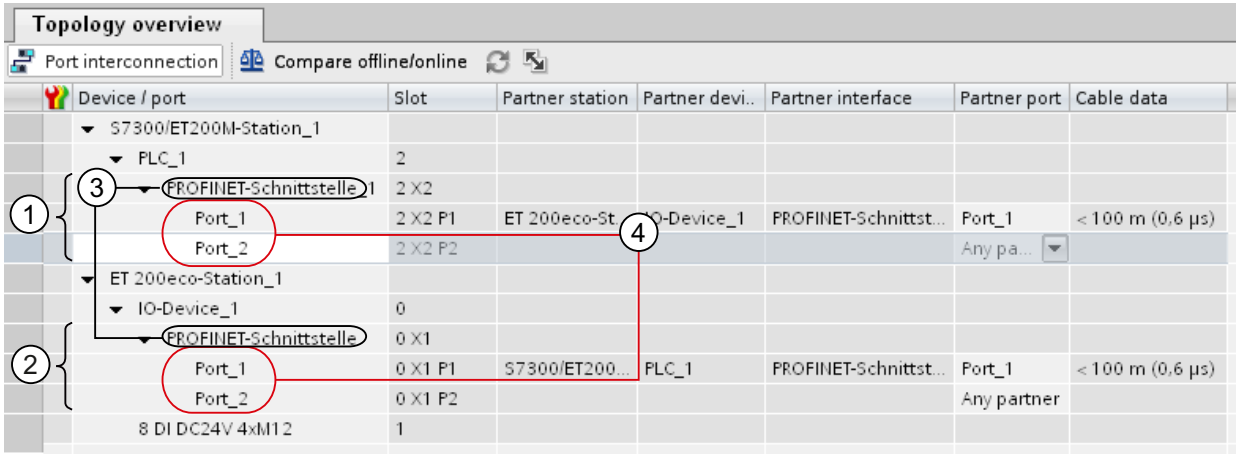
Three examples illustrate the rules for identifying PROFINET interfaces:

Table 2- 5 Examples for identifying PROFINET interfaces

Sample labeling	Interface number	Port number
X2 P1	2	1
X1 P2	1	2
X1 P1 R	1	1 (ring port)

Representation of PROFINET Interfaces in the Topology Overview in STEP 7

You can find the PROFINET interface in the topology overview in STEP 7 The PROFINET interface for an IO controller and an IO device is represented as follows in STEP 7:



Number	Description
①	PROFINET interface of an IO controller in STEP 7
②	PROFINET interface of an IO device in STEP 7
③	These lines represent the PROFINET interface.
④	These lines represent the "ports" of a PROFINET interface.

Figure 2-5 Representation of the PROFINET interfaces in STEP 7

Schematic Representation of a PROFINET Interface with Integrated Switch

The following schematic diagram shows the PROFINET interface with integrated switch and its ports for all PROFINETdevices.

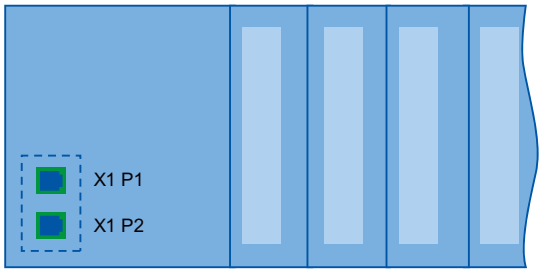


Figure 2-6 PROFINET interface with integrated switch

2.1.4 Implementation of the PROFINET device model in SIMATIC

Slots and modules

A PROFINET device can have a modular and compact structure. A modular PROFINET device consists of slots into which the modules are inserted. The modules have channels which are used to read and output process signals. A compact device has the same design and can include modules, however, it cannot be physically expanded, which means that no modules can be inserted.

This is illustrated by the following graphic.

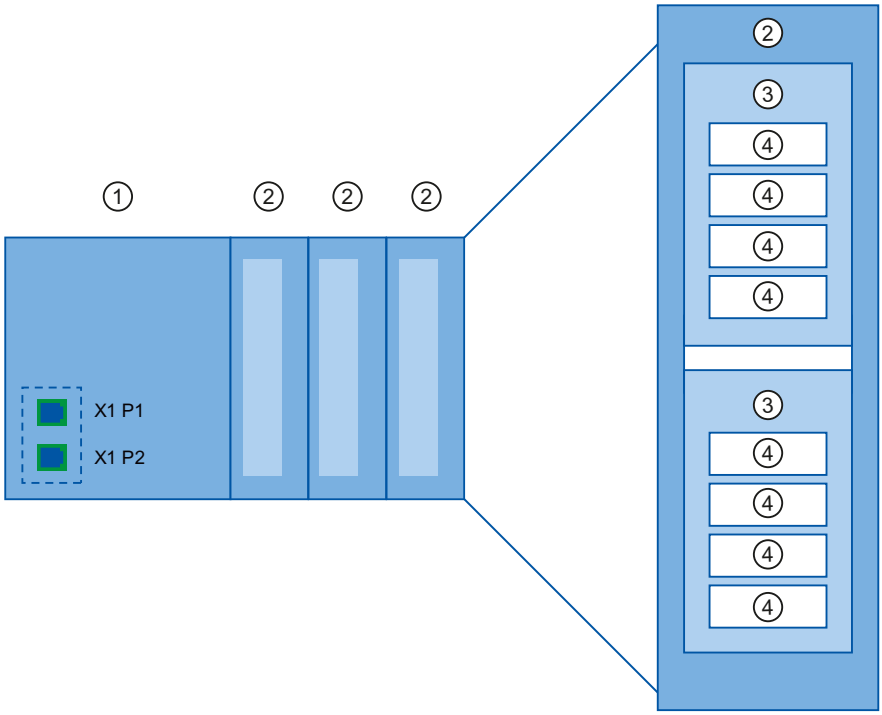


Figure 2-7 Configuration of a PROFINET device

Number	Description
①	Slot with bus interface
②	Slot with module
③	Subslot with submodule
④	Channel

A module can contain multiple submodules.

Representation of PROFINET Device Model in the Device View of STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

Device overview

Module	Rack	Slot	I address	Q address	Type
IO-Device_1	0	1			IM 155-5 PN ST
PROFINET-Schnittstelle	0	1 X1			PROFINET interface
Port_1	0	1 X1 P1			Port
Port_2	0	1 X1 P2			Port
DI 32x24VDC HF_1	0	2	16...19		DI32 x 24VDC HF
DQ 32x24VDC/0.5A ST_1	0	3		0...3	DQ32 x 24VDC / 0.5A ST

Figure 2-8 PROFINET device model in the device view of STEP 7

2.2 Setting up PROFINET

Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors, etc.
- Overview of the most important active network components: These are network components that actively affect a signal, for example switches, routers, etc.
- Overview of the most common network structures (topologies).

Physical connections of industrial networks

PROFINET devices can be networked in industrial systems in two different physical ways:

- Connected line
  - By means of electrical pulses via copper cables
  - By means of optical pulses via fiber-optic cables
- Wireless via wireless network using electromagnetic waves

PROFINET devices and cabling technology in SIMATIC are suited for industrial use, as they are based on Fast Ethernet and Industrial Ethernet.

- Fast Ethernet

  You can use Fast Ethernet to transfer data at a speed of 100 Mbps.
  This transmission technology uses the 100 Base-T standard for this.

- Industrial Ethernet

  Structure of Ethernet in industrial environment.

  The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

2.2.1 Active Network Components

Introduction

The following active network components are available for PROFINET:

- Switch
- Router

Switched Ethernet

PROFINET IO is based on switched Ethernet with full-duplex operation and a transmission bandwidth of 100 Mbps. As a result, the network can be used very efficiently through the simultaneous data transfer of several devices. The PROFINET IO frames are processed with high priority.

Switches

Switches are network components used to connect several terminal devices or network segments in a local network (LAN).

For the communication of a device with several other devices on PROFINET, the device is connected to the port of a switch. Other communication devices (including switches) can then be connected to the other ports of the switch. The connection between a communication device and the switch is a point-to-point connection.

A switch has the task of receiving and distributing frames. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those frames that are intended for the connected PROFINET device or the connected switch.

Switch dimensions

Switches are available in two models:

- Integrated into a PROFINET device

  For PROFINET devices with multiple ports (two or more), we are dealing with devices with an integrated switch (for example, CPU 1516-3 PN/DP).
- As autonomous device (for example, switches of the SCALANCE product family)

Selection Guide for Switches

To use PROFINET with the RT class "RT", you can use any switch of "PROFINET Conformance Class A" or higher. All switches of the SCALANCE product family meet these requirements.

If you want to use PROFINET functions that provide an additional value, such as topology recognition, diagnostics, device exchange without exchangeable medium/programming device, you have to use a switch of the "PROFINET Conformance Class B" or higher.

To use PROFINET with the RT class "IRT", you must use a switch of "PROFINET Conformance Class C". With switches of the SCALANCE product family, watch out for the catalog feature "IRT PROFINET IO switch".

To select appropriate switches, we recommend the SIMATIC NET Selection Tool on the Internet (http://support.automation.siemens.com/WW/view/en/39134641).

Switches of the SCALANCE product family

Use the switches of the SCALANCE product family if you want to use the full scope of PROFINET. They are optimized for use in PROFINET IO.

In the SCALANCE X device family, you will find switches with electrical and optical ports and with a combination of both variants. SCALANCE X202-2IRT, for example, has two electrical ports and two optical ports and supports IRT communication.

With STEP 7, you can configure and perform diagnostics on and address switches from the SCALANCE X device family as PROFINET IO devices.

Router

A router connects separated network segments from each other (e.g. management level and control level). The volume of data volume must be coordinated with the services of the respective network segment. A router also separates two networks and acts as a mediator between both networks. It thus reduces the network load. Routing functionality is provided in the SCALANCE X device family, with SCALANCE X300 or higher.

Communication devices on different sides of a router can only communicate with one another if you have explicitly enabled communication between them via the router.

If you want to access manufacturing data directly from SAP, for example, use a router to connect your Industrial Ethernet in the factory with the Ethernet in your office.

Note

If devices need to communicate beyond the limits of a network, you must configure the router so that it allows this communication to take place.

The CPU 1516-3 PN/DP and the communication processor CP 1543-1, for example, implement an integrated network separation between control level and production level, and offer the following advantages:

- separate network connection for control level and production level on one module
- Cross-network utilization of IT services, such as access to web servers, via IP routing

2.2.2 Cabling technology

Cables for PROFINET

Electrical and optical cables are available for PROFINET. The type of cable depends on the data transfer requirements and on the ambient conditions.

Simple method for the prefabrication of twisted pair cables

When you set up your PROFINET system, you can cut the twisted-pair cable to the required length on site, strip it with the *stripping tool* (for Industrial Ethernet), and fit the *Industrial Ethernet Fast Connect RJ45 plugs* using the cut-and-clamp method. For more information on installation, refer to the installation instructions in the "SIMATIC NET Industrial Ethernet Network Manual" (http://support.automation.siemens.com/WW/view/en/27069465).

Note

A maximum of six plug-in connections are allowed between two switches per Ethernet path.

Simple method for the prefabrication of fiber-optic cables

The FastConnect FO cabling system is available for the easy, fast and error-free prefabrication of fiber-optic cables. The glass-fiber optic cable consists of:

- FC FO Termination Kit for SC and BFOC plug
  (cleave tool, Kevlar scissors, buffer grip, fiber remains container)
- FC BFOC plug
- FC SC duplex plug
- FO FC standard cable
- FO FC trailing cable

Simple method for the prefabrication of POF and PCF cables

The following special tools provide an easy and safe way to prefabricate POF / PCF cables and fit the SC RJ POF plugs:

- POF cable

  Prefabrication case IE Termination Kit SC RJ POF plug
- PCF cable

  Prefabrication case IE Termination Kit SC RJ PCF plug

Overview of transmission media with PROFINET

The following table summarizes the technical specifications of a PROFINET interface with integrated switch or an external switch, and possible transmission media.

Table 2- 6 Transmission media with PROFINET

Physical properties	Connection methods	Cable type / transmission medium standard	Transmission rate / mode	Max. segment length (between two devices)	Advantages
Electrical	RJ45 connector ISO 60603-7	100Base-TX 2x2 twisted, symmetrical and shielded copper cable, CAT 5 transmission requirement IEEE 802.3	100 Mbps, full duplex	100 m	Simple and cheap cable connection
Optical	SCRJ 45 ISO/IEC 61754-24	100Base-FX POF fiber-optic cable (Polymer Optical Fiber, POF) 980/1000 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	50 m	Use when there are large differences in potential Insensitive towards electromagnetic radiation Low line attenuation Considerably longer segments possible
		Plastic-cladded glass fiber (Polymer Cladded Fiber, PCF) 200/230 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	100 m	
	BFOC (Bayonet Fiber Optic Connector) and SC (Subscriber Connector) ISO/IEC 60874	Monomode glass fiber optic cable 10/125 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	26 km	
		Multimode glass fiber optic cable 50/125 µm and 62.5/125 µm (core diameter / external diameter) ISO/IEC 9314-4	100 Mbps, full duplex	3000 m	
Electromagnetic waves	-	IEEE 802.11 x	Depending on the expansion used (a, g, h, etc.)	100 m	Greater mobility Cost-effective networking to remote, difficult to access devices

See also

PROFINET interface (Page 21)

SIMATIC NET Twisted Pair and Fiber Optic Networks
(http://support.automation.siemens.com/WW/view/en/8763736)

PROFINET Installation Guideline
(http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/)

2.2.3 Wireless design

2.2.3.1 Basics

What is Industrial Wireless LAN?

In addition to data communication in accordance with the IEEE 802.11 standard, the SIMATIC NET Industrial Wireless LAN provides a number of enhancements which offer significant benefits for industrial customers. IWLAN is particularly suitable for demanding industrial applications that require reliable wireless communication. This is supported by the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)
- Cost savings generated by using a single wireless network for reliable operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)
- Cost-effective connection to devices in remote environments that are difficult to access
- Predictable data traffic (deterministic) and defined response times
- Cyclical monitoring of the wireless link (link check)

Objectives and advantages of Industrial Wireless LAN

Wireless data transmission achieves the following objectives:

- Seamless integration of PROFINET devices into the existing bus system via the wireless interface
- Mobile use of PROFINET devices for different production-linked tasks
- Flexible configuration of the system components for fast development in accordance with customer requirements
- Maintenance costs are minimized by savings in cables

Application examples

- Communication with mobile subscribers (mobile controllers and devices, for example), conveyor lines, production belts, translation stages , and rotating machines
- Wireless coupling of communication segments for fast commissioning or cost-effective networking where routing of wires is extremely expensive (e.g. public streets, railroad lines)
- Stacker trucks, automated guided vehicle systems and suspended monorail systems

The following graphic illustrates the many possible applications and configurations for SIMATIC device family wireless networks.

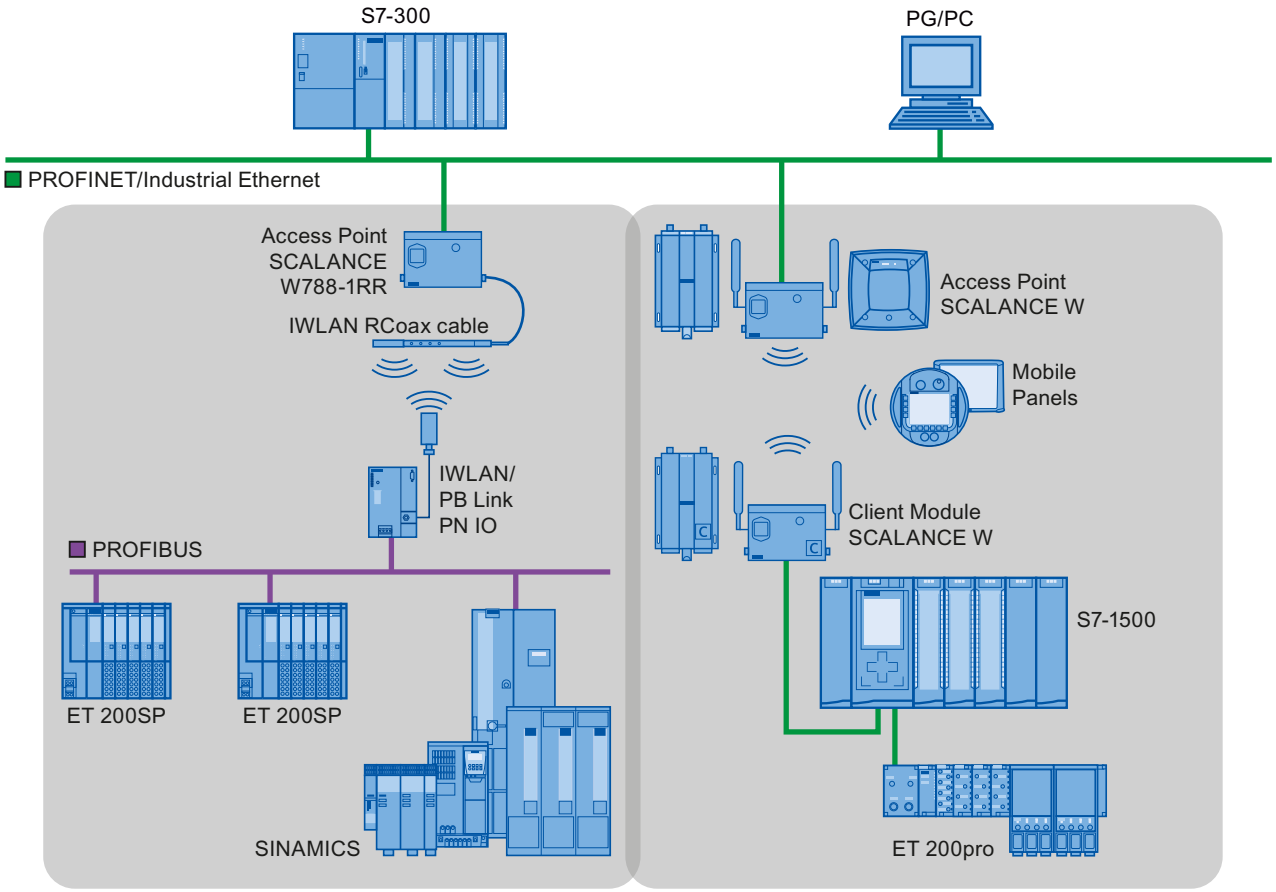


Figure 2-9 Possible application examples for Industrial Wireless LAN

Data transmission rate

In Industrial Wireless LAN, gross data transmission rates of 11 Mbps or 54 Mbps without full duplex are permitted.

Range

With SCALANCE W (access points), wireless networks can be set up indoors and outdoors. Multiple access points can be installed to create large wireless networks in which mobile subscribers are transferred seamlessly from one access point to another (roaming).

As an alternative to a wireless network, point-to-point connections of Industrial Ethernet segments can also be set up over large distances (several hundred meters). In this case, the range and characteristics of the RF field are determined by the antennas used.

Note

Range

The range can be considerably less, depending on spatial factors, the wireless standard used, the data rate, and the antennas on the send and receive sides.

2.2.3.2 Tips on assembly

Wireless networks, SCALANCE device family

With PROFINET, you can also set up wireless networks with Industrial Wireless Local Area Network (IWLAN) technology. We recommend implementing the SCALANCE W device line for this.

Update time in STEP 7

If you set up PROFINET with Industrial Wireless LAN, you may have to increase the update time for the wireless devices. The IWLAN interface provides lower performance than the wired data network: Several communication stations have to share the limited transmission bandwidth. For wired solutions, 100 Mbps is available for each communication device.

The Update time parameter can be found in the "Realtime settings" section in the Inspector window of IO devices in STEP 7.

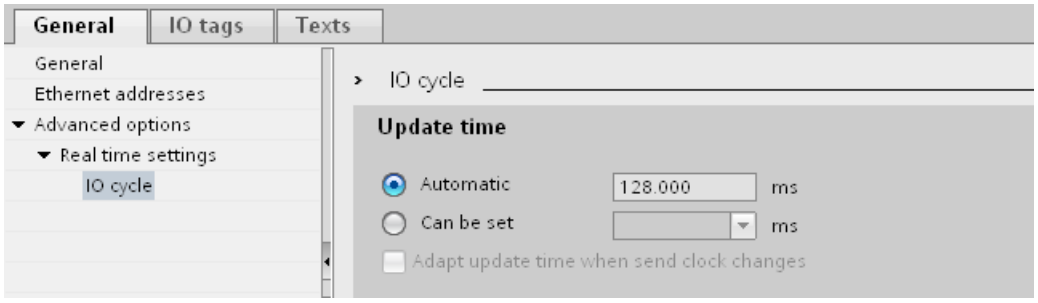


Figure 2-10 Update time in STEP 7

Additional information

More information about SCALANCE W Industrial Wireless LAN components can be found in the manual SIMATIC NET SCALANCE W-700 (http://support.automation.siemens.com/WW/view/en/42784493).

More information about wired data transmission can be found in the manual SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736).

More information about wireless data transmission can be found in the manual Basics for configuring an industrial wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764).

You should also read the PROFINET installation guideline of the PROFIBUS User Organization on the Internet (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

2.2.4 Network security

2.2.4.1 Basics

Introduction

The topic of data security and access protection (Security) has become increasingly important in the industrial environment. The increased networking of entire industrial systems, vertical integration and networking of levels within a company and new techniques such as remote maintenance all result in higher requirements for protecting the industrial plant.

Data security solutions for office environments cannot simply be transferred one-to-one to industrial applications to protect against manipulation in sensitive systems and production networks.

Requirements

Additional security requirements arise from the specific communication requirements in the industrial environment (real-time communication, for example):

- Protection against interaction between automated cells
- Protection of network segments
- Protection against faulty and unauthorized access
- Scalability of network security
- Must not influence the network structure

Definition of security

Generic term for all the measures taken to protect against:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to destruction of data,
  for example, through faulty configuration and denial-of-service attacks

Threats

Threats can arise from external and internal manipulation.
The loss of data security is not always caused by intentional actions.

Internal threats can arise due to:

- Technical errors
- Operator errors
- Defective programs

Added to these internal threats there are also external ones. The external threats are not really any different to the known threats in the office environment:

- Software viruses and worms
- Trojans
- Man-in-the-middle attacks
- Password Phishing
- Denial of Service

Protective measures

The most important precautions to prevent manipulation and loss of data security in the industrial environment are:

- Filtering and control of data traffic by means of firewall
- A virtual private network (VPN) is used to exchange private data on a public network (Internet, for example).

  The most common VPN technology is IPsec. IPsec (Internet Protocol Security) is a collection of security protocols that are used as the basis for the IP protocol at the mediation level and allow a secured communication via potentially unsecure IP networks.
- Segmenting in protected automation cells

  This concept has the aim of protecting the lower-level network devices by means of security modules. A group of protected devices forms a protected automation cell.
- Authentication (identification) of the devices

  The security modules identify each other over a safe (encrypted) channel using authentication procedures. It is therefore impossible for unauthorized parties to access a protected segment.
- Encrypting the data traffic

  The confidentiality of data is ensured by encrypting the data traffic.
  Each security module is given a VPN certificate which includes the encryption key.

2.2.4.2 Network components and software

Protection against unauthorized access

The following solutions may be used to connect industrial networks to the intranet and Internet to protect against internal and external threats:

- Communication processors, such as the SIMATIC CP 1543-1
- SCALANCE X-300 and SCALANCE S - the data security components of the SIMATIC NET product family
- SOFTNET security client for use on PCs

Features

Both of these products have a wide variety of features, such as:

- Easy integration of existing networks without configuration, with integrated firewall.
- Segmenting in protected automation cells
- Authentication (identification) of the devices
- Encrypting the data traffic

2.2.4.3 Application example

Data security at the office and production levels

The following graphic contains an application example with protected areas at different levels of the company created using SCALANCE S and the security client. The protected areas are highlighted in light gray.

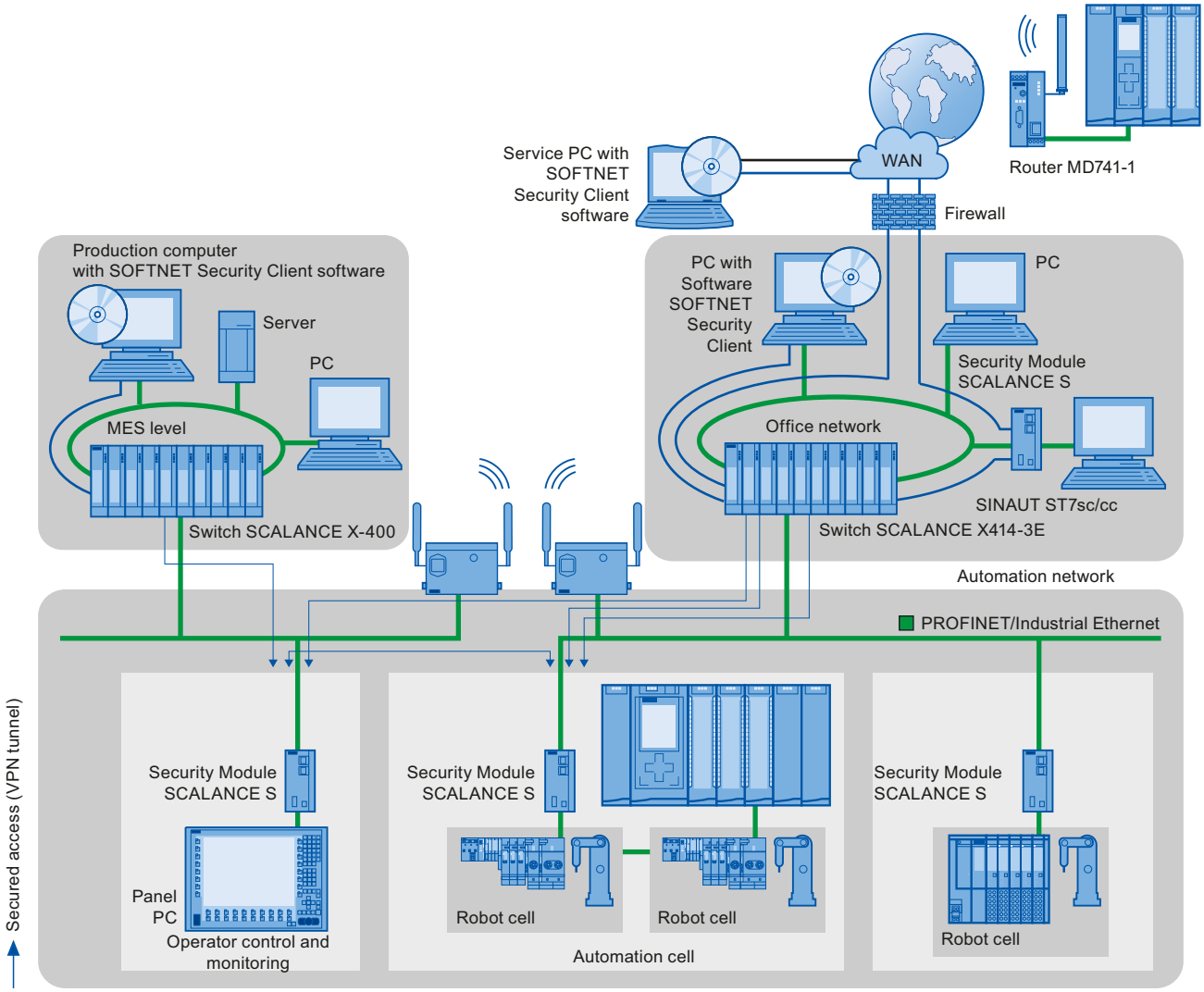


Figure 2-11 Network configuration with the SCALANCE S security module and the SOFTNET security client

Additional information

Additional information on the configuration of a security standard in PROFINET, is available:

- In the PROFINET security guideline. These guidelines can be found on the homepage of the PROFIBUS user organization on the Internet (http://www.profinet.com).
- In the Industrial Ethernet Security (http://support.automation.siemens.com/WW/view/en/56577508) manual
- In the SCALANCE S and SOFTNET Security Client (http://support.automation.siemens.com/WW/view/en/21718449) manual

You can find general information on industrial security concepts, functions and news on the Industrial Security website (http://www.siemens.com/industrialsecurity).

Parameter assignment/addressing 3

To set up an automation system, you will need to configure, assign parameters and interlink the individual hardware components. In STEP 7, the work needed for this is undertaken in the device, topology and network view.

Configuring

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device, topology or network view.

An I/O address is automatically assigned to each module. The I/O addresses can be subsequently modified.

The CPU compares the configuration preset in STEP 7 with the actual current configuration of the system. In this way, potential errors can be detected and reported straight away.

The exact procedure for configuring the equipment is described in detail in the STEP 7 online help.

Assigning parameters

"Assigning parameters" is understood to mean setting the properties of the components used. The settings for the hardware components and for data communication are configured at the same time.

In STEP 7, you can "assign parameters" for the following settings PROFINET:

- Device names and IP address parameters
- Port interconnection and topology
- Module properties / parameters

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules are easy to replace from spare parts, as the parameters assigned for the SIMATIC CPUs are automatically loaded into the new module at each startup.

Adjusting the hardware to the project requirements

You need to configure hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your structure, link these with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset such that in many cases they do not have to be assigned parameters again.

Parameter assignment is however needed in the following cases:

- You want to change the default parameter settings of a module.
- You want to use special functions.
- You want to configure communication connections.

3.1 Assigning an IO device to an IO controller

PROFINET IO System

A PROFINET IO system is comprised of a PROFINET IO controller and its assigned PROFINET IO devices. After these devices have been placed in the network or topology view, STEP 7 assigns default values for them. Initially, you only have to worry about the assignment of IO devices to an IO controller.

Requirements

- The STEP 7 network view is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IO device has been placed (e.g., IM 155-6 PN ST).

Procedure

To assign IO devices to an IO controller, proceed as follows:

1. In the IO device, left-click the "Not assigned" link. The "Select IO controller" menu opens.

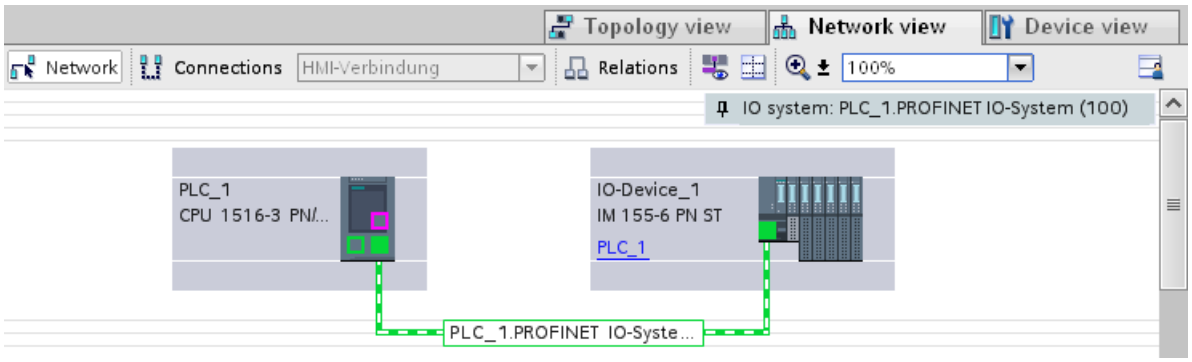


Figure 3-1 Assigning an IO device to an IO controller in the network view of STEP 7

2. In the menu, select the PROFINET interface of the CPU to which you want to assign the IO device.

   → A subnet is created with an IO system on the PROFINET CPU. The CPU is now the PROFINET IO controller. The IO device is assigned to the IO controller.

3. Repeat steps 1 and 2 for each IO device that you want to assign to the IO controller.

Checking the assignment

You can find an overview of the communication relationships in the "IO communication" tab in the tabular area of the network view. This table is context-sensitive for selection in the graphic area:

- Selection of the interface shows the I/O communication of the respective interface.
- Selection of the CPU shows all I/O communication of the CPU (including PROFIBUS).
- Selection of the station (as in the above figure) interface shows the I/O communication of the complete station.

3.2 Device name and IP address

Introduction

In order that the PROFINET device can be addressed as node on PROFINET, the following are required:

- A unique PROFINET device name
- A unique IP address in the relevant IP subnet

STEP 7 assigns a device name during the arrangement of a PROFINET device in the hardware and network editor. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name.

You can change the name and IP address manually.

In STEP 7

You can find the device name and the IP address under "Ethernet addresses" in the properties of the PROFINET interface in the Inspector window.

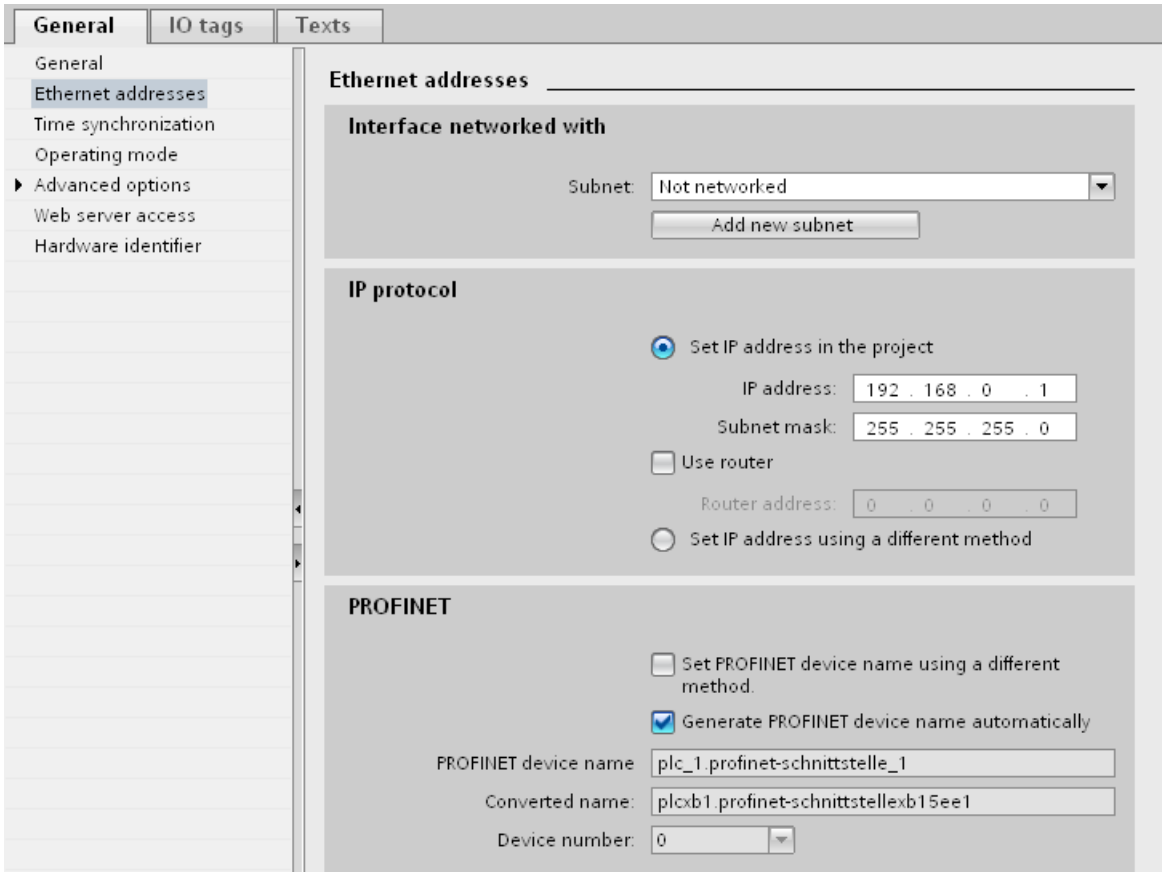


Figure 3-2 Device name and IP address in STEP 7

The function, the assignment and the changing of the device name and the IP address are described in the following sections.

3.2.1 Device name

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

The assignment of a device name for a specific IO device can be compared to setting the PROFIBUS address of a DP slave.

In delivery state, an IO device does not have a device name. A device name must first be assigned with the programming device or PC before an IO device can be addressed by an IO controller, for example, for transferring configuration data (IP address, etc.) during startup or for user data exchange in cyclic operation.

IO devices that have a slot for removable storage media provide the option of writing the device name directly to the removable storage medium in the programming device.

When a device is replaced by a device without removable medium, the IO controller assigns the device name based on topological configuration (see section Configuring topology (Page 59)).

Structured device names

The device names for PROFINET devices S7-1200, S7-1500, ET 200MP and ET 200SP are assigned automatically when these are configured in STEP 7. The names are formed from the name of the CPU or the name of the interface module. For devices with several PROFINET interfaces, the name of the interface is enhanced, for example, "plc_1.profinet-schnittstelle_2" or "io-device_1".

You can structure the device names using DNS conventions.

These conventions are defined by "Internationalizing Domain Names in Applications (IDNA). According to this, device names are written in lower case.

The "Domain Name System" (DNS) is a distributed database (http://iana.org), which manages the name space on the Internet. To structure the names, you use the dot ("."). The hierarchy is shown in ascending order from left to right.

...<Subdomain name>.<Domain name>.<Top-level domain name>

If the name is not DNS-compliant, the name will be converted by STEP 7, for example, to "plcxb1.profinet-schnittstellexb2022c" or "io-devicexb15b32".

Device number

In addition to the device name, STEP 7 also assigns a device number beginning with "1" when an IO device is allocated.

The device number is located in the Inspector window in the properties of the PROFINET interface, under "Ethernet addresses" in the area PROFINET.

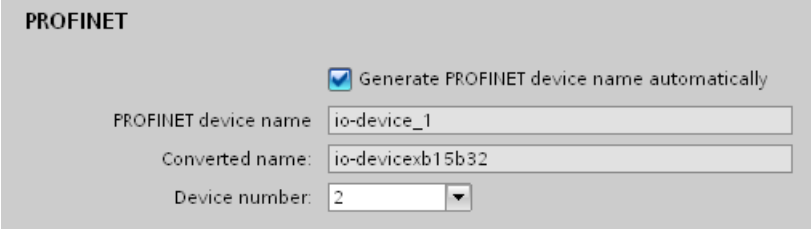


Figure 3-3 Device number

This device number can be used to identify an IO device in the user program (for example, with the instruction "LOG2GEO"). In contrast to the device number, the device name is not visible in the user program.

3.2.2 IP address

IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique on that network. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name. If it is a standalone network, you can apply the IP address and subnet mask suggested by STEP 7. If the network is part of an existing Ethernet company network, obtain the information from your network administrator.

Configuration of the IP address

In accordance with Internet Protocol version 4 (IPv4), the IP address is made up of four decimal numbers, each with a range of values from 0 through 255. The decimal numbers are separated from one another by a period (for example, 192.162.0.0).

The IP address consists of the following:

- Address of the network
- Address of the device (PROFINET interface of the IO controller/IO device)

Generating IP addresses

The IP addresses of the IO devices are generated by STEP 7 and first assigned to the IO devices when the CPU starts up. In addition, for some IO devices (e.g., SCALANCE X, S7-300 CPs), the option exists to set the IP address not during startup of the IO controller, but beforehand using a different method (see Set device name and IP address using a different method (Page 57)).

The IP addresses of the IO devices always have the same subnet mask as the IO controller and are assigned from the IP address of the IO controller in ascending order. The IP address can be changed manually, if necessary.

For devices with several PROFINET interfaces (e.g., CPU 1516-3 PN/DP), the IP addresses must be located in different subnets.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

Example of the subnet mask

Subnet mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary)

IP address: 192.168.0.2 (decimal) = 11000000.10101000.00000000.00000010 (binary)

Meaning: The first 2 bytes of the IP address determine the network - i.e., 192.168.
The last two bytes address the device, i.e. 0.2.

Default router

The default router is used when data has to be forwarded via TCP/IP or UDP to a partner located outside the local network.

In STEP 7, the default router is named Router. You can activate the use of a router in the Inspector window of a CPU with the "Use router" check box in the"IP protocol" section. STEP 7 assigns the local IP address to the default router by default.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO devices.

Relation between IP address and default subnet mask

An agreement exists relating to the assignment of IP address ranges and so-called "Default subnet masks". The first decimal number (from the left) in the IP address determines the structure of the default subnet mask with respect to the number of "1" values (binary) as follows:

IP address (decimal)	IP address (binary)	Address class	Default subnet mask
0 to 126	0xxxxxxx.xxxxxxxx....	A	255.0.0.0
128 to 191	10xxxxxx.xxxxxxxx...	B	255.255.0.0
192 to 223	110xxxxx.xxxxxxxx...	C	255.255.255.0

Note

Range of values for the first decimal point

A value of between 224 and 255 is also possible for the first decimal number of the IP address (address class D etc.). However, this is not recommended because there is no address check for these values.

Masking other subnets

You can use the subnet mask to add further structures and form "private" subnets for a subnet that is assigned one of the address classes A, B or C. This is done by setting other, less significant bits of the subnet mask to "1". For each bit set to "1", the number of "private" networks doubles and the number of devices they contain is halved. Externally, the network continues to function as an individual network.

Example:

You have a subnet of address class B (for example, IP address 129.80.xxx.xxx) and change the default subnet mask as follows:

Masks	Decimal	Binary
Default subnet mask	255.255.0.0	11111111.11111111.00000000.00000000
Subnet mask	255.255.128.0	11111111.11111111.10000000.00000000

Result:

All devices with addresses from 129.80.001.000 to 129.80.127.254 are located in a subnet, all devices with addresses from 129.80.128.000 to 129.80.255.254 in a different subnet.

3.2.3 Assigning a device name and IP address

Assigning an IP address and subnet mask for an IO controller the first time

You have the following options:

- **By means of a programming device or PC:**

  Connect your programming device/PC to the same network as the relevant PROFINET device. The interface of the programming device/PC must be set to TCP/IP mode. During the download, first of all display all available devices via the "Accessible devices" download dialog box. Select the target device via its MAC address and then assign its IP address before you download the hardware configuration including the configured IP address (IP address is saved retentively).

- **Using display of a S7-1500 CPU:**

  The S7-1500 CPUs have a front cover with a display and operating keys. You can use this display to assign or change the IP address. To set the IP address, navigate on the display via the menu items "Settings" > "Addresses" > "X1 (IE/PN)" > "Parameters".

- **Assign via memory card**

  If your PROFINET device is equipped for a memory card (Micro Memory Card/SIMATIC memory card), plug this into your programming device/PC and save the hardware configuration together with the configured IP address on this memory card. Then plug the memory card into the PROFINET device. Once inserted, the PROFINET device automatically applies the IP address.

  If you have saved a configuration to the memory card with the "Set IP address using a different method" option, you must assign the IP address using a different method after inserting the memory card. (See chapter Set device name and IP address using a different method (Page 57))

Assigning device names and IP address for "Device replacement without exchangeable medium/programming device"

For devices without exchangeable medium (e.g., ET 200MP, ET 200SP) and devices that support "Device replacement without exchangeable medium/PG" (e.g., ET 200S), the IO controller can identify the device without name from the neighbor relationships specified by the set topology and from actual neighbor relationships determined by the real PROFINET devices. The IO controller then assigns the PROFINET device the configured name and incorporates the PROFINET device in the user data traffic.
(See also Device replacement without exchangeable medium (Page 138)).

IP address assignment when replacing IO devices with exchangeable mediumPG

The following is contained on the memory card of the programmable logic controller:

- On the IO controller: Device name and IP address
- On the IO device: Device name

When you remove the memory card from a PROFINET device and insert it in another PROFINET device with exchangeable medium (e.g., ET 200S), device-specific information and the device name are loaded to the device.

If an IO device has to be replaced in its entirety due to a device or module defect, the IO controller automatically assigns parameters and configures the replaced device or module. The cyclic exchange of user data is then restarted. In addition to this, before the power ON of the IO device, the memory card with the valid name must be removed from the faulty IO device and added to the replaced device.

In the event of an error in the PROFINET device, the memory card allows you to replace a module without a programming device/PC. You can also transfer the device data directly from the programming device/PC to the memory card.

Procedure: Changing the device name of a PROFINET device

1. In STEP 7, select the "Network overview" tab in the tabular area of the network view.
2. In the "Device" column, overwrite the name in the row of the relevant PROFINET device.

The name is also changed accordingly in the graphic area of the network view.

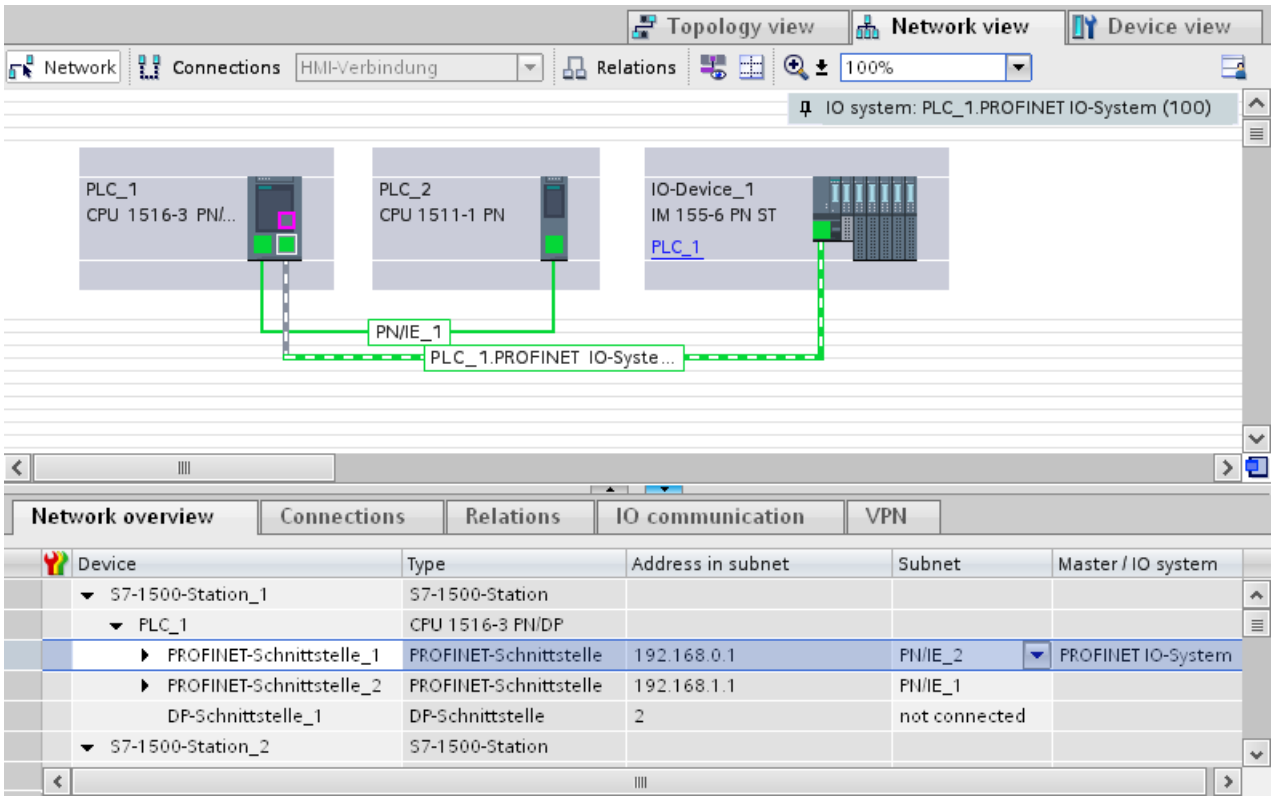


Figure 3-4 Changing the device name of a PROFINET device in STEP 7

Alternative procedure using properties of the PROFINET interface

You can use the properties of the PROFINET interface to change the PROFINET name. This is useful when the PROFINET device has not been assigned the previous name for the automatic generation, for example, during a migration.

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the PROFINET area.
3. Clear the "Generate PROFINET device name automatically" check box.
4. Enter the new PROFINET device name in the relevant field.

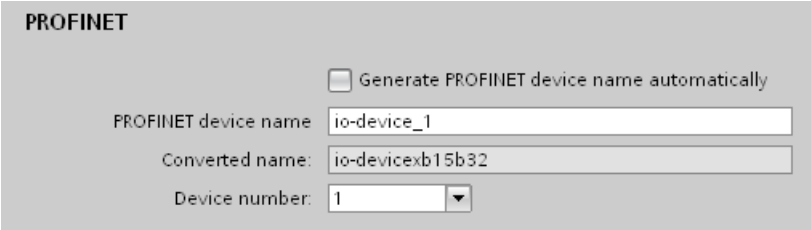


Figure 3-5 Changing the device name of a PROFINET device in the properties

Procedure: Changing the IP address

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the "IP protocol" area.
3. Check that the option "Set IP address in the project" is selected.
4. Enter the new IP address in the relevant field.

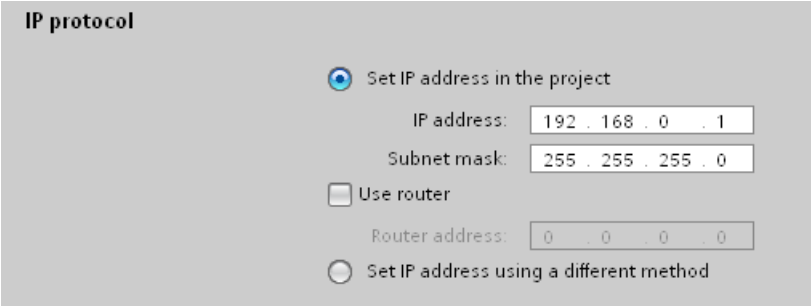


Figure 3-6 Changing the IP address of a PROFINET device in STEP 7

Downloading configured device name to IO device

1. Connect your programming device/PC to the same network as the relevant IO device. The interface of the programming device/PC must be set to TCP/IP mode.
2. In STEP 7, select the relevant IO device in the "Accessible devices" dialog based on the MAC address.
3. Load the configured device name in the IO device.

   The IO controller recognizes the IO device automatically by its device name and automatically assigns the configured IP address to it.

Identification of the PROFINET device

To clearly identify a device from several identical devices in a control cabinet, for example, you can flash the link LED of the PROFINET device.

In STEP 7, select the menu command **Online > Accessible devices...**.
In the "Accessible devices" dialog, set the PG/PC interface by means of which you are connected to the devices. STEP 7 will now automatically search for the accessible devices and display them in the "Accessible devices in target subnet" table. Select the desired PROFINET device and click on the "Flash LED" button. The PROFINET device is identified based on its MAC address.

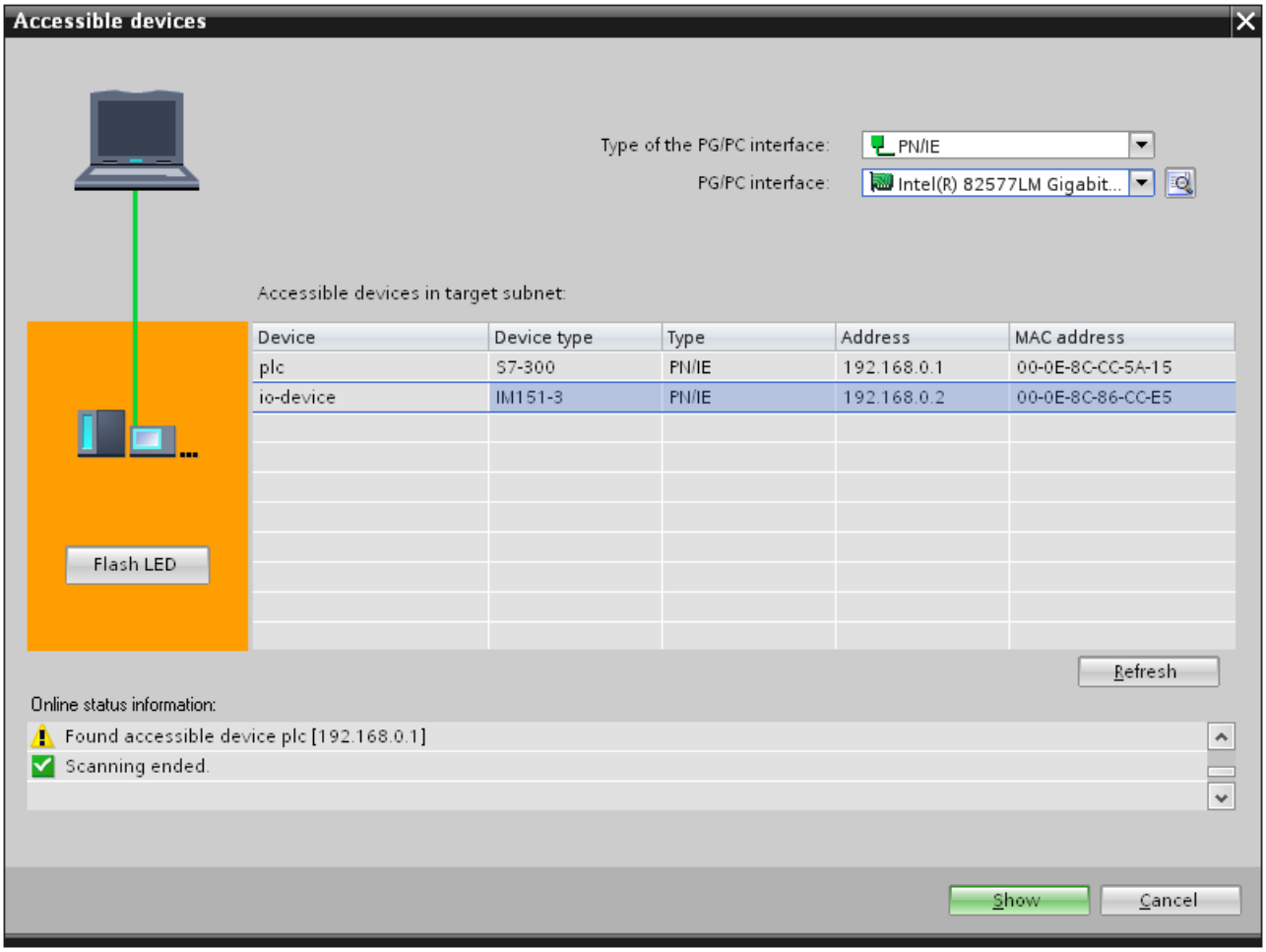


Figure 3-7 "Accessible devices" dialog

Using an different way to assign IP addresses for IO devices

Various IO devices, for example, SCALANCE X,S7-300 CPs, support the option of not having the IP addresses assigned by the IO controller during startup.
In this case, the IP address is assigned in a different way. For additional information, refer to the manual of the respective PROFINET device of the SIMATIC device family.

Further information

You can find a detailed description of the operation and functions of the display of the S7-1500 CPUs in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

3.2.4 Set device name and IP address using a different method

Introduction

Machines are frequently commissioned on site or integrated into the existing infrastructure without STEP 7. You can find typical applications in all areas of the series machine building. Alternative means for assigning the IP address are available for this.

Procedure

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of an IO controller.
2. Navigate in the Inspector window to "Ethernet addresses".
3. Select the "Set IP address using a different method" option in the "IP protocol" area.
4. In the "PROFINET" area, select the check box "Set "PROFINET" device name using a different method".

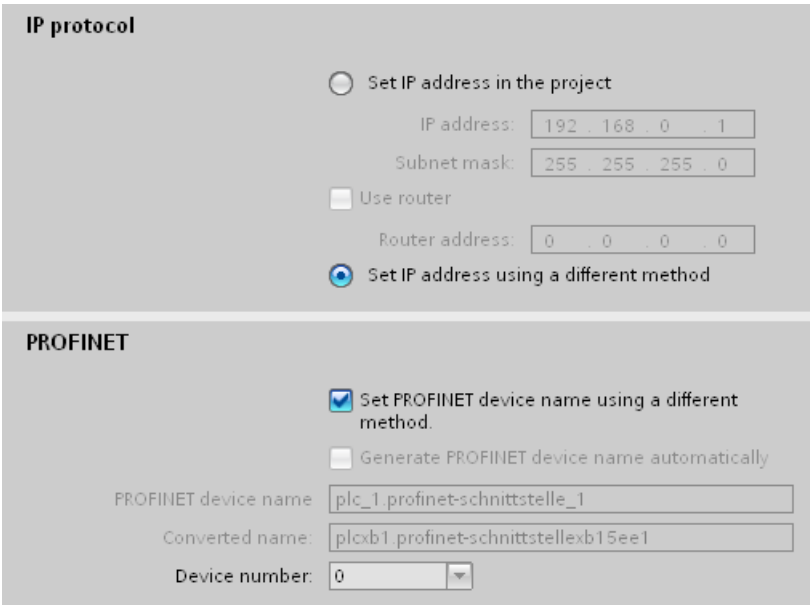


Figure 3-8 Set device name and IP address using a different method

Note

Gateway

If the option "Set IP address/device name using a different method" is used in a PROFINET device, the corresponding PROFINET device cannot be used as gateway.

Options for assigning IP addresses and device names

Apart from the known address and device name assignment in the "Ethernet addresses" section of the Inspector window, there are other ways in which the IP address and name can be assigned:

- Assigning by means of the user program with the instruction "T_CONFIG"
- Assignment when downloading the configuration to the target system via the "Extended download to device" dialog box.
- Assignment via the Primary Setup Tool (PST)

Further information

For information on the instruction "T_CONFIG" and on downloading to the target system, refer to the STEP 7 online help.

A free Download (http://support.automation.siemens.com/WW/view/en/14929629) of the Primary Setup Tool (PST) can be found on the Internet. On this Internet page, you will also find a list of devices for which the PST is approved.

3.3 Configuring topology

Introduction

If an IO device is assigned to an IO controller, this does not yet specify how the ports are connected to each other.

A port interconnection is not required to use RT, but it provides the following advantages:

- A set topology is assigned with the port interconnection. Based on an online-offline comparison, it is possible to conduct a set-actual comparison with all devices that support this function.
- The "Device replacement without exchangeable medium" function can be used.

A port interconnection is an essential requirement for using IRT.

An overview of various options for setting up a PROFINET network is given below.

Line

All the communication devices are connected in a linear bus topology.

In PROFINET, the linear bus topology is implemented with switches that are already integrated into the PROFINET devices. Therefore, the linear bus topology at PROFINET is merely a special form of tree / star topology.

If a link element (switch, for example) fails, communication across the failed link element is no longer possible. The network is then divided into 2 subsegments.

Linear bus topology structures require the least cabling.

Star

If you connect communication devices to a switch with more than two PROFINET ports, you automatically create a star network topology.

If an individual PROFINET device fails, this does not automatically lead to failure of the entire network, in contrast to other structures. It is only if a switch fails that part of the communication network will fail as well

Tree

If you interconnect several star structures, you obtain a tree network topology.

Ring

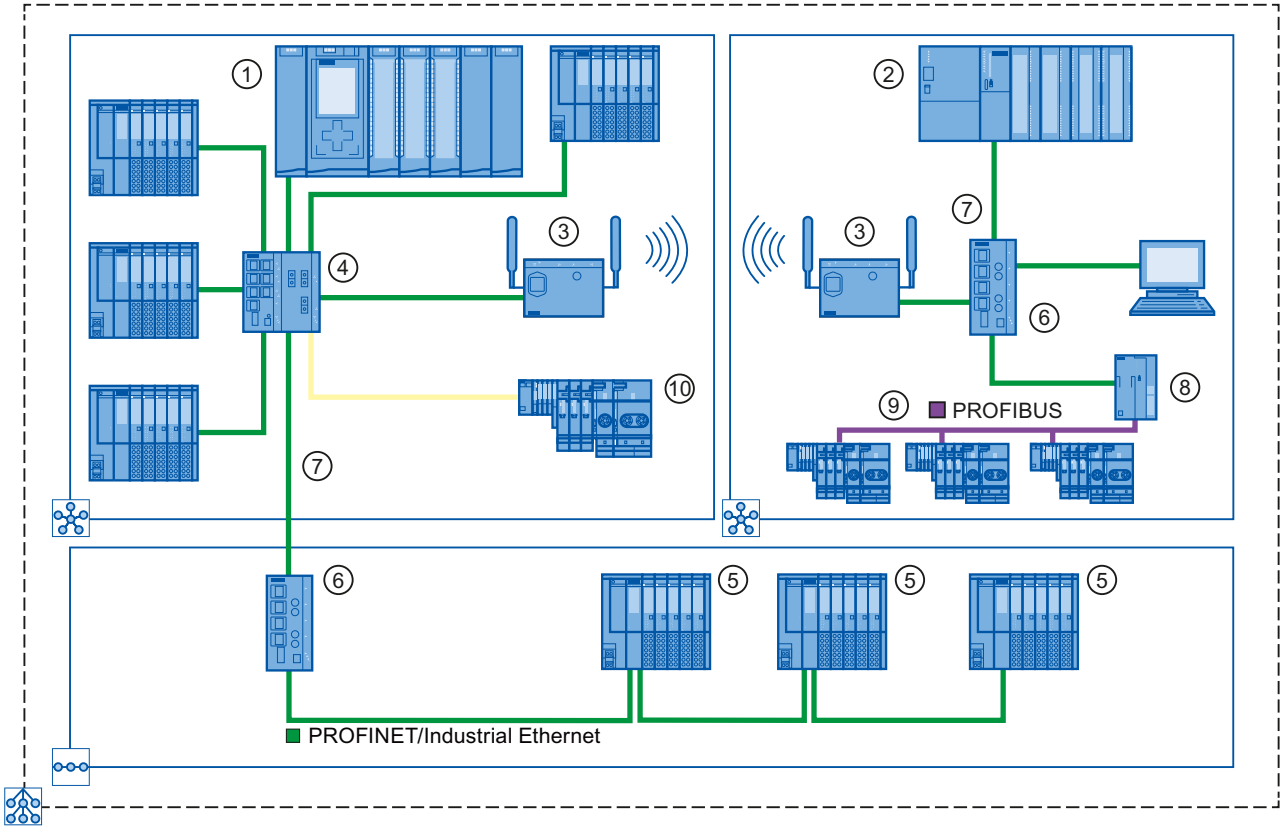
In order to increase the availability of a network, use ring structures. In principle, a linear bus topology is connected to a ring through a so-called redundancy manager.

The task of the redundancy manager is managed by an external switch SCALANCE X, a CPU that supports the Media Redundancy Protocol MRP (e.g., CPU 1516-3 PN/DP) or a CP (e.g., CP 343-1 Lean).

If there is a break in the network, the redundancy manager ensures that the data is redirected over an alternative network connection in the ring.

Example for topology

The following example shows a combination of different topologies.



Number	Meaning
①	S7-1500 as IO controller
②	S7-300 as IO controller
③	Industrial WLAN with SCALANCE W
④	SCALANCE X 307-3 with seven electrical and three optical ports
⑤	ET 200SP with integrated 2-port switch
⑥	SCALANCE X 204 with four electrical ports
⑦	PROFINET / Industrial Ethernet
⑧	IE/PB link PN IO
⑨	PROFIBUS DP
⑩	ET 200S with two optical ports
	Star topology
	Linear bus topology
	The combination of topology forms results in a tree topology.

Figure 3-9 Combined topology

Additional information

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736) manual.

You should also read the PROFINET Installation Guideline from the PROFIBUS User Organization (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

You can find basic information in the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) manual.

3.3.1 Topology view in STEP 7

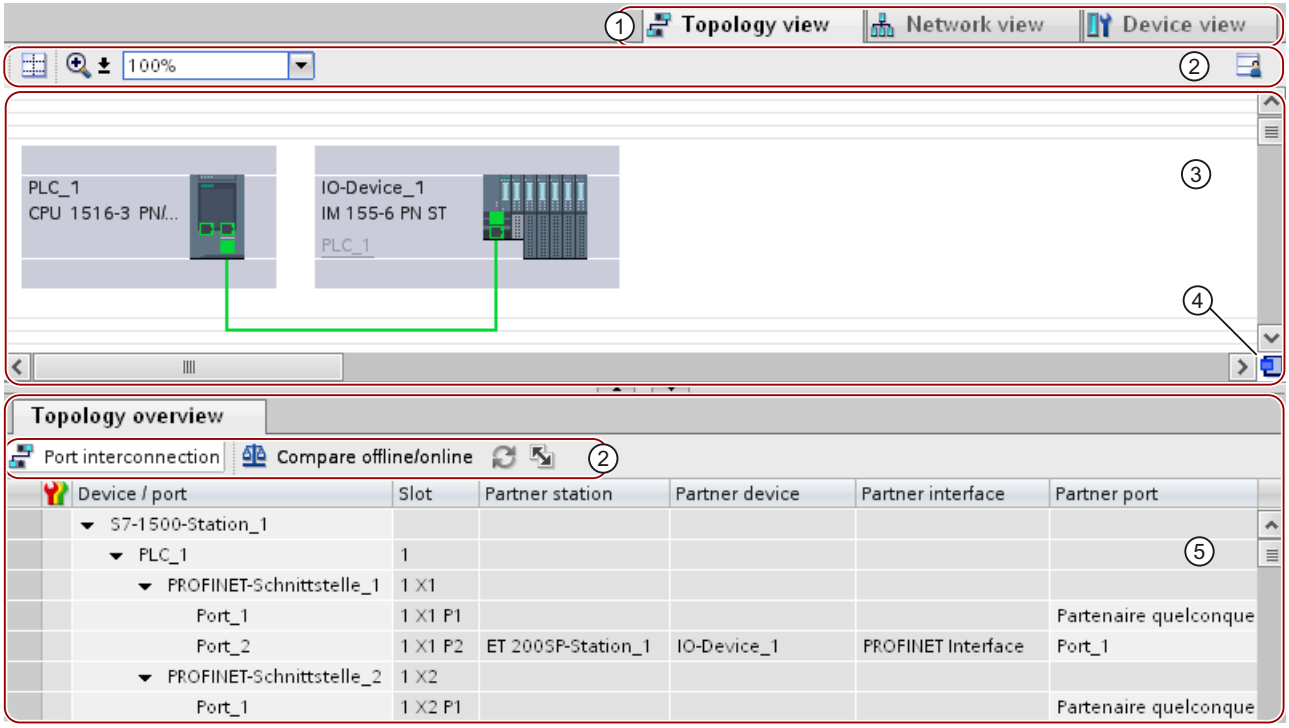
Introduction

The topology view is one of three working areas of the hardware and network editor. You undertake the following tasks here:

- Displaying the Ethernet topology
- Configuring the Ethernet topology
- Identify and minimize differences between the set and actual topology (online)

Structure

The following figure provides an overview of the topology view.



① Changeover switch: device view / network view / topology view
② Toolbars
③ Graphic area of the topology view
④ Overview navigation
⑤ Table area of the topology view

Figure 3-10 Interconnecting ports in the topology view in STEP 7

Graphic area

The graphic area of the topology view displays PROFINET devices with their appropriate ports and port connections. Here you can add more PROFINET devices.

Overview navigation

Click in the overview navigation to obtain an overview of the created objects in the graphic area. By holding down the mouse button, you can quickly navigate to the desired objects and display them in the graphic area.

Table area

This displays the Ethernet or PROFINET devices with their appropriate ports and port connections in a table. This table corresponds to the network overview table in the network view.

3.3.2 Interconnecting ports in the topology view

Requirements

You are in the graphic view of the topology view.

Procedure

1. Left-click the port to be interconnected and keep the mouse button pressed.
2. Move the mouse to the target port.
3. Release the mouse button.

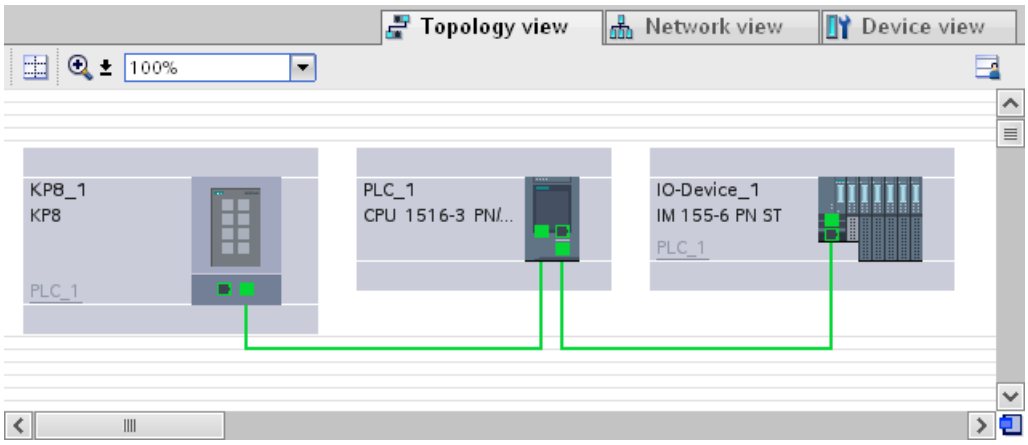


Figure 3-11 Interconnecting ports in the topology view

Result

A new port interconnection has been created.

3.3.3 Interconnecting ports - Inspector window

Interconnecting ports in the Inspector window

To interconnect ports, follow these steps:

1. In the device or network view, select the PROFINET device or PROFINET interface.
2. In the Inspector window, navigate to the port property "Port interconnection".

   When the PROFINET interface is selected, you can find this setting in the Inspector window as follows: "Properties > General > Advanced Options > Port [...] > Port Interconnection."
3. In the "Local port" section, you can find the settings at the local port.
   In the case of fiber-optic cable you can, for example, set the cable names here.

   In the "Partner port" area, select the drop-down list for "Partner port" in order to display the available partner ports and make a selection.

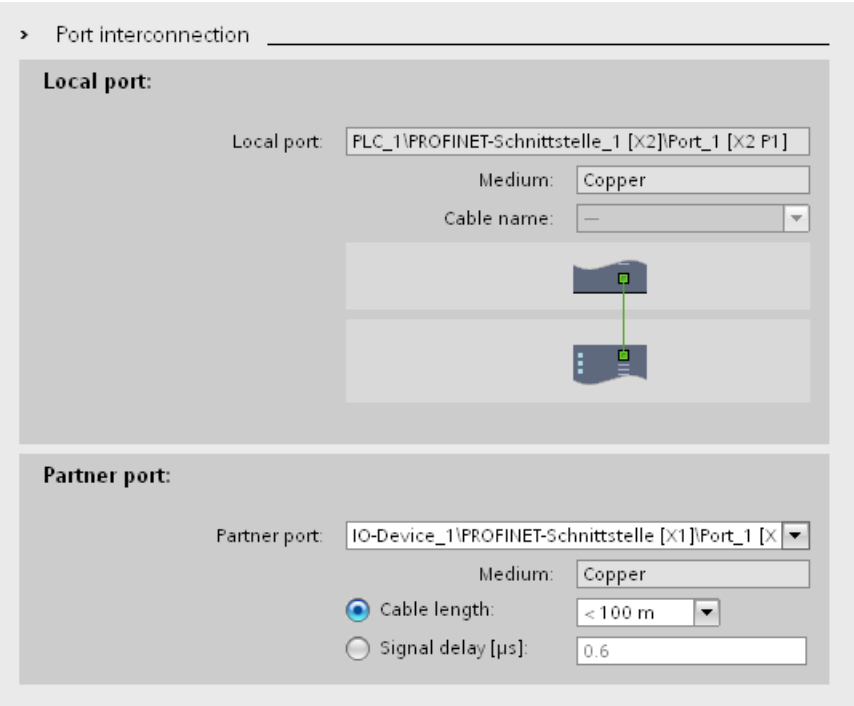


Figure 3-12 Interconnecting ports in the Inspector window in STEP 7

If the PROFINET interface was disconnected, it is automatically connected by this action. In the properties of the subnet you can set whether this subnet should or should not be used for the networking.

3.3.4 Automatic assignment of devices by offline/online comparison

Overview

During the offline/online comparison, the configured topology is compared with the actually existing topology. Devices identified online are automatically assigned to configured devices as far as this is possible.

The assignment of the devices is a requirement to apply the port interconnection in the project. (Apply the devices identified online in the project (Page 67))

Requirements

A device identified in the offline/online comparison is automatically assigned to a configured device if the following properties of the two devices match up:

- Device name
- Order number
- Number of ports

Procedure

To perform an online/offline comparison, follow these steps:

1. Click the "Compare offline/online" button in the tabular area of the topology view.
2. You restart the offline/online comparison by clicking the "Update" button.

Note

The offline/online comparison takes a few seconds.
During this time, no user input is possible.

The status bar shows the progress of the offline/online comparison.

No automatic assignment

In the following situations, no automatic assignment is possible:

- No device can be identified online to match a configured device. This means that the corresponding columns in the "Online topology" area of the topology overview table are empty.

  In this case, you should add the already configured device to your system or delete the configured device from the configuration.
- A device identified online cannot be assigned to any configured device. In this case the corresponding columns in the "Offline topology" area of the topology overview table are empty.

  In this case, you can apply the device identified online in the project.

3.3.5 Apply the devices identified online in the project

Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online was assigned to a configured device and that there are differences relating to the interconnection.

Procedure

To manually apply one or more port interconnections identified online in the project, follow these steps:

1. Select the value "Apply" in the "Action" column for a port of a configured device to which a device identified online was assigned.
2. Repeat the step if necessary for other ports of the same configured device.
3. Repeat the steps up to now if necessary for other configured devices to which devices identified online were assigned and for which there are differences relating to the interconnection.
4. Click the "Synchronize" button.

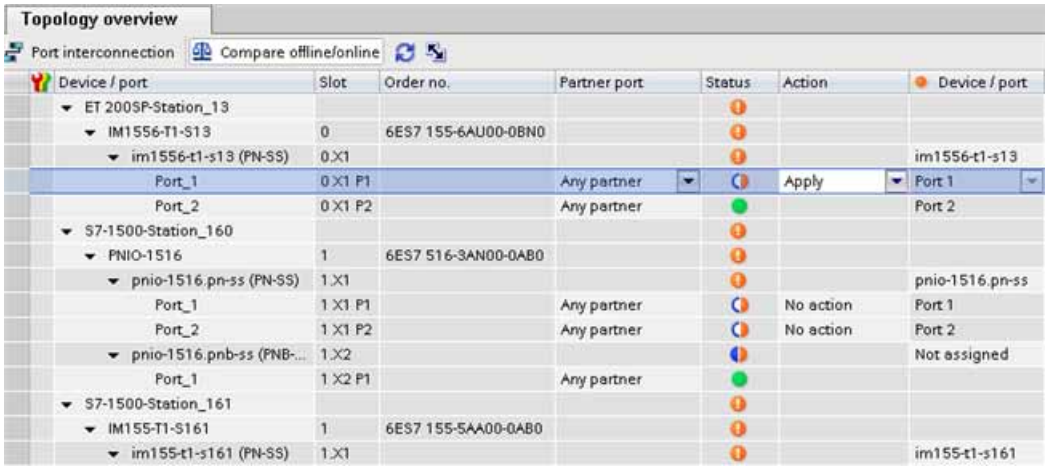


Figure 3-13 Apply the devices identified online in the project

Result

The port interconnections identified online and the cable information for the corresponding devices are applied in the project. Successful application is indicated by the diagnostics icon "Identical topology information" for each port.

Note

If other port interconnections are recognized for a device identified online and these differ from those in the project, applying these in the project means that the port interconnections that were previously in the project are replaced by those identified online.

If no interconnections are detected for a device identified online, applying in the project means that all the port interconnections of this device are deleted in the project.

Diagnostics 4

4.1 Diagnostic mechanisms of PROFINET IO

Totally Integrated Diagnostics Concept

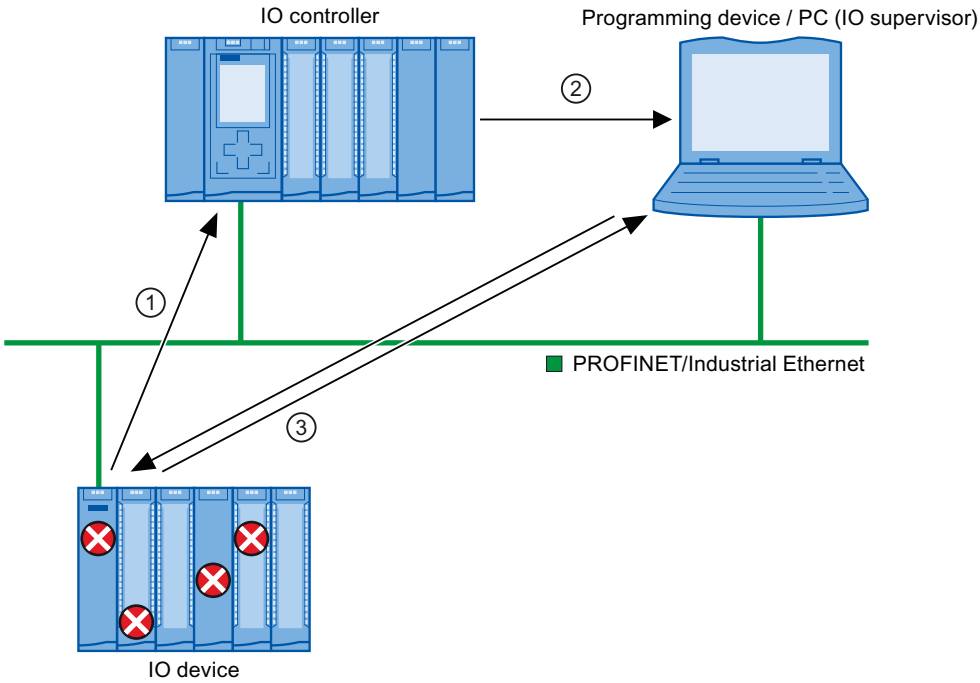
All SIMATIC products have integrated diagnostic functions that they can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information.

Each individual error or several errors occurring concurrently are transferred from the IO device to the IO controller. If you require the full status of the IO device including any pending errors, you can also read the status directly from the IO device.

The following sections provide basic information on using diagnostics via PROFINET IO. You can find a detailed description of the system diagnostics for S7-1500, ET 200MP and ET 200SP in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

Accessing the status of an IO device with a PG/PC or an HMI device

If you are connected to the Industrial Ethernet via a PG/PC with STEP 7 or an HMI device, you can also call up diagnostic information online. This is illustrated by the following graphic.



Number	Description
①	The IO device detects an error and sends diagnostic data to the IO controller.
②	The IO controller notifies the programming/HMI device. The display of the system diagnostics is updated.
③	In STEP 7, you can read the station status for "Accessible devices" directly from the IO device regardless of the IO controller. This is only possible if the programming device/HMI is connected to the Industrial Ethernet. This means that you can access diagnostic information during the commissioning phase or for servicing even if the IO controller is not operational.

Figure 4-1 PROFINET IO diagnostics with PG/PC or HMI device

4.1.1 Diagnostic levels in PROFINET IO

Concept

The IO device sends all error messages that occur to the IO controller. The scope and volume of diagnostic information varies according to the level of diagnostic data evaluation and the PROFINET devices you are using.

Diagnostic levels

You can evaluate diagnostic data at different levels.
The number and type of channels is selected, for example, at the diagnostic level 4.

The following figure shows the diagnostic levels with PROFINET IO.

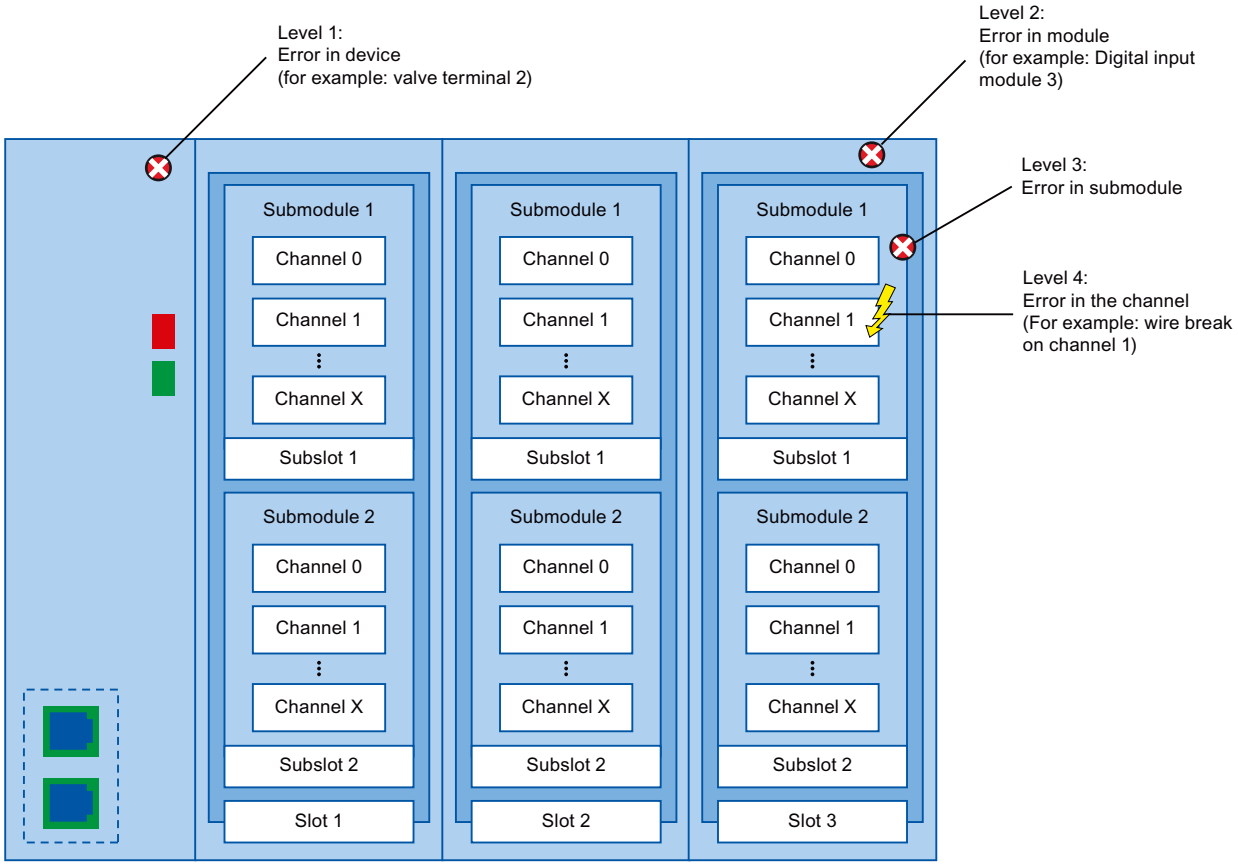


Figure 4-2 Diagnostic levels with PROFINET IO

Representation of diagnostic levels in the device view in STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

Number	Description	
①	Level 1:	Error(s) in the device
②	Level 2:	Error(s) in the module

Figure 4-3 Diagnostic levels in the device view of STEP 7

4.1.2 I&M data (identification and maintenance)

Definition and properties

Identification and maintenance data (I&M) is information saved to module memory in order to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only vendor-specific module data.

Maintenance data (M data) is plant-specific information such as the location identifier and installation date. M data is created during configuration.

The modules can be uniquely identified in online mode by means of the I&M data.

Further information

To find out whether and to what extent a PROFINET device supports I&M data, refer to the documentation of the relevant device.

4.2 Diagnostics using status LEDs

LEDs for diagnostics on PROFINET

Each port of a PROFINET interface of a SIMATIC device has one LED.

The following table shows a summary of the meaning of these LEDs in the S7-1500, ET 200MP and ET 200SP systems.

Table 4- 1 S7-1500, ET 200MP, ET 200SP: LEDs for diagnostics on PROFINET

Meaning	LED image	S7-1500	ET 200MP	ET 200SP
		LINK/TX/RX LED		LK LED
There is no Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner (e.g. IO controller).	LED off	X	X	X
There is no Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner (for example, IO controller).	LED green	X	X	X
The "Node flash test" is performed.	LED flashes green	X	X	X
There is active data traffic (sending/receiving) via the Ethernet connection.	LED yellow	X	X	-

Further information

You can find a detailed description of all LEDs of the module with cause of the error and remedies in the relevant documentation for the module.

4.3 Diagnostics via the display of the S7-1500 CPUs

Display of the S7-1500 CPUs

Each CPU in the S7-1500 automation system has a front cover with a display.
Control and status information is shown in various menus on the display.
You use the operating keys to navigate through the menus.

Diagnostics via the display

The following indicators can be evaluated for diagnostic purposes on the display:

- Error and alarm texts (system diagnostics, alarm messages)
- Module status for central and distributed modules

In the following example of a display of the CPU 1516-3 PN/DP, you can see a warning on the diagnostics icon and an exclamation mark on the icon for module.

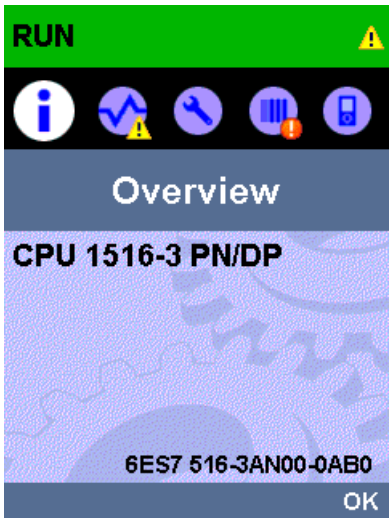


Figure 4-4 Display overview

Module status

To show the module status, navigate on the display through the menu items "Module" > "PROFINET I/O (X1)" > "Station" > "Slot" > "Status" > "Module status".

The module status indicates that a fault has occurred in the module. The "lower-level status" is the status of the module in the diagnostic level below this. In the example, the status is "good", i.e., the fault is not in the lower diagnostic level submodule or channel, but instead in the module.

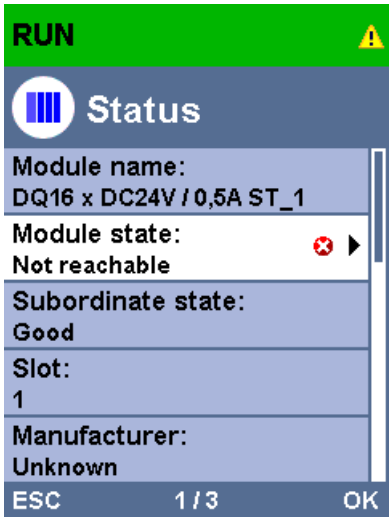


Figure 4-5 Display module status

Error and alarm texts

You can show diagnostic buffer entries and alarm messages for the relevant automation system on the display.

To show the diagnostic buffer entries of the CPU, navigate on the display via the menu items "Diagnostics" > "Diagnostic buffer".

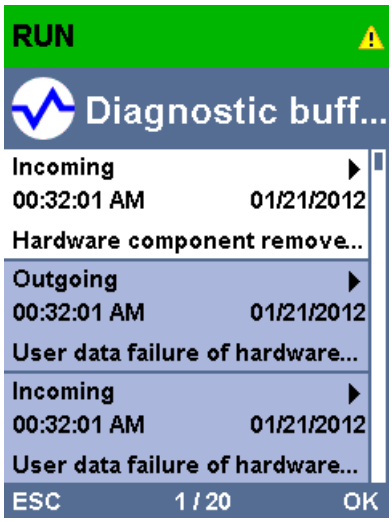


Figure 4-6 Display diagnostic buffer

To show the alarm messages of the automation system, navigate through the menu items "Diagnostics" > "Alarms" > "Alarm text" on the display.

Note

Updating the alarm display

The display shows the currently read status of the CPU in static form, the display is not automatically updated. The alarm display is updated after it has been exited and opened again.

Figure 4-7 Display of alarms

Figure 4-8 Display of alarm message

Additional information

You can find the description of the operation and functions of the display in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

4.4 Diagnostics via Web server

The CPUs belonging to the S7 family have their own integrated Web server with a wide range of functions.

For diagnostics, the Web server supports you with the following displays:

- Contents of the diagnostic buffer
- Module status
- Actual topology of the PROFINET system
- Set topology of the PROFINET system (from the configuration)

Set topology and actual topology - graphic view

Requirements for displaying the set and actual topology:

- You have configured the PROFINET ports in the topology editor of the hardware and network editor of STEP 7.
- You have loaded the entire project with STEP 7 in the CPU.

The following shows an example of the graphic view.

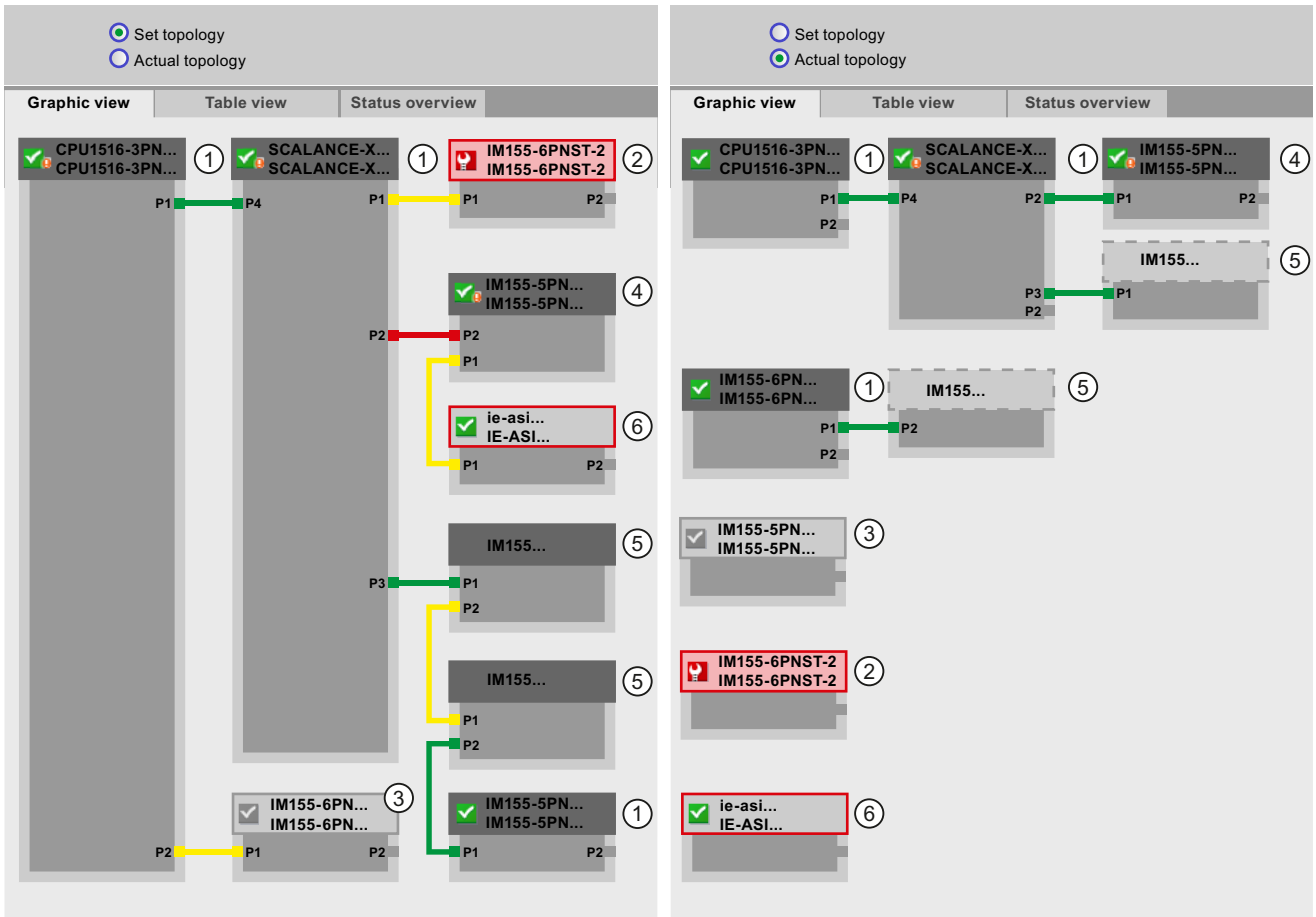


Figure 4-9 Topology - graphic view via the Web server

Meaning of the colored connections in the set/actual topology:

Table 4- 2 Meaning of the colored connections in the set/actual topology:

Connection	Meaning	
	Set topology	Actual topology
green	The current actual connection matches the configured set connection.	detected connections
red	The current actual connection does not match the configured set connection (e.g., port interchanged).	-
yellow	The connection cannot be diagnosed. Causes: • The communication to an IO device has been disrupted (e.g., cable removed) • Connection to a passive component • Connection to PROFINET devices of another IO controller or PROFINET system	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed dark-gray. Connections show the ports through which the PROFINET devices of a station are connected.

① Configured but not accessible PROFINET devices

The configured but not accessible PROFINET devices are displayed in pink with red border (e.g., device has failed, cable disconnected).

③ Disabled devices

All disabled, configured PROFINET devices are displayed light-gray.

④ Interchanged ports

Interchanged ports are marked red in the set topology view. The currently connected ports are displayed in the actual topology, the configured set connection in the set topology.

⑤ PROFINET devices of another PROFINET IO system

- In the set topology:

  A PROFINET device of another PROFINET IO system is displayed with a green connection (or red connected if the ports have been interchanged), when it is directly adjoining a configured and accessible PROFINET device ① and it is also accessible. When the PROFINET device of another PROFINET IO system is not accessible, a yellow connection line is displayed.

  The connection between two PROFINET devices that both belong to a different PROFINET IO system, cannot be determined and is always displayed in yellow.

- In the actual topology:

  A PROFINET device of another PROFINET IO system is only displayed if the PROFINET device is in direct proximity to a configured PROFINET device. The PROFINET device is displayed light-gray and with dashed line.

For PROFINET devices of a different PROFINET IO system, **no** status display is shown on the device head.

⑥ Representation of faulty neighbor relations

The devices whose neighbor relations cannot be read out completely or correctly are displayed light-gray with red border.

Additional information

The tabular view of the actual topology and the status overview of the PROFINET devices in the project are possible.

You can find these views, additional topology examples, and detailed information on the operation and the functions of the Web server in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) manual.

4.5 Diagnostics in STEP 7

For PROFINET, you have the following options to evaluate diagnostics in STEP 7:

- Online & diagnostics - Devices & networks
- Online & diagnostics - diagnostics of PROFINET ports

Online & diagnostics network view

In the hardware and network editor (launched from the "Project tree" by double-clicking "Devices & networks"), you can get an overview of the current state of your system by clicking on the "Go online" button. It also shows the configuration information (for example, non-configured modules). This option is also available in the topology view in similar form.

Schematic drawing of the network view (online):

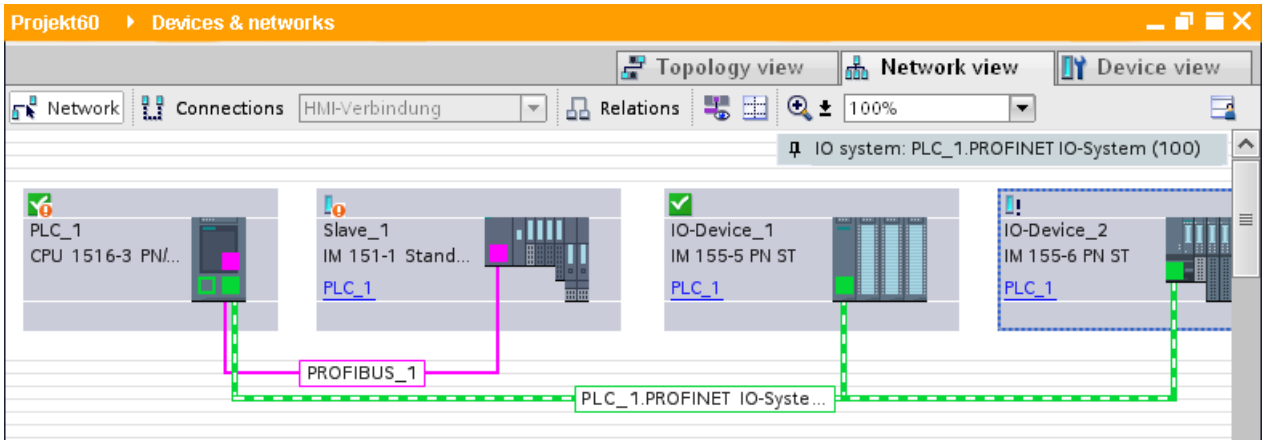


Figure 4-10 Online & diagnostics network view

Online & diagnostics device view

In STEP 7, you can display an overview of the modules in which faults have occurred. To do this, select the menu command "Online > Online & diagnostics". Once you are connected, you can see the status of the accessible devices in the project tree.

Double-click the device which displays an alarm message to access the faulty module directly. The device view is opened in the work area. In the device view of the device that reports the fault you can see directly in which module the fault occurs.

Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Schematic drawing of the device view (online):

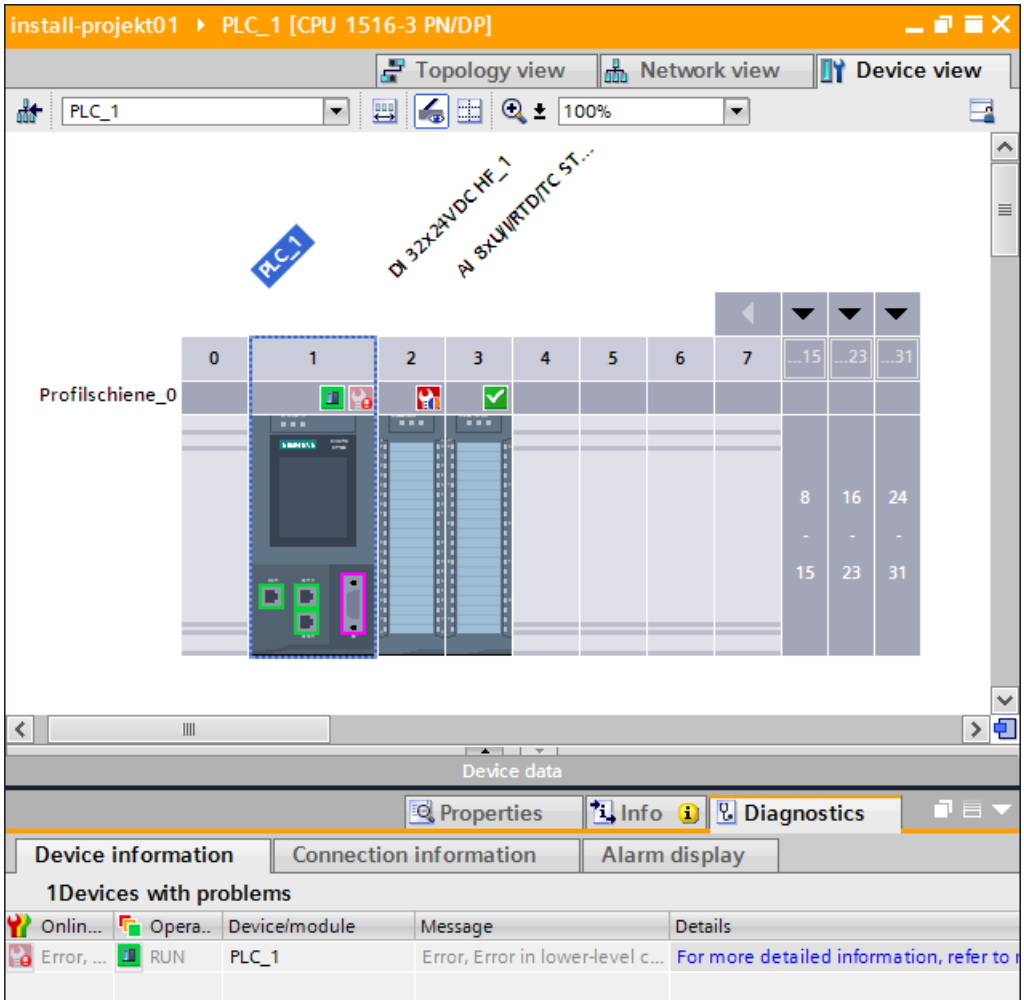


Figure 4-11 Online & diagnostics device view

Diagnostics of PROFINET ports

If you select "PROFINET interface > Ports" in the Diagnostics area in the online & diagnostics device view of a PROFINET device, the ports of the PROFINET interface are listed in a table.

The table provides you with the following information about the ports of the PROFINET interface.

- Name
- Status
- Settings
- Operating mode

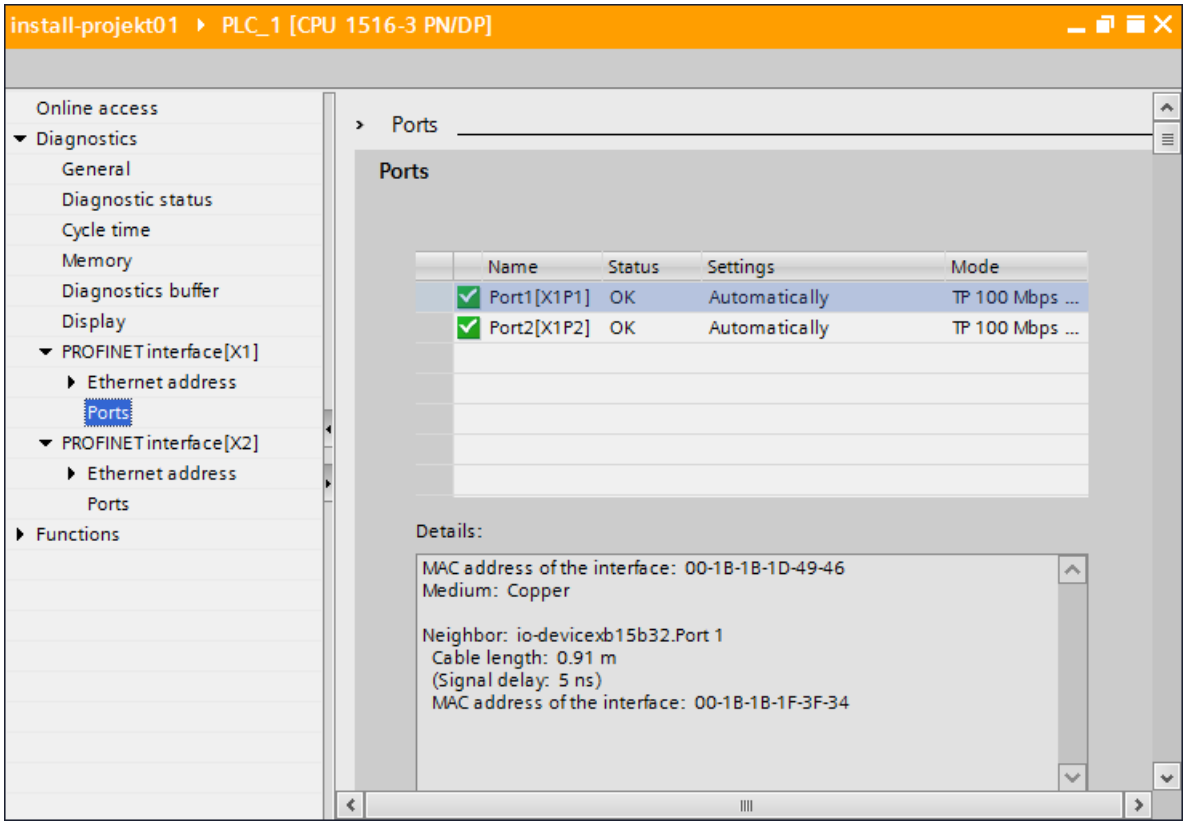


Figure 4-12 Diagnostics of PROFINET ports in STEP 7

Further information

You can find information on the system diagnostics for S7-1500, ET 200MP and ET 200SP in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual and in the STEP 7 online help.

4.6 Extended maintenance concept

Extended maintenance concept

The PROFINET interfaces with integrated switch of the SIMATIC devices support the four-level diagnostics concept in accordance with PROFINET specification Version V2.3 or higher with the following status:

Table 4- 3 Classification of the diagnostic status

Diagnostic status	Symbol		Severity of the error
Good	Green checkmark		low
Maintenance required	Green wrench		
Maintenance demanded	Yellow wrench		
Bad	Red wrench		high

The aim of the diagnostics concept is the early detection and elimination of potential faults - before they cause a production outage.

Other status information is defined in addition to the Good (no fault) and Bad (fault) status information for a PROFINET device.

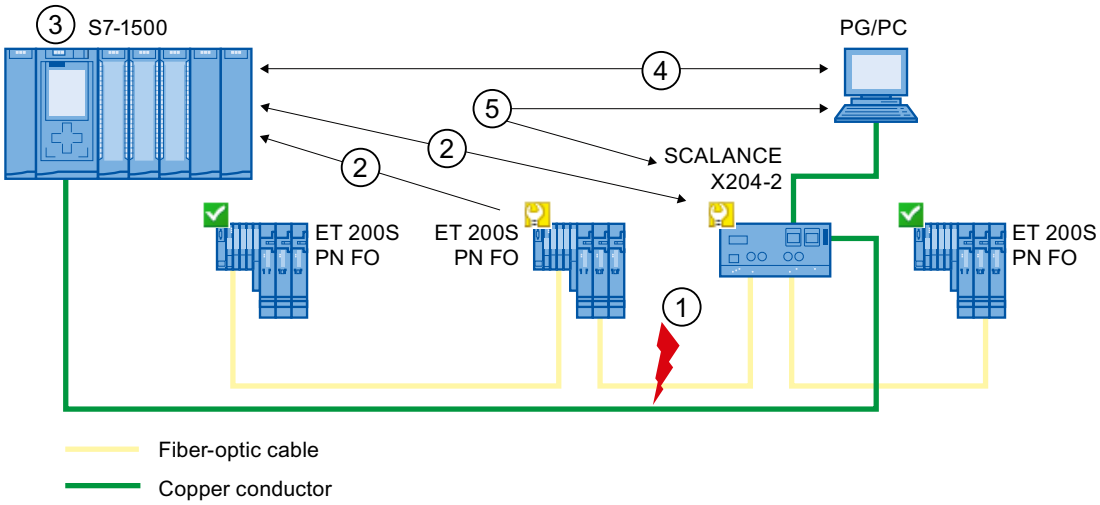
The maintenance information is generated with the following system alarms:

- Maintenance required (symbolized by a green wrench) and
- Maintenance demanded (symbolized by a yellow wrench)

The times at which the two system alarms are generated can be customized for most wear parameters.

Example: Maintenance demanded for a PROFINET cable

The following graphic illustrates how diagnostics information is exchanged when the transmission quality on the optical cable decreases due to ageing, for example. In this example, the scenario is considered after a maintenance required has already been diagnosed.



Number	Description
①	The system reserve of the fiber-optic cable drops below 0 dB.
②	Both the ET 200S PN FO and the switch send the maintenance demanded alarm to the IO controller.
③	Based on the interrupts, the IO controller detects the maintenance demanded from the switch and from the IO device. The module information data is updated in the IO controller and the corresponding error OBs are called. Note: To be able to start the error OBs in the IO controller, the "Call the user program if communication errors occur" property must be selected in STEP 7 for the relevant IO controller.
④	In STEP 7 (on the programming device/PC), the maintenance demanded message is indicated on the IO device and at the switch by a yellow wrench symbol.
⑤	STEP 7 can also read out detailed information directly from the switch.

Figure 4-13 Maintenance demanded for a PROFINET cable

4.7 Diagnostics of the network topology

Availability

As an open standard, you can use any SNMP based systems or software solutions for diagnostics in PROFINET.

Network diagnostics

The network management protocol SNMP (Simple Network Management Protocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics.

MIB

The MIB (Management Information Base) is the database of a device. SNMP clients access this database in the device. The S7 device family supports the following standard MIBs:

- MIB II, standardized in the RFC 1213
- LLDP-MIB, standardized in the international standard IEC 802.1AB
- LLDP-PNIO-MIB, standardized in the international standard IEC 61158-6-10

Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbor. LLDP enables a device to send information about itself and to receive information from its neighbor devices. This information is then saved in the LLDP MIB, for example, and can be queried using SNMP. This information allows a network management system to determine the network topology.

Use of SNMP in the SIMATIC NET environment

SNMP-compliant devices from the SIMATIC NET family can be monitored and operated via a conventional standard Internet browser. The management system known as web-based management offers a wide range of device-specific information (network statistics, status of redundant supply, for example).

Using SNMP

SNMP can be used as follows:

- By users to integrate network diagnostics into a central HMI/SCADA system using the SIMATIC NET OPC server
- By the IT administration of machine and plant operators to monitor their Industrial Ethernet network using standard network management systems.
- By the IT administration, to monitor the automation network, alongside the office network, using standard network management systems.

4.8 Diagnostics in the user program

4.8.1 Diagnostics and configuration data records

Diagnostics mechanism

The IO device outputs a diagnostic error interrupt to the IO controller when it detects faults such as wire break on an IO module. This interrupt calls a corresponding organization block in the user program (diagnostic error interrupt OB82), in order to generate a defined (programmed) response to the fault and passes a diagnostic data record.

Diagnostic data records in PROFINET IO

There are two different types of diagnostic data record:

1. Channel diagnostic data records

   Channel diagnostic data records are generated if a channel is in an error state and / or has triggered an interrupt.

   A diagnostic data record of length 0 is returned if there is no fault.

2. Vendor-specific diagnostic data records

   The structure and size of vendor-specific diagnostic data records depend on the vendor's settings.

   For information about vendor-specific diagnostic data records, refer to the appropriate device manual.

Addressing levels of diagnostic data records

Diagnostics and configuration data is evaluated at the following addressing levels:

- AR (Application Relation)
- API (Application Process Identifier)
- Slot
- Subslot

A group of diagnostics and configuration data records are available at each addressing level. In HEX representation, the individual groups of data records are distinguished by the first letter of the data record number.

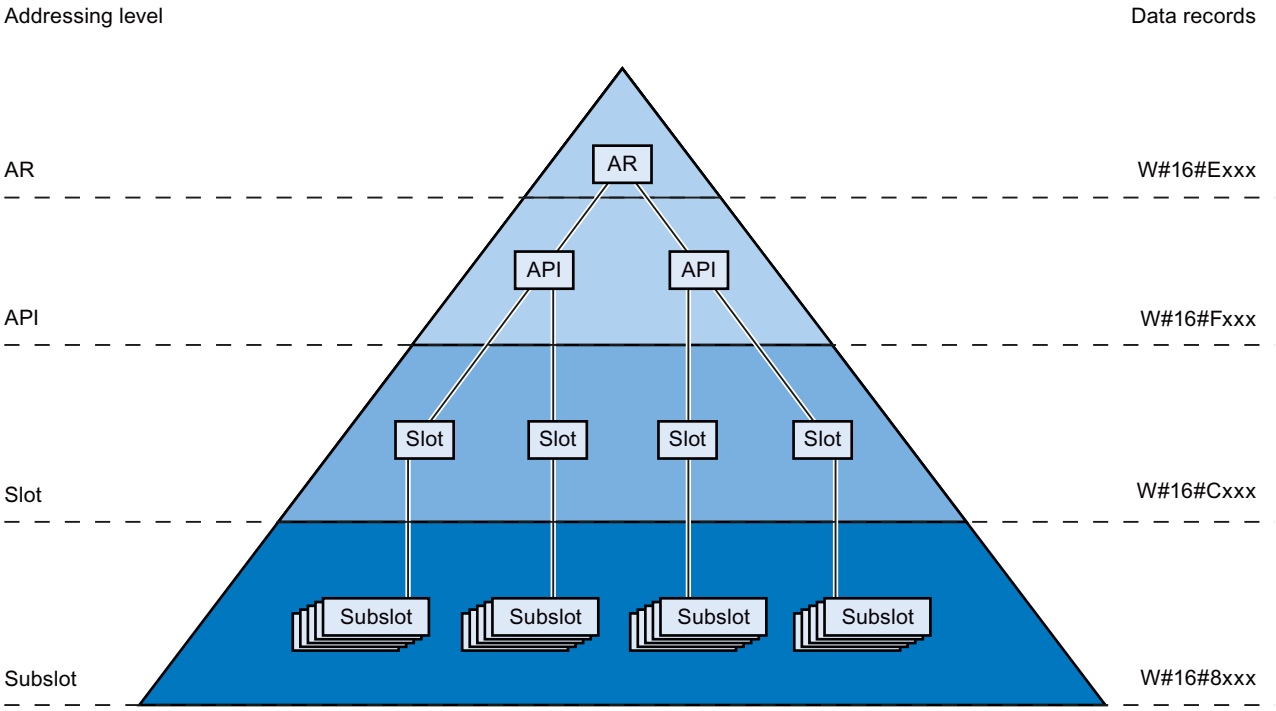


Figure 4-14 Addressing levels of diagnostic data records

The information for each IO device (addressing level AR), module (addressing level slot) or submodule (addressing level subslot) is always transferred in separate diagnostic or configuration data records. The data record returns diagnostic data or configuration data for one or more subslots, slots and APIs, depending on the addressing level.

Note

The diagnostic information is only generated for configured modules / submodules / channels.

4.8.2 Evaluate diagnostics in the user program

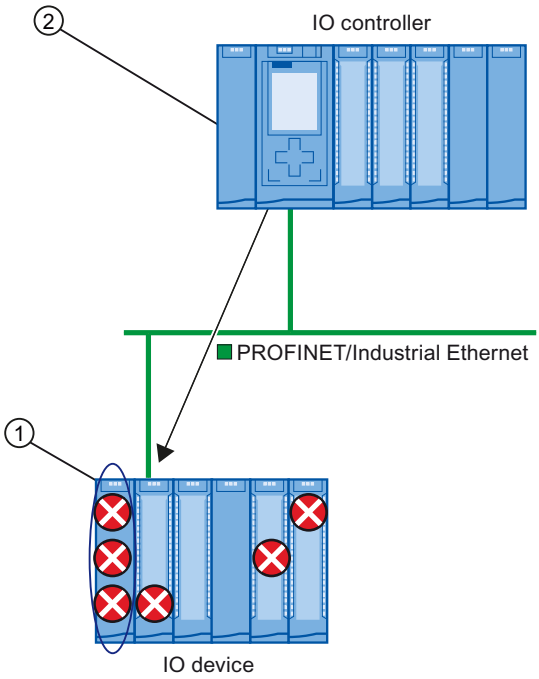
Diagnostics in the user program

For PROFINET IO, a cross-vendor structure of data records with diagnostic information applies. Diagnostic information is created only for channels on which a fault has occurred. With PROFINET, there are two basic ways to obtain diagnostic information.

1. Evaluating the diagnostic status

Read out the diagnostics of your PROFINET IO system using the instructions "DeviceStates" and "ModuleStates", to localize those stations / modules or station / modules with maintenance demanded or maintenance required that have faults within a PROFINET IO system.

The instruction RDREC (read data record) is then used to read various diagnostic data records directly from the module concerned and thus obtain detailed information about the error.

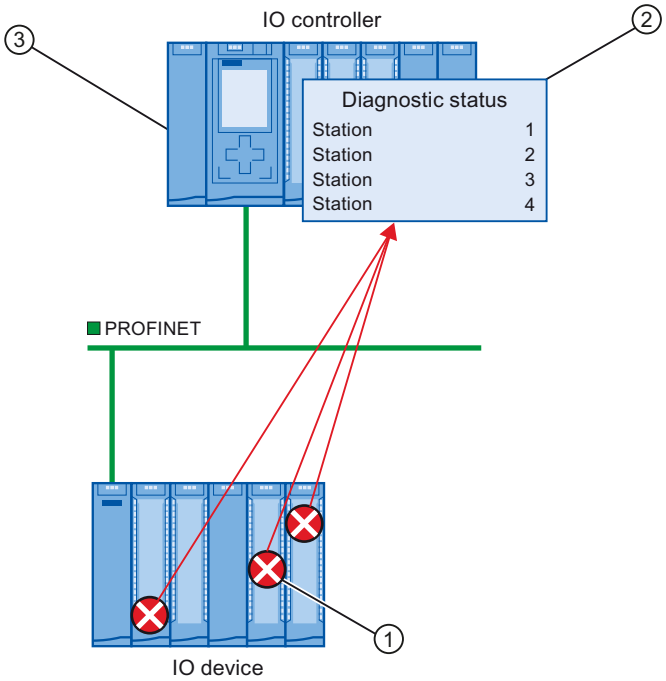


Number	Description
①	All individual errors are collected in a single data record on the interface module.
②	In your user program, the instruction "RDREC" reads the entire station status asynchronously directly from the IO device.

Figure 4-15 Example: Evaluating diagnostic data records with the instruction "RDREC"

2. Evaluation of interrupts

When the error OB (OB 82) is called, the OB's start information provides you with information on the cause and location of the error. Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).



Number	Description
①	Every error is sent to the IO controller individually as channel diagnostic information in the form of an interrupt.
②	In the IO controller, the module status data is updated automatically and the error OB (OB 82) is started.
③	In your user program in the error OB (OB 82), the instruction "RALRM" reads the error synchronously from the IO controller without addressing the IO device.

Figure 4-16 Diagnostics with OB 82 and the instruction "RALRM"

Instructions and OBs

You can find information on the instructions and OBs in the online help of STEP 7.

Functions 5

Introduction

The following section describes the PROFINET IO functions for field of application, properties and configuration in STEP 7.

Refer to the documentation for the respective device to see to what extent the PROFINET devices support the described functions.

You can find a tabular overview of the PROFINET devices and the functions these support on the Internet (http://support.automation.siemens.com/WW/view/en/44383954).

5.1 Connecting other bus systems

Fieldbus integration

PROFINET allows you to use a proxy to integrate existing fieldbus systems (for example, PROFIBUS) into PROFINET. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This allows a continuous exchange of information.

Linking PROFINET and PROFIBUS

With a proxy-capable PROFINET device which is equipped with a PROFINET interface in addition to a PROFIBUS interface (for example, IE/PB Link), you can integrate existing PROFIBUS configurations into the PROFINET configuration.

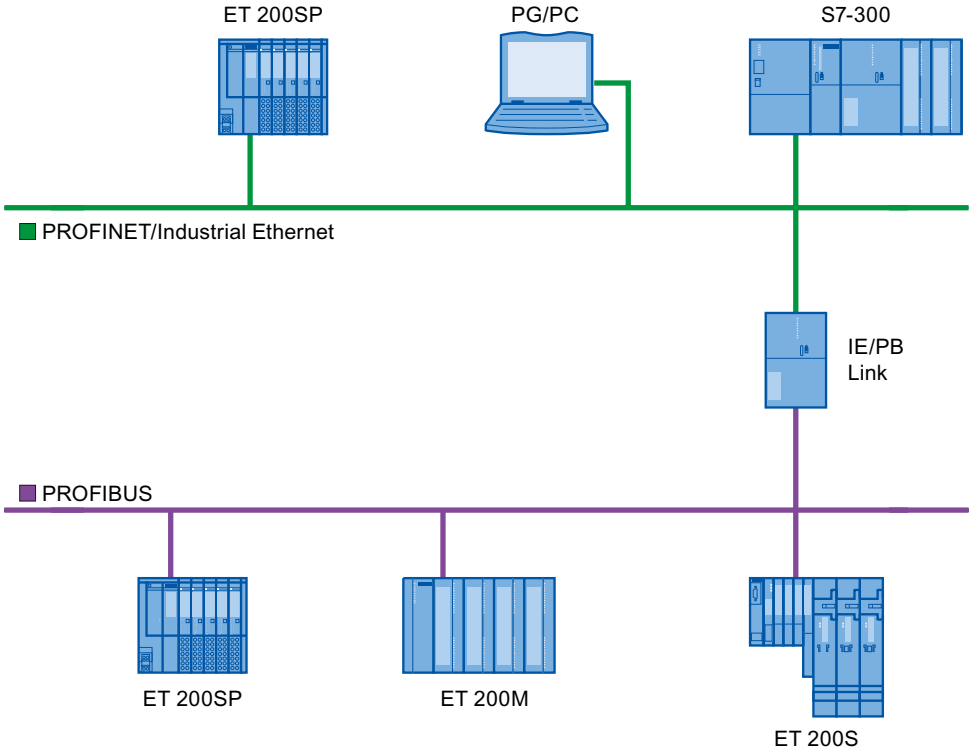


Figure 5-1 Connecting PROFINET and PROFIBUS via proxy

PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the help, for example, of an IE/PB link, using an S7-300 or S7-400 IO controller. The IE/PB link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

5.2 Intelligent IO devices (I-devices)

5.2.1 I-device functionality

I-device functionality

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller and operation of the CPU as intelligent preprocessing unit of sub processes, for example. The I-device is linked as an IO device to a "higher-level" IO controller.

The preprocessing is handled by the user program on the CPU. The process values acquired in the centralized or distributed (PROFINET IO or PROFIBUS DP) I/O are preprocessed by the user program and made available via a PROFINET IO interface to the CPU of a higher-level station.

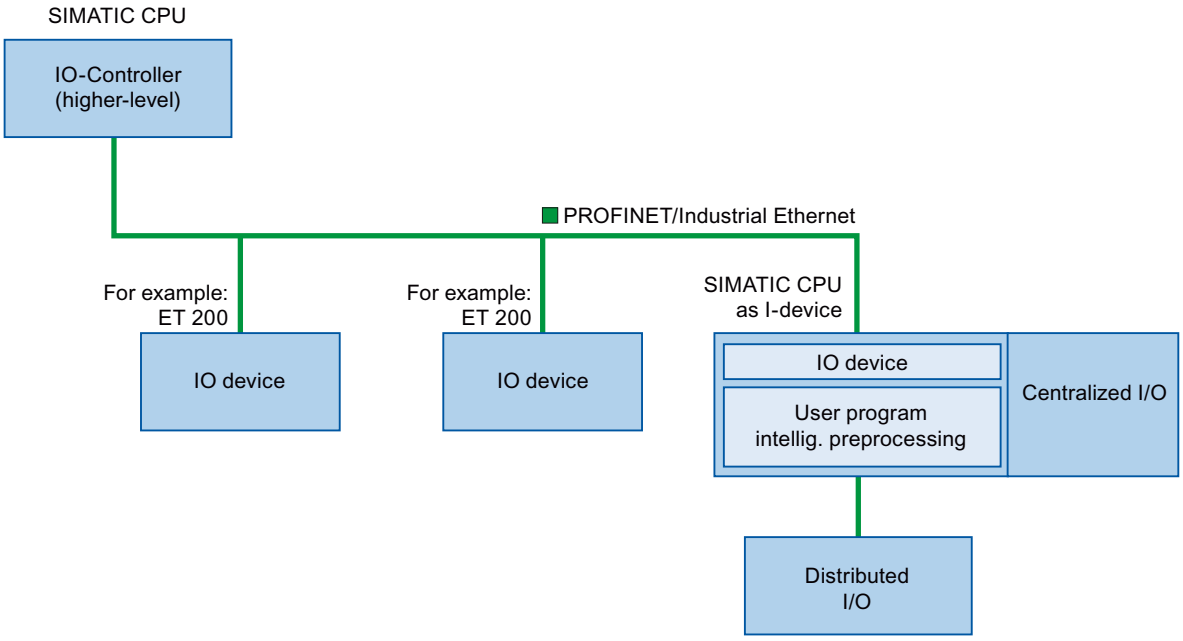


Figure 5-2 I-device

"I-device" naming conventions

In the remainder of this description, a CPU or a CP with I-device functionality is simply called an "I-device".

5.2.2 Properties and Advantages of the I-Device

Fields of application

Fields of application of the I-device:

- Distributed processing

  A complex automation task can be divided into smaller units/subprocesses.
  This results in manageable processes which lead to simplified subtasks.

- Separating subprocesses

  Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-devices. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.

- Know-how protection

  Components can only be delivered with a GSD file for the I-device interface description instead of with a STEP 7 project. The know-how of the user program must no longer be published.

Properties

Properties of the I-device:

- Unlinking STEP 7 projects

  Creators and users of an I-device can have completely separated STEP 7 automation projects. The GSD file forms the interface between the STEP 7 projects.
  This allows a link to standard IO controllers via a standardized interface.

- Real-time communication

  The I-device is provided with a deterministic PROFINET IO system via a PROFINET IO interface and therefore supports RT (real-time communication) and IRT (isochronous real time).

Advantages

The I-device has the following advantages:

- Simple linking of IO controllers
- Real-time communication between IO controllers
- Relieving the IO controller by distributing the computing capacity to I-devices.
- Lower communications load by processing process data locally.
- Manageable, due to processing of subtasks in separate STEP 7 projects

5.2.3 Characteristics of an I-Device

Principle

An I-device is included in an IO system like a standard IO device.

I-device without lower-level PROFINET IO system

The I-device does not have its own distributed I/O. The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example ET 200).

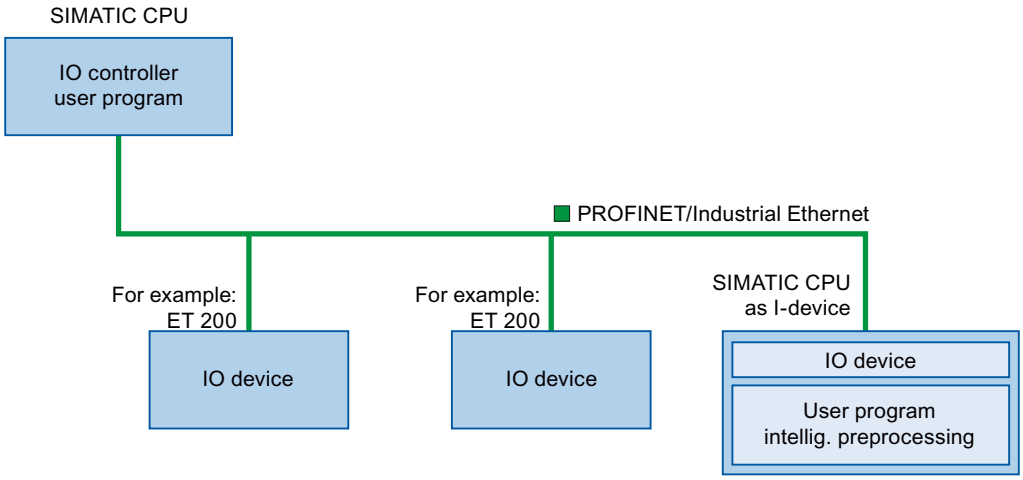


Figure 5-3 I-device without lower-level PROFINET IO system

I-device with lower-level PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of an IO device.

This means that the I-device can be part of a higher-level IO system via its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices (see figure below). This makes hierarchically structured IO systems possible.

In addition to its role as IO controller, an I-device can also be used via a PROFIBUS interface as DP master for a lower-level PROFIBUS system.

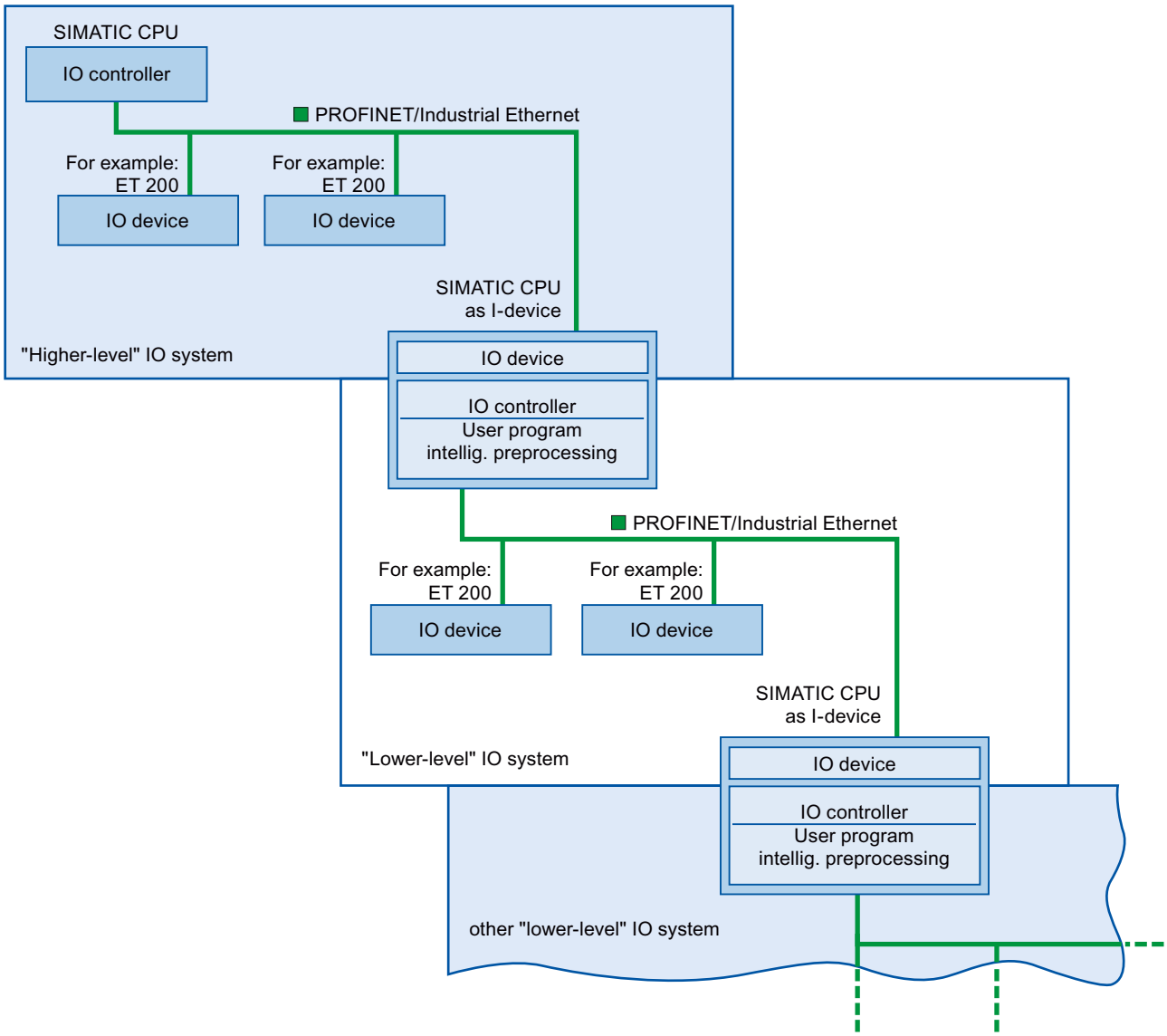


Figure 5-4 I-device with lower-level IO system

Example - the I-device as IO device and IO controller

The I-device as IO device and IO controller is explained based on the example of a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.

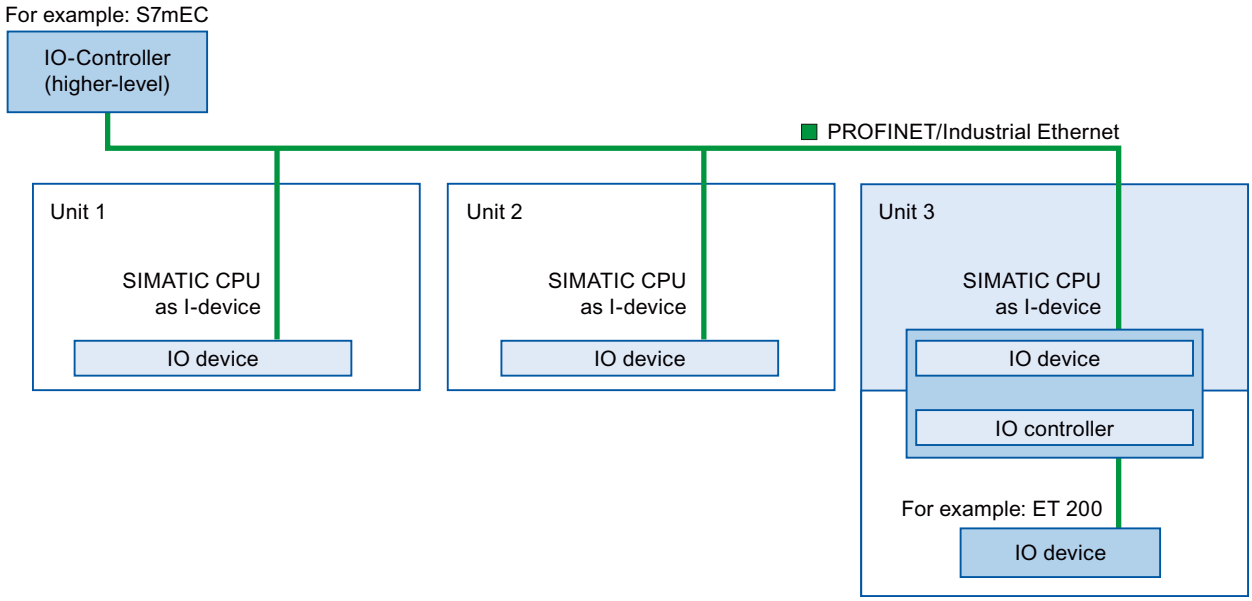


Figure 5-5 Example - the I-device as IO device and IO controller

Unit 1 and unit 2 each consist of an I-device with centralized I/O.
The I-device along with the distributed I/O system (for example ET 200) forms unit 3.

The user program on the I-device is responsible for preprocessing the process data. For this task, the user program of the I-device requires default settings (for example control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example status of its subtask).

5.2.4 Data Exchange between higher- and lower-level IO system

Introduction

The next chapter shows the data exchange between the higher- and lower-level IO system.

Transfer areas

Transfer areas are an interface to the user program of the I-device CPU.
Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between IO controller and I-device is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently between IO controller and I-device. You can find more information on configuration and use of transfer areas in the section Configuring the I-device (Page 102).

The next figure shows the data exchange between the higher- and lower-level IO system. The individual communication relations are explained below based on the numbers.

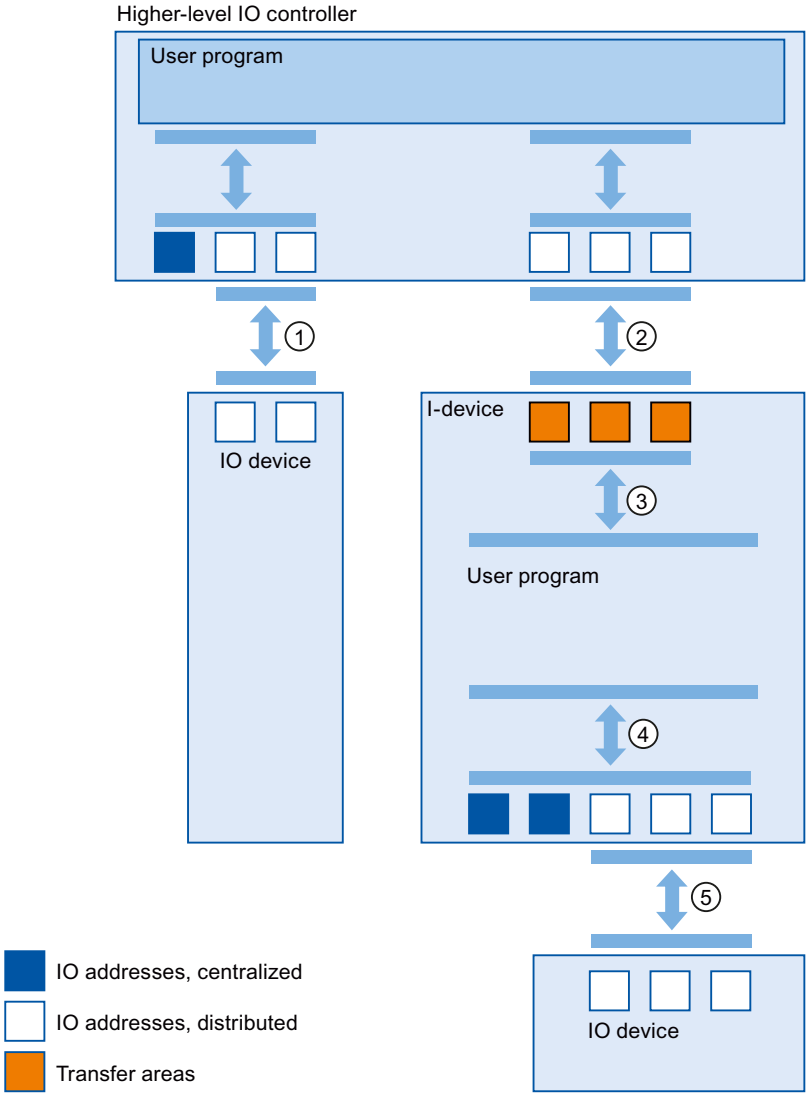


Figure 5-6 Data exchange between higher- and lower-level IO system

① Data exchange between higher-level IO controller and normal IO-device

In this way, the IO controller and IO devices exchange data through PROFINET.

② Data exchange between higher-level IO controller and I-device

In this way, the IO controller and the I-device exchange data through PROFINET.

The data exchange between a higher-level IO controller and an I-device is based on the conventional IO controller / IO device relationship.

For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.

The output data of the IO controller is the input data of the I-device.
Analogously, the input data of the IO controller is the output data of the I-device.

③ Transfer relationship between the user program and the transfer area

In this way, the user program and the transfer area exchange input and output data.

④ Data exchange between the user program and the I/O of the I-device

In this way, the user program and the centralized / distributed I/O exchange input and output data.

⑤ Data exchange between the I-device and a lower-level IO device

In this way, the I-device and its IO devices exchange data.
The data transfer is via PROFINET.

5.2.5 Configuring the I-device

Introduction

There are basically two possibilities for configuration:

- Configuration of an I-device within a project
- Configuration of an I-device that is used in another project or in another engineering system.

STEP 7 allows you to configure an I-device for another project or for another engineering system by exporting a configured I-device to a GSD file. You import the GSD file in other projects or engineering systems as with other GSD files. The transfer areas for the data exchange, among other data, are stored in this GSD file.

Configuration of an I-device within a project

1. Drag-and-drop a PROFINET CPU from the hardware catalog into the network view.
2. Drag-and-drop a PROFINET CPU, which can also be configured as an IO device, from the hardware catalog into the network view. This device is configured as I-device (e.g., CPU 1516-3 PN/DP).
3. Select the PROFINET interface for the I-device.
4. In the Inspector window in the area navigation choose "Operating mode" and select the check box "IO device".
5. Now you have the option of choosing the IO controller in the "Assigned IO controller" drop-down list.

   Once you have chosen the IO controller, the networking and the IO system between both devices are displayed in the network view.

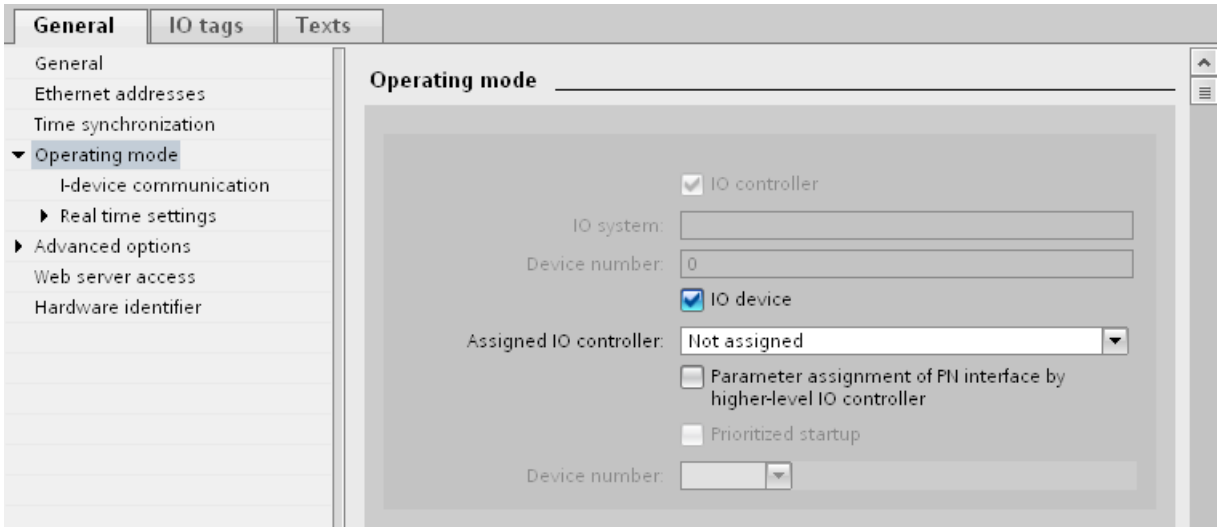
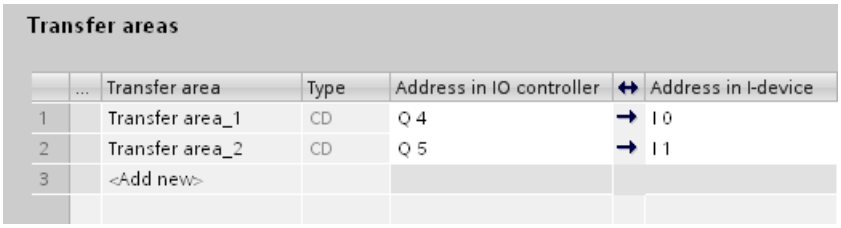


Figure 5-7 Configuring the I-device

6. With the "Parameter assignment of PN interface by higher-level IO controller" check box, you specify whether the interface parameters will be assigned by the I-device itself or by a higher-level IO controller.

   If you operate the I-device with a lower-level IO system, then the parameters of the I-device PROFINET interface (for example, port parameter) cannot be assigned with the higher-level IO controller.

7. Configure the transfer areas. The transfer areas are found in the area navigation section "I-device communication".
   - Click in the first field of the "Transfer area" column. STEP 7 assigns a default name which you can change.
   - Select the type of communication relation: you can currently only select CD or F-CD for "Controller-device communication relation".
   - Addresses are automatically preset; you can correct addresses if necessary, and determine the length of the transfer area which is to be consistently transferred.



Transfer areas

	...	Transfer area	Type	Address in IO controller	↔	Address in I-device
1		Transfer area_1	CD	Q 4	→	I 0
2		Transfer area_2	CD	Q 5	→	I 1
3		<Add new>				

Figure 5-8 Configuring the transfer areas

8. A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

Configuring an I-device with a GSD file

If you use an I-device in another project, or if the I-device is used in another engineering system, then configure the higher-level IO controller and the I-device as described above.

However, click on the "Export" button after configuring the transfer areas so a new GSD file is created from the I-device. This GSD file represents the configured I-device in other projects.

The "Export" button is found in the "I-device communication" section of the Inspector window.

The hardware configuration is compiled and the export dialog opened.

Assign a name for the I-device proxy as well as a description in the fields provided. Click the "Export" button to complete your process.

Finally, import the GSD file, for example, in another project.

5.2.6 Program examples

Introduction

This simple program example explains how the preprocessing can be implemented with an I-device.

Preprocessing on the I-device

Task

The result of a simple "AND" operation on the I-device will be made available on the higher-level IO controller for further processing.

Requirements

You have configured a transfer area on the I-device with the following properties:

- Local I-device address type: Output
- Start address 568, length 1

Solution

Table 5- 1 STL code: I-device

```
STL
U I1.0
U I1.1   // AND operation from I1.0 (Sensor 1) and I1.1 (Sensor 2)
= Q      // Write result of logic operation to Q568.0 (transfer area of the I-device)
568.0
```

Table 5- 2 STL code: Higher-level IO controller

```
STL
U I      // corresponds with the Q568.0 of the I-device
68.0     // sets the initial state of Q0.0
= Q 0.0
```

Note

The addresses of the transfer areas are preset by STEP 7. You can change the addresses as usual. In this case, the byte address I 68 was specified for the transfer area.

5.2.7 Diagnostics and interrupt characteristics

Diagnostics and interrupt characteristics

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors or failures of lower-level IO systems. These diagnostic messages reduce down times and simplify localization and elimination of problems.

Diagnostic options in the higher-level IO controller and in the I-device

The following diagnostic functions are available to the higher-level IO controller and the I-device CPU:

- OB 83 (removal/insertion)
- OB 86 (rack failure)
- OB 122 (I/O access error)

Note

The diagnostic messages of the I/O can be processed in the user program of the I-device CPU and passed on from there to the higher-level IO controller via transfer areas.

Operating state changes and station failure / station return

In the following table, you can see which consequences the operating state change or the failure of a S7-1500 IO controller / I-device has on the respective other(s):

Table 5- 3 Operating state changes and station failure / station return

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	The I-device CPU changes to STOP	/	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)
I-device CPU is in STOP higher-level IO controller is in RUN	The I-device CPU is starting up	Call of OB 100 (startup). Call of OB 83 (remove/insert) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error)	Call of OB 83 (remove/insert) for all transfer areas to the I-device. Until call of OB 83 in the case of direct access to the transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)
I-device CPU is in RUN, higher-level IO controller is in RUN	The higher-level IO controller changes to STOP	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error) Note: Output transfer areas can still be accessed.	/
Higher-level IO controller is in STOP, I-device CPU in RUN	The higher-level IO controller starts up	Call of OB 83 (remove/insert) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error)	Call of OB 100 (startup).

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	Station failure I-device, for example, through bus interruption	If the I-device continues to run without a bus connection: Call of OB 86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error)	Call of OB86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)
I-device CPU is in RUN, higher-level IO controller is in RUN, communication connection between IO controller and I-device is interrupted (bus interruption).	The bus connection between the IO controller and I-device has been reestablished and the I-device is again included in the user data traffic.	Call of OB 86 (rack failure). Call of OB 83 (remove/insert) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 86 (rack failure). Until reporting of station re-integration by OB 86 with direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)

Note

Special characteristic during startup of the higher-level IO controller

In contrast to the station return message from IO devices in the IO controller, which are covered completely by the call of the OB 86, the station return message of a higher-level IO controller in the I-device is separated into 2 parts:

1. Call of the OB 86: The initial values for the outputs of the I-device are set. However, the input values are not yet valid. These values will first be valid with the opening of OB 86 in the higher-level IO controller.
2. Call of OB 83 for each input transfer area; with this call, the validity of an input transfer area is displayed. The starting up of the I device is first complete when the OB 83 has been called for the input transfer areas. This step can be delayed or not occur at all in the following situations:
   - Higher-level IO controller is in STOP: OB 83 is first called at the STOP-RUN transition of the higher-level IO controller.
   - The IRT communication has been disrupted (sync-master failure, topology error, ...). OB 83 is opened only after the IRT communication has taken place.

Reference

For more information on error handling during direct IO access, refer to the online help for STEP 7, under "Error handling".

5.2.8 Rules for the Topology of a PROFINET IO System with I-Device

Introduction

The following recommendations for the structure and configuration of an IO system when using I-devices will help you to keep the bandwidths required for keeping communication small.

The following communication paths should not overlap:

- Communication paths between the IO controller and the IO device of its IO system.
- Communications paths of the I-device CPU and the IO devices of its IO system.

I-device with one port

Connect an I-device with only one port to a PROFINET switch that is uncoupled from the higher-level IO system. Connect the lower-level IO system to another port of the switch as shown in the following figure.

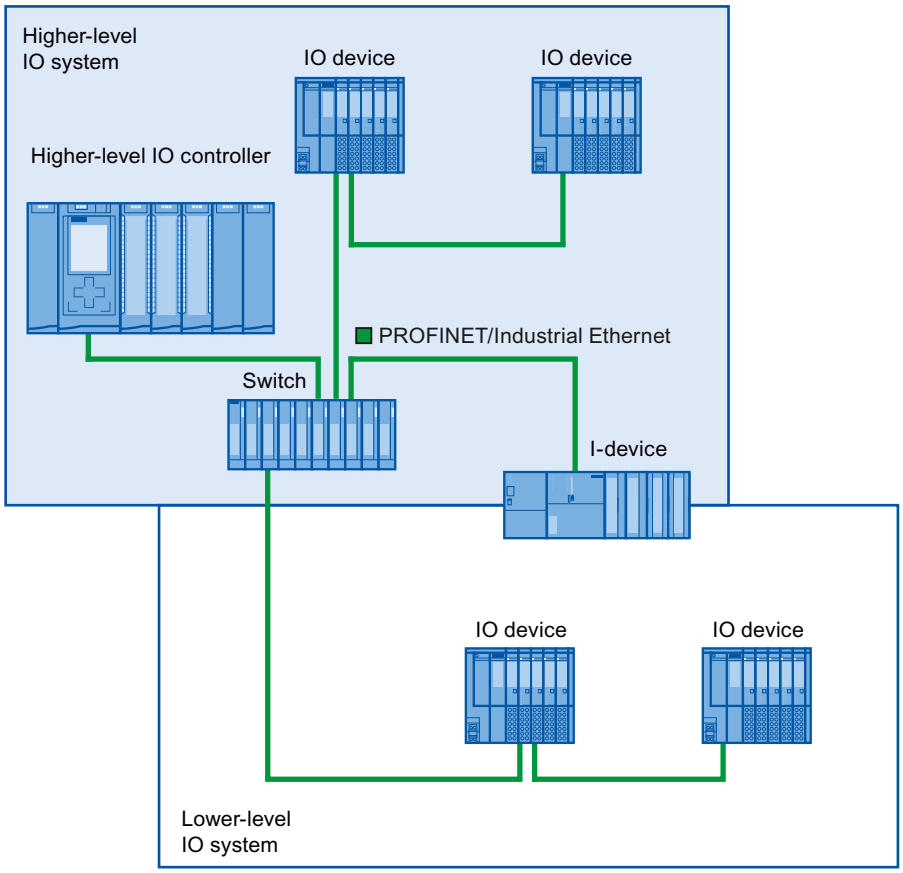


Figure 5-9 I-device with one port

I-device with two ports

With an I-device with two ports, connect one port, uncoupled from the higher-level IO system, to the port of the PROFINET switch. Use the second port for the lower-level IO system as shown in the following figure.

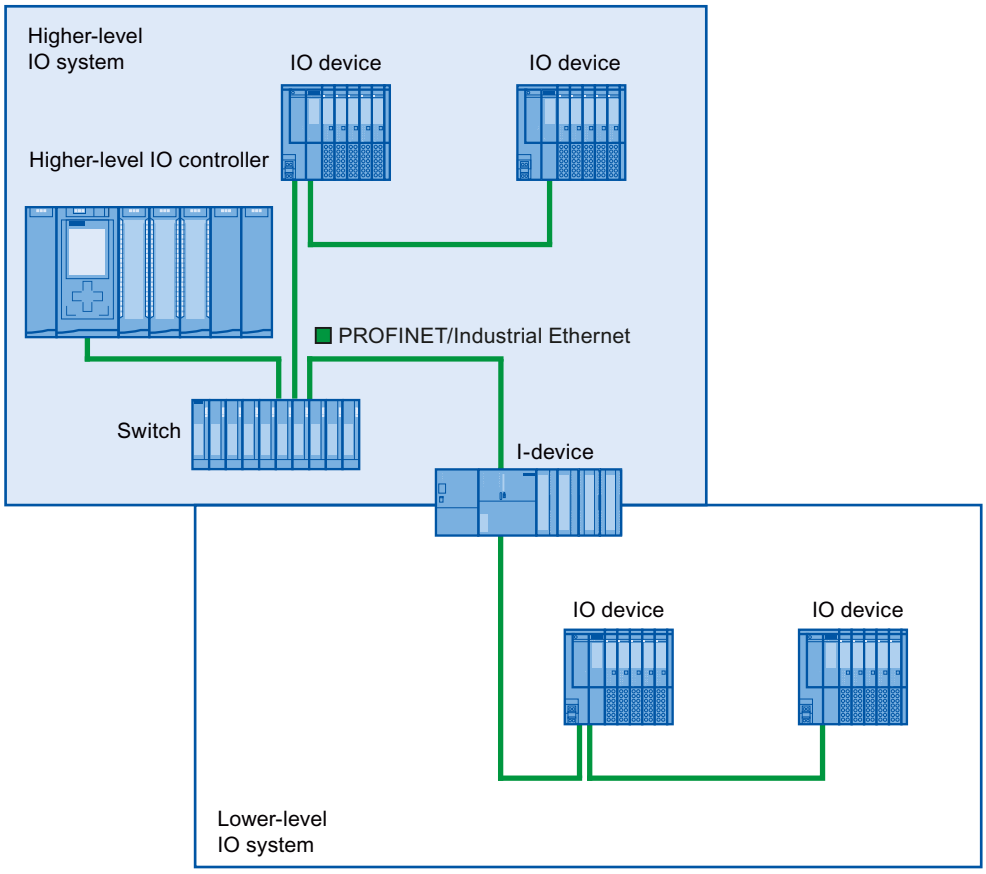


Figure 5-10 I-device with two ports

I-device with three or more ports

If you have an I-device with three or more ports, connect the I-device to one or both ports to the higher-level IO system in a linear bus topology.
Connect the third port to the lower-level IO system uncoupled from the linear bus topology as shown in the following figure.

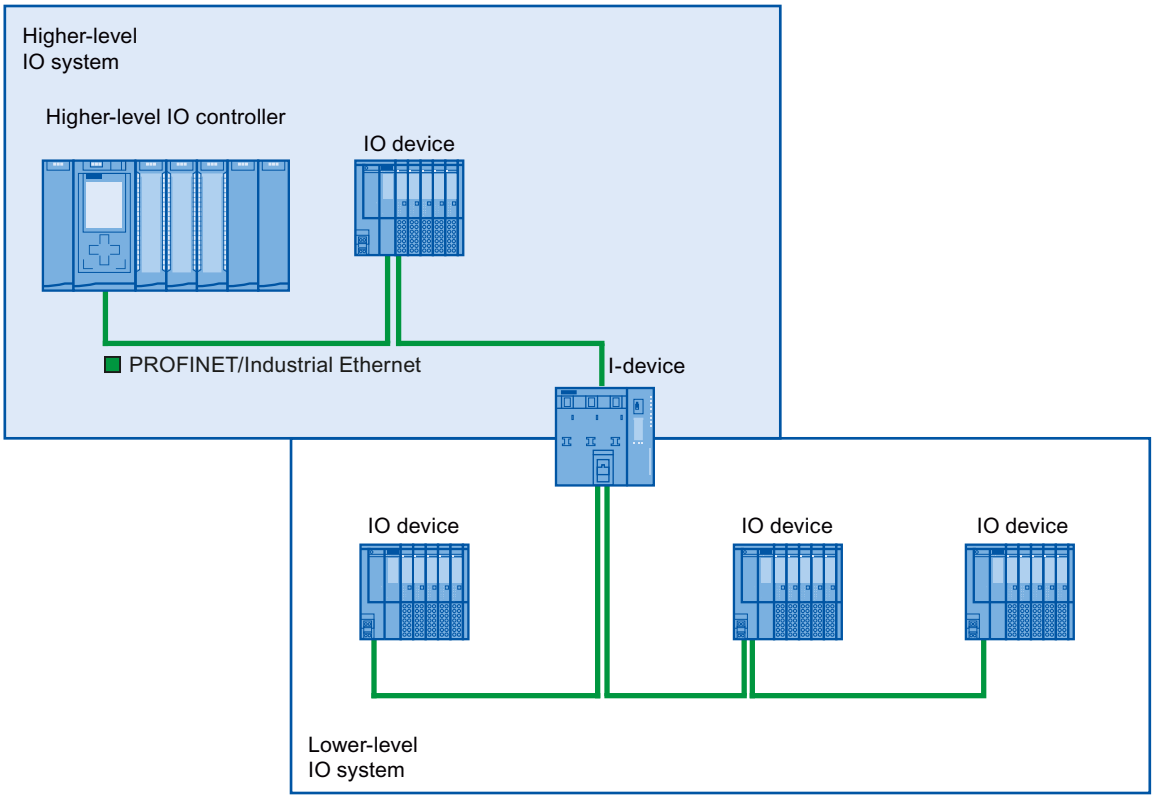


Figure 5-11 I-device with three or more ports

5.2.9 Boundary conditions when using I-devices

Note the following boundary conditions when using I-devices:

Bandwidth

The number of addresses of the configured transfer areas affects the usable bandwidth of the I-device:

- Bandwidth of the transfer areas + bandwidth of the lower-level IO system = total bandwidth used on the I-device

If the address space of the transfer areas is too large, this indicates a larger bandwidth requirement and can thus lead to longer update times.

Tip: Keep the address space of the transfer area as small as possible.

Rules for RT and IRT communication.

IO systems with I-devices are also suitable for setting up real-time applications with RT and IRT communication. The following rules must be followed for this:

- Both the higher-level and the lower-level IO system support RT communication. You can use RT communication for both IO systems at the same time.
- IRT communication can be combined with RT communication. IRT communication, however, cannot be used in both IO systems at the same time. IRT is possible where the parameters of the IO interface are set.

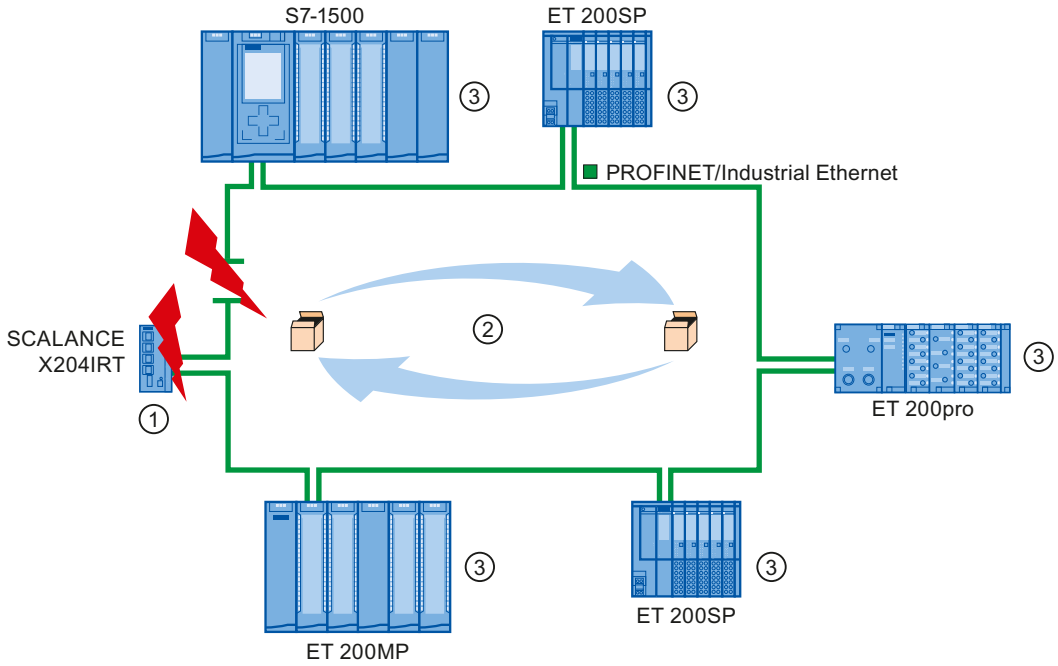
5.3 Media redundancy (ring topologies)

In order to increase the network availability of an Industrial Ethernet network with optical or electrical linear bus topologies, you can convert a linear bus topology to a ring topology by joining the ends together.

Media redundancy in ring topologies

Devices in a ring topology can be IO devices, IO controllers, external switches and/or the integrated switches of communication modules.

To set up a ring topology with media redundancy, you need to bring together the two free ends of a linear bus topology in one device. Closing the linear bus topology to form a ring is achieved with two ports (ring ports) of a device in the ring. One device of the resulting ring then takes over the role of the redundancy manager. All other devices in the ring are redundancy clients.



① Redundancy manager
② Test frames
③ Redundancy clients

Figure 5-12 Media redundancy in ring topology

The ring ports of a device are the ports that establish the connection to the two neighboring devices in the ring topology. The ring ports are selected and set in the configuration of the relevant device (is also preset, if applicable).

How media redundancy works in a ring topology

The data paths between the individual devices are automatically reconfigured if the ring is interrupted at any point. The devices are available again after reconfiguration.

In the redundancy manager, one of the two ring ports is blocked in uninterrupted network operation for normal communication so that no data frames are circulated. In terms of data transmission, the ring topology is a linear bus topology. The redundancy manager monitors the ring for interruptions. It does this by sending test frames both from ring port 1 and ring port 2. The test frames run round the ring in both directions until they arrive at the other ring port of the redundancy manager.

An interruption of the ring can be caused by loss of the connection between two devices or by failure of a device in the ring.

If the test frames of the redundancy manager no longer arrive at the other ring port during an interruption of the ring, the redundancy manager connects its two ring ports. This substitute path once again restores a functioning connection between all remaining devices in the form of a linear bus topology.

The time between the ring interruption and restoration of a functional linear topology is known as the reconfiguration time.

As soon as the interruption is eliminated, the original transmission paths are established again, the two ring ports of the redundancy manager are disconnected and the redundancy clients informed of the change. The redundancy clients then use the original paths again to the other devices.

Media redundancy method

The standard method of media redundancy in SIMATIC is MRP (Media Redundancy Protocol) with a typical reconfiguration time of 200 ms. Up to 50 devices can participate per ring.

5.3.1 Media Redundancy Protocol (MRP)

Media Redundancy Protocol (MRP)

The "MRP" process works in conformity with Media Redundancy Protocol (MRP), which is specified in IEC 61158 Type 10 "PROFINET".

Requirements

The following requirements must be met for error-free operation with the media redundancy protocol MRP:

- The ring in which you want to use MRP may only consist of devices that support this function.
- "MRP" must be activated for all devices in the ring.
- All devices must be interconnected via their ring ports.
- At least one redundancy manager (role "Manager (Auto)") must be available.
- The ring must contain not more than 50 devices. Otherwise, reconfiguration times of greater than or equal to 200 ms may occur.
- All partner ports within the rings must have the identical settings.

Topology

The following schematic shows a possible topology for devices in a ring with MRP. The devices inside the shaded oval are in the redundancy domain.

Example of a ring topology with the MRP media redundancy protocol:

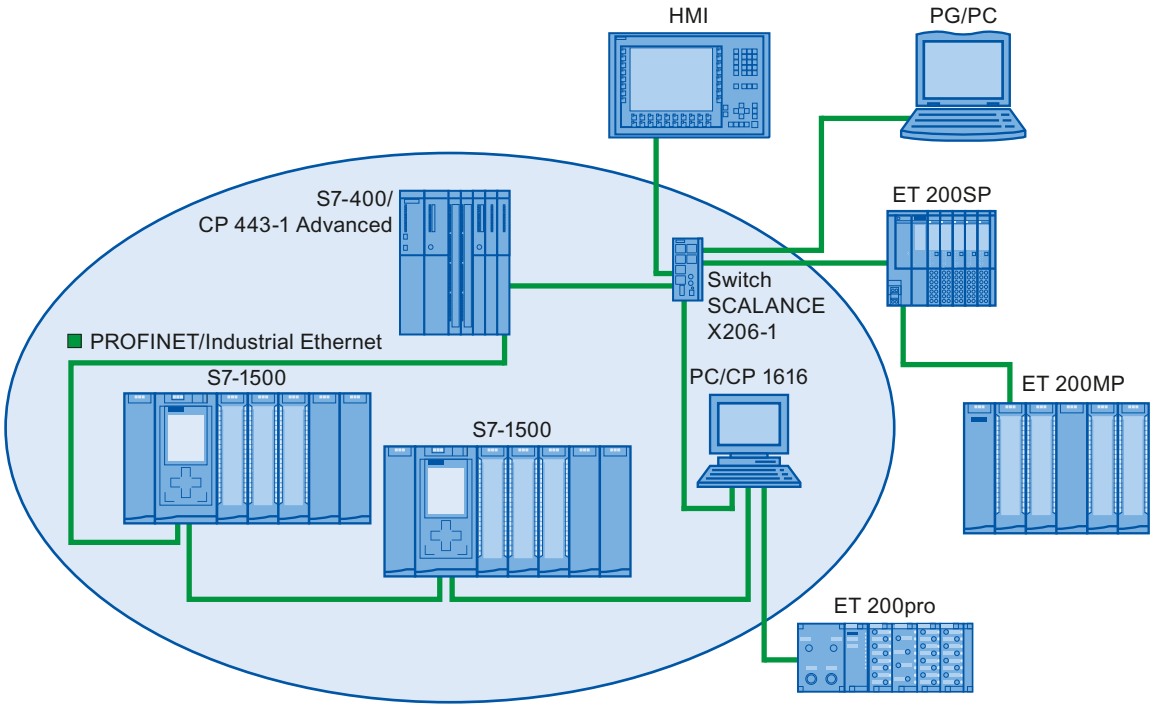


Figure 5-13 Example of a ring topology with the MRP media redundancy protocol:

The following rules apply to a ring topology with media redundancy using MRP:

- All devices in the ring belong to the same redundancy domain.
- One device in the ring has the role of a redundancy manager.
- All other devices in the ring are redundancy clients.

Non MRP-compliant devices can, for example, be connected to the ring via a SCALANCE X switch or via a PC with a CP 1616.

Boundary conditions

MRP and RT

RT operation is possible with the use of MRP.

Note

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. This is why you should select a response monitoring time of the IO devices that is sufficiently large.

MRP and IRT

IRT mode is not possible together with MRP.

MRP and TCP/IP (TSEND, HTTP, ...)

The TCP/IP communication with MRP is possible, because lost data packages are resent, if applicable.

MRP and prioritized startup

If you configure MRP in a ring, you cannot use the "prioritized startup" function in PROFINET applications on the devices involved.

If you want to use the "prioritized startup" function, then you must disable MRP in the configuration (the device may also not be part of the ring).

MRP on PROFINET devices with more than two ports

If you operate a PROFINET device with more than two ports in a ring, you should set a sync boundary on the ports that are not in the ring. By setting the sync boundary, you define a boundary for a sync domain. No forwarding of sync frames transmitted to synchronize devices within a sync domain.

5.3.2 Configuring media redundancy

Requirements for media redundancy with MRP

- The involved components must support the media redundancy protocol (MRP).
- No IRT communication is configured.

Procedure

To configure media redundancy, proceed as follows:

1. Establish a ring by means of appropriate port interconnections (e.g., in the topology view).
2. Select a PROFINET device for which you want to configure media redundancy.
3. In the Inspector window, navigate to "PROFINET" interface [X1]"> "Advanced options">"Media redundancy".

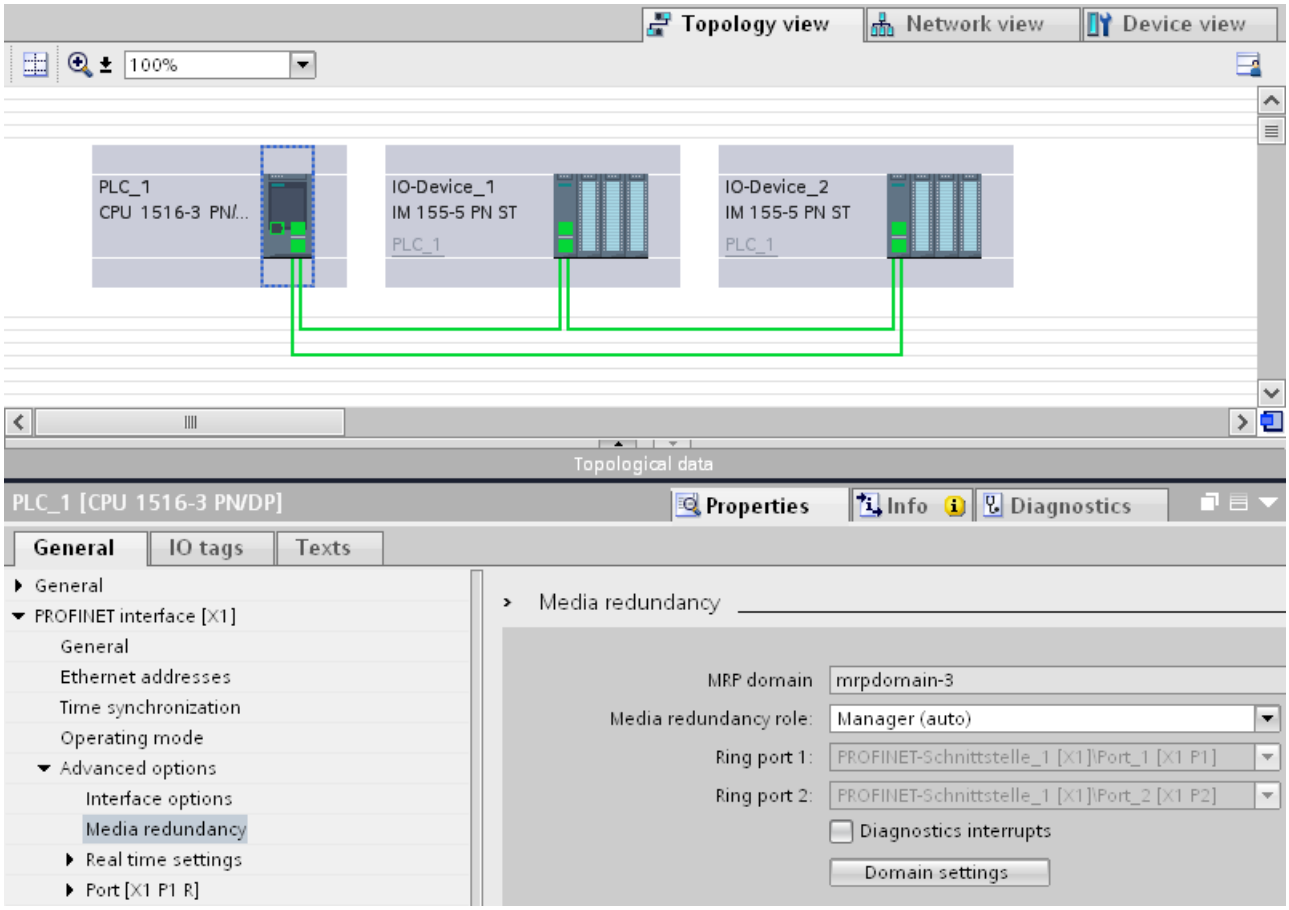


Figure 5-14 Configuring media redundancy

4. Under "Media redundancy role", assign the "Manager (Auto)", "Client", or "Not device in the ring" role to the device.
5. Repeat steps 2 to 4 for all PROFINET devices in the ring.

Or

1. Highlight the PROFINET IO system in the network view.
2. Click on the PROFINET IO system.
3. Navigate to the device of the required MRP domain in the inspector window.

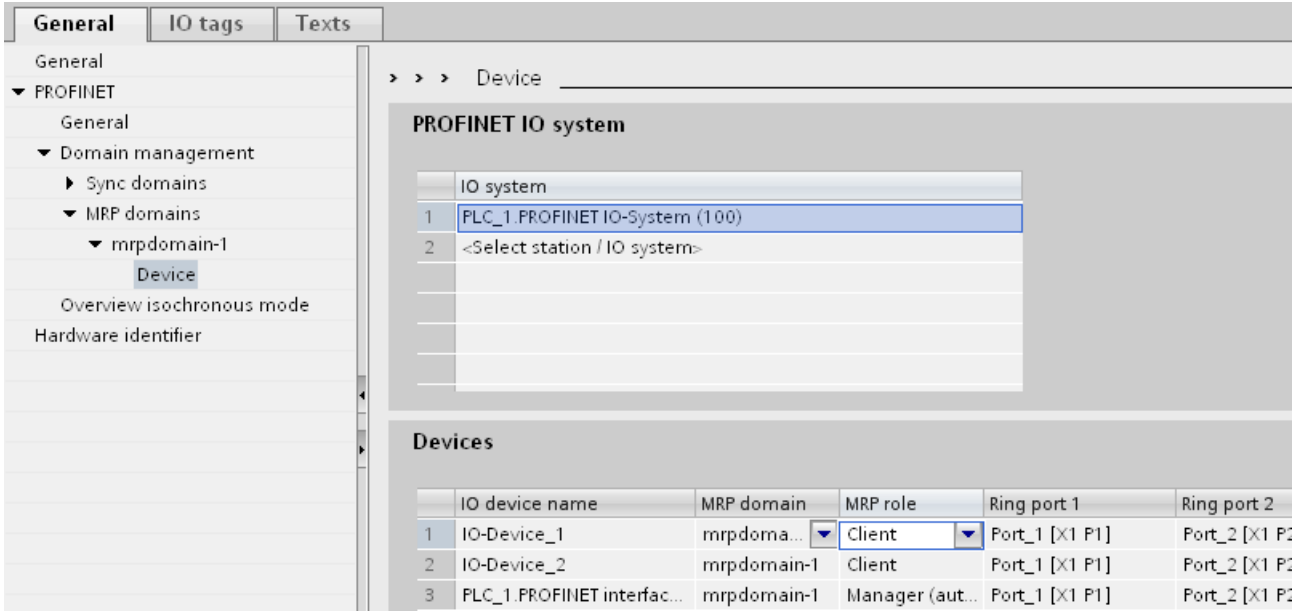


Figure 5-15 MRP domain

4. For the PROFINET devices, set the "Manager (Auto)", "Client", or "Not device in the ring" role.

"Media redundancy" setting options

Media redundancy role

Depending on the device used, the roles "Manager", "Manager (Auto)", "Client" and "Not device in the ring" are available.

Rules:

- A ring must have precisely one device with the role "Manager". No additional devices with the role "Manager" or "Manager (Auto)" are permissible. All other devices may only have the role "Client" or "Not device in the ring".
- If a ring has no device with the "Manager" role, the ring must at least have a device with the role "Manager (Auto)". A ring may have any number of devices with the roles "Client" and "Not device in the ring".

Ring port 1 / Ring port 2

Select one at a time those ports you want to configure as ring port 1 or ring port 2.
The drop-down list box shows the selection of possible ports for each device type.
If the ports are set at the factory, then the fields are unavailable.

Diagnostic interrupts

If diagnostic interrupts to the MRP state are to be output in the local CPU, select the "Diagnostic interrupts" check box. The following diagnostic interrupts can be configured:

- Wiring or port error

  Diagnostic interrupts will be generated for the following errors in the ring ports:

  – A neighbor of the ring port does not support MRP.

  – A ring port is connected to a non-ring port

  – A ring port is connected to the ring port of another MRP domain.
- Interruption / return (redundancy manager only)

  If the ring is interrupted and the original configuration is returned, diagnostic interrupts will be generated. If both of these interrupts occur within 0.2 seconds, this indicates an interruption of the ring.

You can respond to these events in the user program by programming the appropriate response in the diagnostic error interrupt OB (OB 82).

Note

Third-party devices as redundancy manager

To assure error-free operation when a third party device is used as redundancy manager in a ring, you must assign the fixed role of "Client" to all other devices in the ring before you close the ring. Otherwise circulating data frames and network failure could occur.

5.4 Real-time communication

5.4.1 Introduction

Properties

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

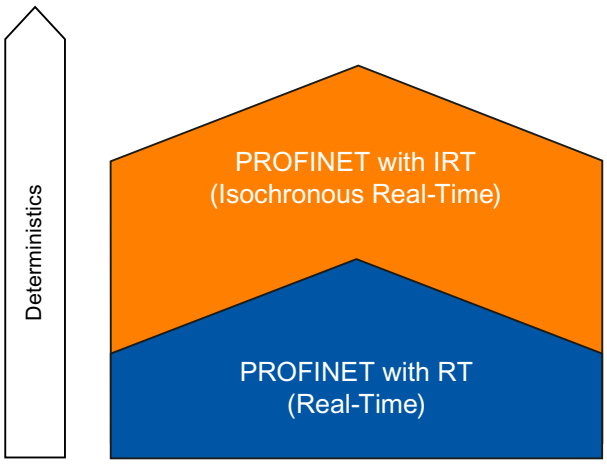


Figure 5-16 Real-time communication performance

Real-time communication and IT communication

Industrial communication, especially in the factory automation and process automation, requires a punctual and deterministic data transmission. This is why, for the cyclic exchange of time-critical IO user data, PROFINET IO does not use TCP/IP, it uses real-time communication (RT) or isochronous real-time communication (IRT) for the synchronized data exchange in reserved time intervals.

Fields of application of PROFINET with RT

PROFINET with RT is suited for:

- Time-critical applications in factory automation
- The implementation of large quantity structures in line process plants

Fields of application of PROFINET with IRT

PROFINET with IRT is particularly suitable for:

- Considerable deterministics with large quantity structures concerning the I/O user data communication (productive data)
- Considerable performance also with many devices concerning the I/O user data communication (productive data)
- Parallel transfer of productive and TCP/IP data via a cable, even with considerable data traffic whilst ensuring the forwarding of productive data by reserving the transmission bandwidth.

International standard IEC 61158

The communication procedures RT and IRT are standardized in the international standard IEC 61158.

5.4.2 RT

PROFINET IO with real-time communication (RT) is the ideal solution for integrating IO systems. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components.
A special hardware support is not required.

If you want to use PROFINET functions that provide an additional value, such as topology detection, diagnostics, device exchange without exchangeable medium/PG, you have to use switches that support the PROFINET standard according to the IEC 61158 standard. In the integrated switches of PROFINET devices and PROFINET switches (e.g., the SCALANCE product family), PROFINET functions in accordance with the PROFINET standard are implemented and can be used without restriction for integration in the PROFINET IO system (see also section Active network components (Page 27)).

Real-time communication (RT)

PROFINET IO frames have priority over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology. The data is transferred via prioritized Ethernet frames. With RT, you can achieve update times ≥ 250 µs with RT.

Switching mechanisms

Switches in SIMATIC meet the real-time requirements with two mechanisms on PROFINET: "Store and forward" and "Cut through".

Store and forward

In the Store and forward method, the switch stores the frames completely and places them in a queue. If the switch supports the international standard IEEE 802.1Q, then the data is sorted according to its priority in the queue. The frames are then forwarded selectively to the specific port that can access the addressed node (Store and forward).

Cut through

In the Cut through process the entire data package is not stored temporarily in a buffer, it is passed directly onto the target port as soon as the target address and the target port have been determined.

The times required by the data package to pass through the switch are then minimal and independent of the frame length. The data are only stored temporarily in accordance with the Store and forward process as per priority when the section between the target segment and the port of the next switch is occupied.

5.4.3 IRT

Isochronous real-time communication (IRT)

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

Advantages

PROFINET with IRT is synchronized communication in reserved time intervals. With IRT you have the option to be able to control time-critical applications such as motion control via PROFINET. With IRT you use further advantages:

- High-precision deterministics allow highest control quality and thus, for example, exact positioning of axes
- Simple and flexible integration of PROFINET devices for real-time applications in existing company networks
- Shortest response times and highest deterministics by means of bandwidth reservation and thus also for applications that have to satisfy highest performance requirements (e.g., printing control/position control for presses, print-mark recognition with packaging machines)
- Secured standard communication parallel to real-time communication via the same transmission medium
- You can continue to use standard components for your PROFINET IO system outside of the sync domain

Properties of isochronous real-time

Topology configuration is a prerequisite for IRT.

In addition to the reserved bandwidth, the telegrams from defined transmission paths are exchanged for the further optimization of data transfers. For this, the topological information from the configuration is used for planning the communication. Thus, transmission and reception points of every individual data telegram at every communication node are guaranteed. This allows you to achieve optimal usage of the bandwidth and reach the best possible performance in the PROFINET IO system.

Use of IRT allows you to achieve update times with highest deterministics ≥ 250 µs and a jitter accuracy of the send clock < 1 µs. Isochronous applications are possible with IRT (see section Isochronous mode (Page 131)).

Note

IWLAN and IRT

PROFINET devices that are connected to PROFINET IO via access points, do not support IRT.

Synchronization

The prerequisite for the IRTcommunication is a synchronization cycle for all PROFINET devices in a sync domain for distributing a mutual time basis. A synchronism of the transmission cycle of the PROFINET devices within a sync domain is achieved with this basic synchronization.

A sync master specifies the clock to which sync slaves are synchronized. An IO controller or an IO device can have the role of sync master. If the sync master fails, all IO devices with IRT will fail.

Sync master and sync slaves are always devices in a sync domain. Bandwidth is reserved within the sync domain for IRT communication. Real-time and non-real-time communication (TCP/IP communication) is possible outside of the reserved bandwidth.

Default sync domain

If you have created a PROFINET subnet, a special sync domain is automatically created: All PROFINET devices configured for the PROFINET subnet automatically belong to this sync domain.

You can find further information on setting up sync domains in the STEP 7 online help.

Time ranges of communication cycles

The communication cycle is divided into three time ranges, which are shown in the following chart:

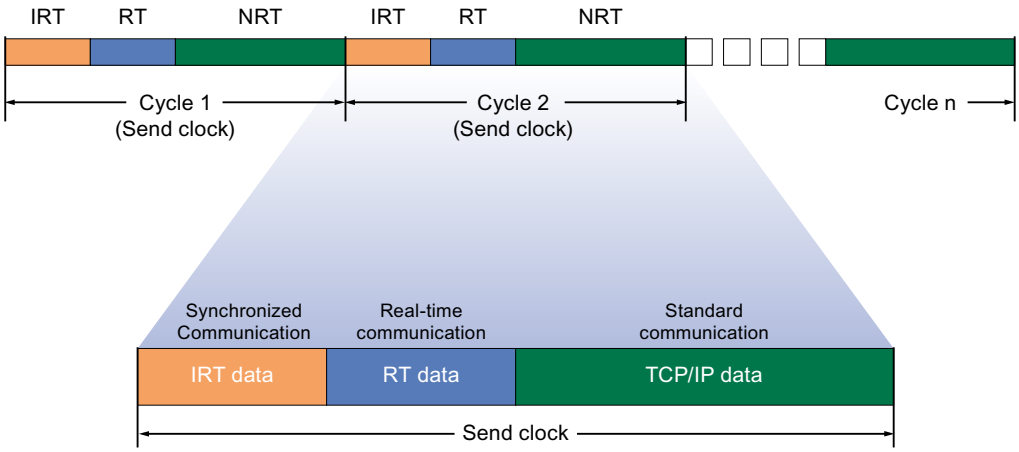


Figure 5-17 Reserving bandwidth

- IRT data (synchronized communication)

  This time range can be reserved in specific steps, depending on the send clock. Only IRT data is transmitted during this time range.

- RT data (real-time communication)

  The cyclic RT data is transmitted in this time range. RT data has a higher priority than "normal" TCP/IP data. TCP/IP data or Ethernet frames can have a priority between 1 and 7. RT data has a priority of 6.

- TCP/IP data (standard communication)

  Standard communication (TCP/IP, etc.) is transmitted in the remaining interval of the communication cycle.

5.4.4 Comparison of RT and IRT

The most important differences between RT and IRT

Table 5- 4 Comparison between RT and IRT

Property	RT	IRT
Transmission method	Prioritizing the RT frames through Ethernet priority (VLAN tag)	Path-based switching on the basis of a communication path plan; no transmission of TCP/IP frames in the time range with IRT communication.
Determinism	Variance of the duration of transmission by the shared use of the transmission bandwidth with other protocols (e.g., TCP/IP)	Exact, planned transmission, transmission and reception times are guaranteed for all topologies.
Hardware support through special Ethernet controllers is required	Not required	Required
Isochronous application	-	Yes (only for the integrated PROFINET IO interface of the CPU)
Starting time of the isochronous application	-	The point in time for the reception of the data is planned exactly. Application can be started synchronized to the cycle.

5.4.5 Configuring PROFINET IO with IRT

Introduction

If you want to configure a PROFINET IO system with IRT, you have to configure the PROFINET IO devices. These PROFINET devices must support IRT.
Set which device acts as the sync master and synchronizes the other devices.
This is done by configuring a sync domain with a sync master and at least one sync slave.

Requirements

- There is an IO system with an IO controller and at least one IO device.
- The devices support IRT.

Procedure

Proceed as follows to enable an existing IO system for the use of IRT:

1. Select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Advanced options > Real-time settings > Synchronization".

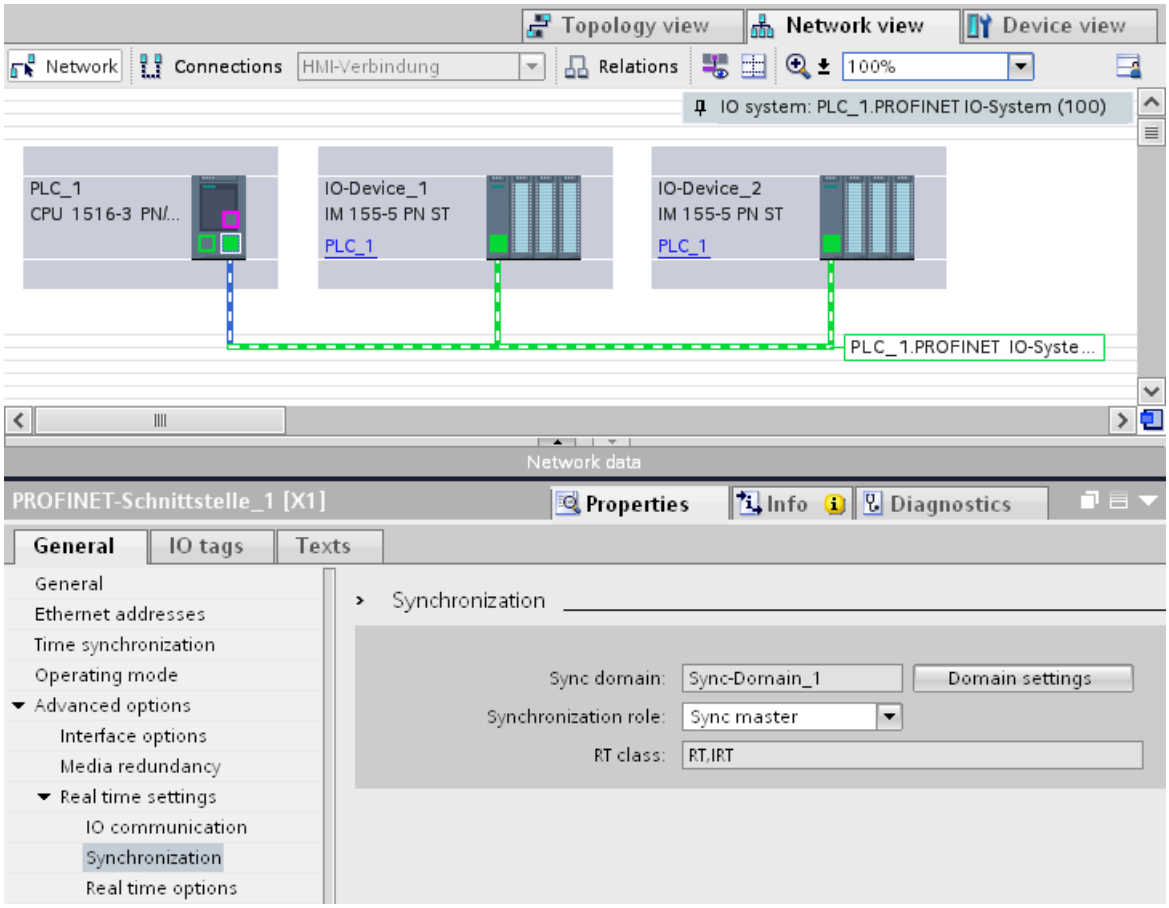


Figure 5-18 IRT configuring sync master

3. Assign the IO controller the role of sync master under "Synchronization role".
4. Select the PROFINET interfaces of an associated IO device.
5. In the Inspector window, navigate to "Advanced options > Real-time settings > Synchronization".

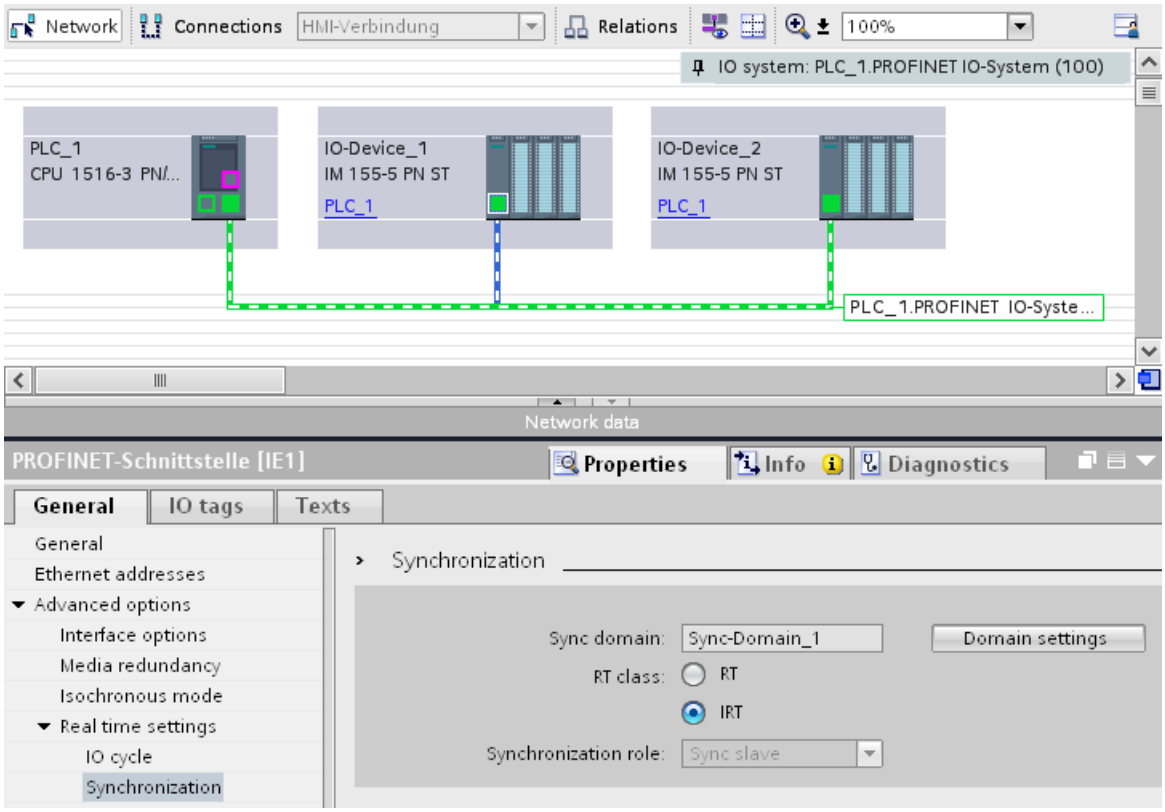


Figure 5-19 IRT configuring sync slave

6. Activate the RT class "IRT". The IO device will then automatically be assigned the synchronization role "sync slave".
7. You can check and correct your settings at any time using the "Domain settings" button.

Or

1. Highlight the PROFINET IO system in the network view.
2. Click on the PROFINET IO system.
3. Navigate to the device of the required sync domain in the Inspector window.

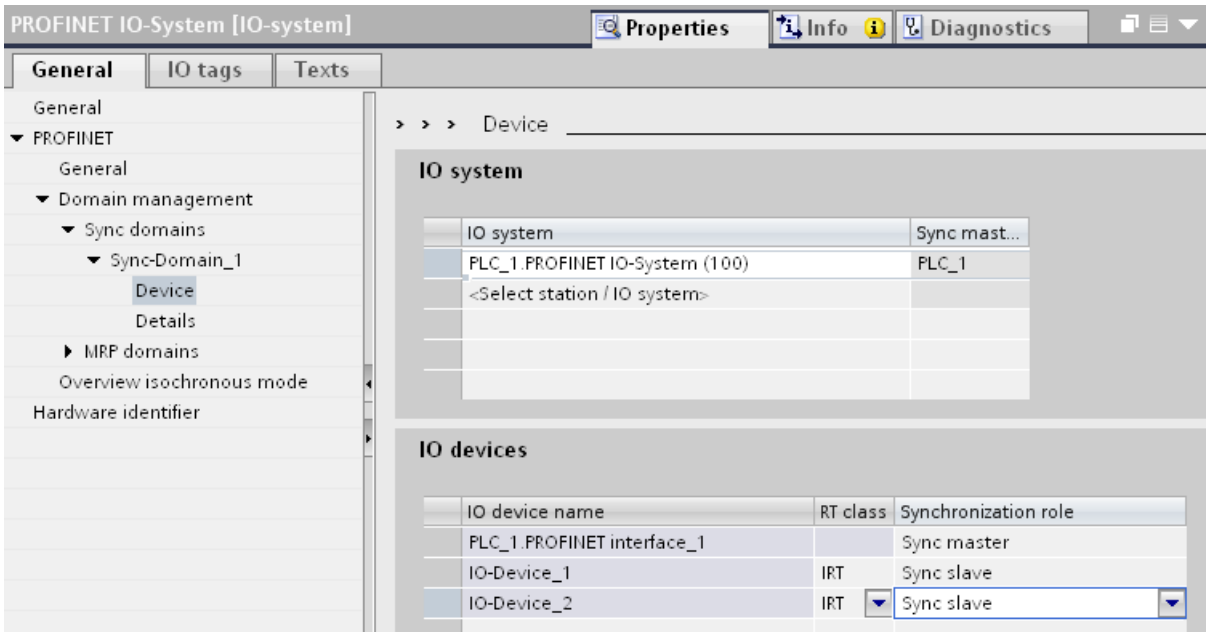


Figure 5-20 IRT configuring sync domain

4. Enter all necessary settings in the tables:
   - Select an IO system.
   - Set the synchronization role "sync master" for the IO controller.
   - Set the RT class for the IO devices to "IRT". The IO devices will then automatically be assigned the synchronization role "sync slave".

You can now load the configuration to the relevant devices with PROFINET IRT.

5.4.6 Setup recommendations for optimizing PROFINET

Optimizing PROFINET with RT

PROFINET provides you with high-performance communication on all levels.

The following figures shows an example of an optimized PROFINET topology.

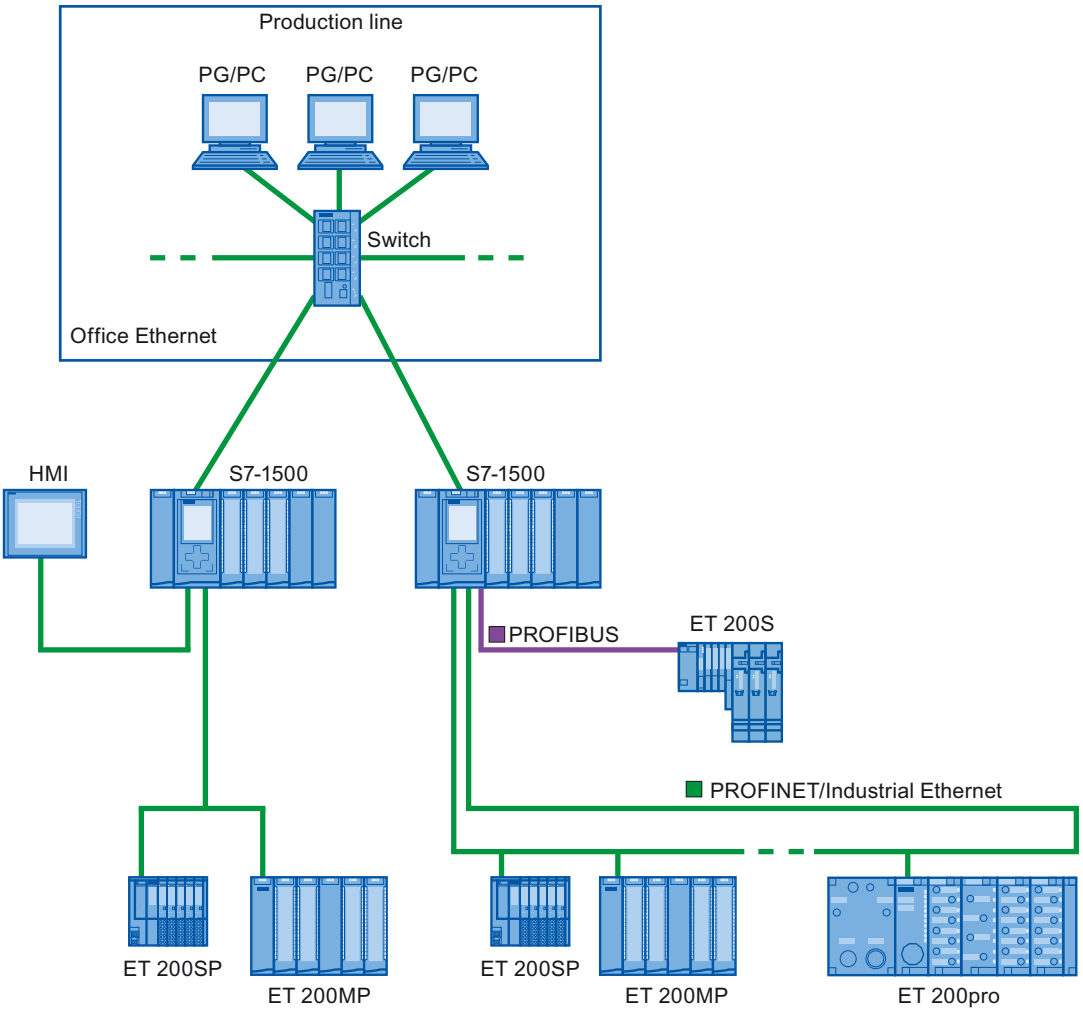


Figure 5-21 Optimized PROFINET topology

Setting up PROFINET with IRT

Keep in mind the following rules for setting up and operating a PROFINET IO system in IRT mode. These rules will ensure best possible operation of your PROFINET IO system.

- When using IRT, you must configure the topology. This will enable exact calculation of the update time, bandwidth, and other parameters.
- If you would like to use multiple sync domains, configure a sync boundary for the port which is currently connected to the PROFINET device of another sync domain.
- In a sync domain, you can only configure one sync master at a time.
- A PROFINET IO system may only be part of a single sync domain.
- If you configure PROFINET devices in a sync domain and want to synchronize with IRT, the PROFINET devices concerned must support IRT communication.
- Wherever possible, use the same PROFINET device as the PROFINET IO controller and sync master.
- If only some of the PROFINET devices in a PROFINET IO system are synchronized, please keep in mind the following: Assign PROFINET devices that are not participating in the IRT communication to the RT class "RT" and the synchronization role "unsynchronized" in the the sync domain.

Installation guidelines of the PROFIBUS user organization

The installation guidelines can be found on the Internet (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

5.5 Isochronous mode

5.5.1 What is isochronous mode?

Objectives of isochronous operation

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground-railway clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

Just-In-Time

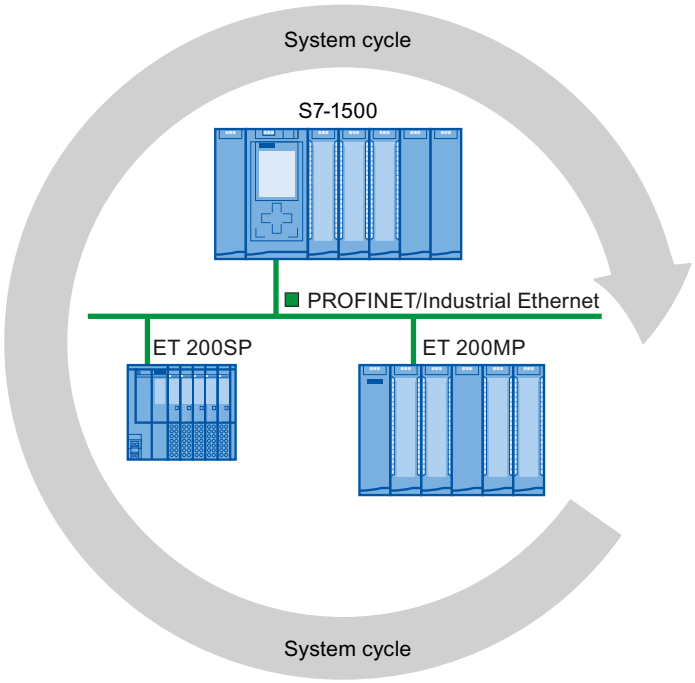


Figure 5-22 System cycle

The high speed and reliable reaction time of a system operating in isochronous mode is based on the fact that all data are provided just-in-time. The isochronous PROFINET IO cycle generates the clock for this.

Advantages of isochronous mode

The use of isochronous mode allows high-precision control.

- Optimized control
- Determinism
- Consistent (simultaneous) reading in of input data
- Consistent (simultaneous) output of output data

5.5.2 Use of isochronous mode

With the "Isochronous mode" system property, measured values and process data can be acquired in a fixed system clock. The signal processing up to the switching-through to the "output terminal" occurs within the same system clock. Isochronous mode thus contributes to high-quality control and hence to greater manufacturing precision.
With isochronous mode, the possible fluctuations of process response times are drastically reduced. The time-assured processing can be utilized to improve machine cycle times.

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process responses must be defined and simultaneously executed, as in the following example. There are thus numerous areas in which isochronous mode can be used.

5.5.3 Isochronous applications

Example: Isochronous measurement at several measuring points

Quality assurance requires precise measurement of dimensions within a camshaft production process.

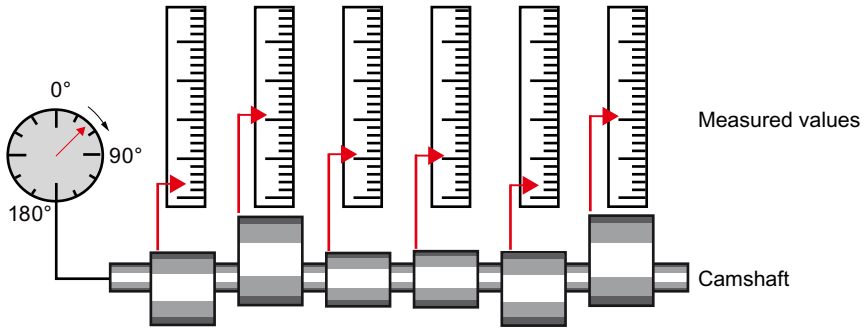


Figure 5-23 Measuring of camshafts

Isochronous workflow

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously and the time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft
- During the continuous turning, measure the positions and cam excursion synchronously
- Process the next cam shaft

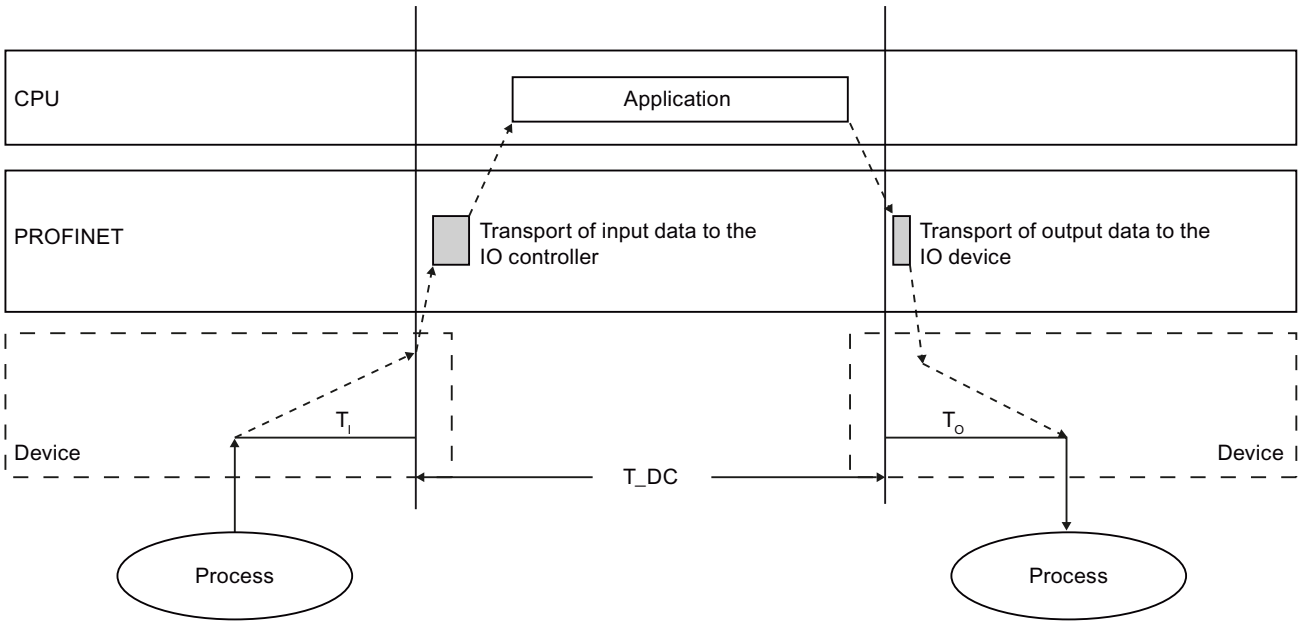
All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

5.5.4 Time sequence of synchronization

From reading-in of input data to outputting of output data

The basic time sequence of all components involved in synchronization is explained in the following:

- Reading-in of input data in isochronous mode
- Transport of input data to the IO controller (CPU) via the PROFINET subnet
- Further processing in the isochronous application of the CPU
- Transport of output data to the outputting IO device via the PROFINET subnet
- Outputting of output data in isochronous mode



T_DC Data cycle (Time_DataCycle)

T_I Time for reading in the input data

T_O Time for outputting the output data

Figure 5-24 Time sequence of synchronization

The start of the I/O read cycle is advanced by the amount of a bias time T_I in order to make all input data available for transfer on the PROFINET IO line at the start of the next PROFINET IO cycle. T_I is the "flashlight" for the inputs; at this instant all synchronized inputs are read in. T_I is necessary in order to compensate for analog-to-digital conversion, backplane bus times, and the like. The bias time T_I can be configured by STEP 7 or by the user. We recommend automatically assigning the bias time T_I of STEP 7.

The PROFINET IO line transports the input data to the IO controller. The application can be started synchronized to the cycle, i.e., the isochronous mode interrupt OB is called after a parameterizable delay time. The user program in the isochronous mode interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

T_O is the compensation arising from the backplane bus and the digital-to-analog conversion within the IO device. T_O is the "flashlight" for the outputs; at this instant the synchronized outputs are output. The time T_O can be configured by STEP 7or by the user.
We recommend automatically assigning the bias time T_o of STEP 7.

Isochronous mode and non isochronous mode distributed I/O

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one IO controller.

5.5.5 Configuring isochronous mode

Introduction

The configuring of isochronous mode of a module is described as IO device in the following based on the ET 200MP distributed I/O system. The procedure described also applies to other distributed I/O systems (e.g., ET 200S or ET 200SP).

The IO controller is an S7-1500 CPU.

Requirements

- The STEP 7 network view is open.
- A S7-1500 CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An interface module IM 155-5 PN HF (ET 200MP) has been placed and networked with the CPU.
- All requirements for an IRT configuration are met, namely:
  - The ports of the CPU and the interface module are interconnected.
  - The RT class of the interface module is set to "IRT" (area "Advanced options > Real-time settings > Synchronization").

Procedure

To create an isochronous connection between the I/O and user program, follow these steps:

1. Select the "IM 155-5 PN HF" in the network view of STEP 7 and switch to the device view.
2. Insert an IO module that can be operated in isochronous mode (module with the extension "HF").
3. Go to the "I/O addresses" area in the Inspector window of the selected I/O module.

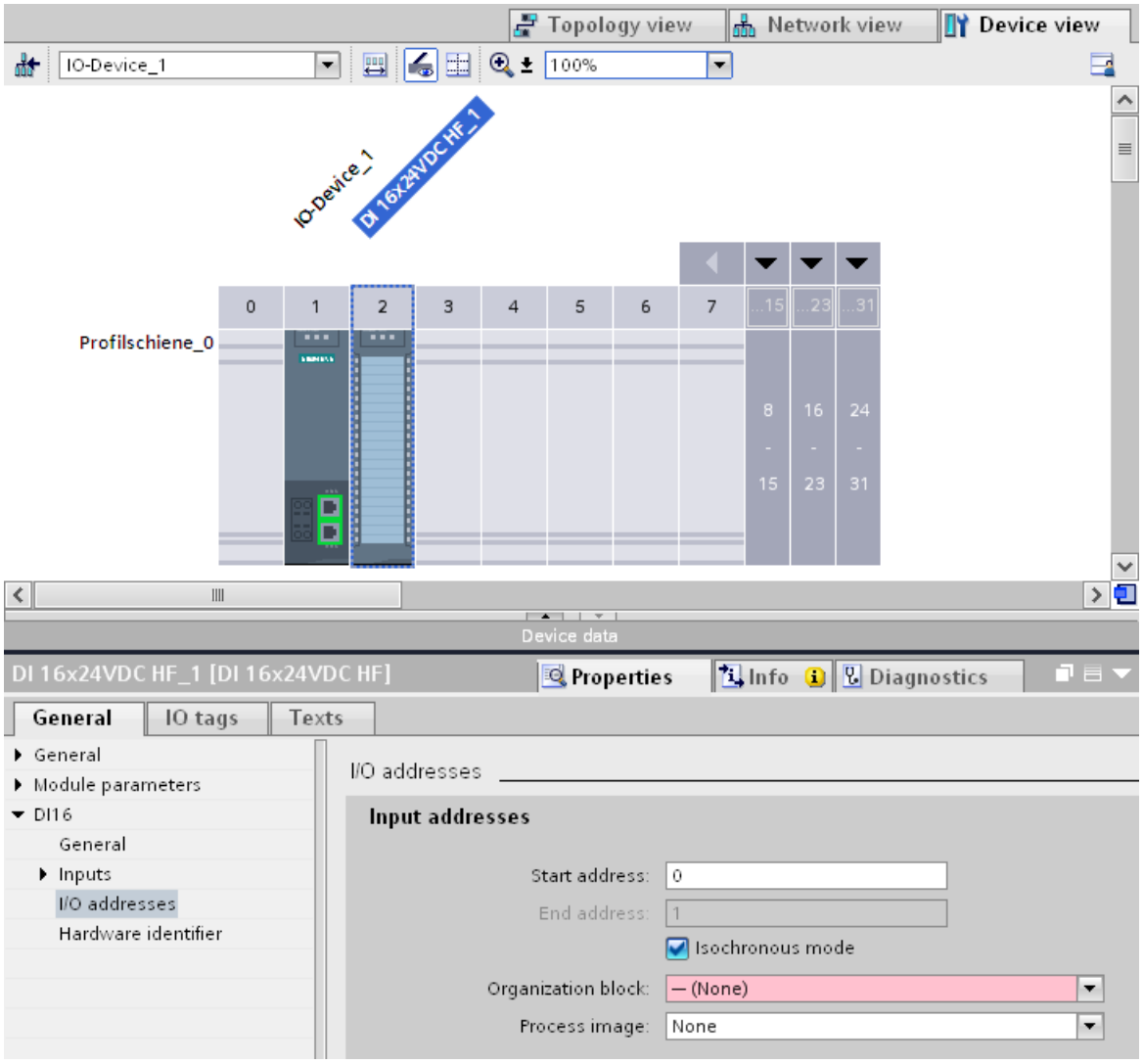


Figure 5-25 Configuring isochronous mode in STEP 7

4. Make the following settings in the I/O addresses area:
   - Select the "Isochronous mode" option.
   - Select a process image partition, e.g., process image partition 1.
   - Click on the "Assigned organization block" in the drop-down list and click the "Add object" button, or select an already existing OB.

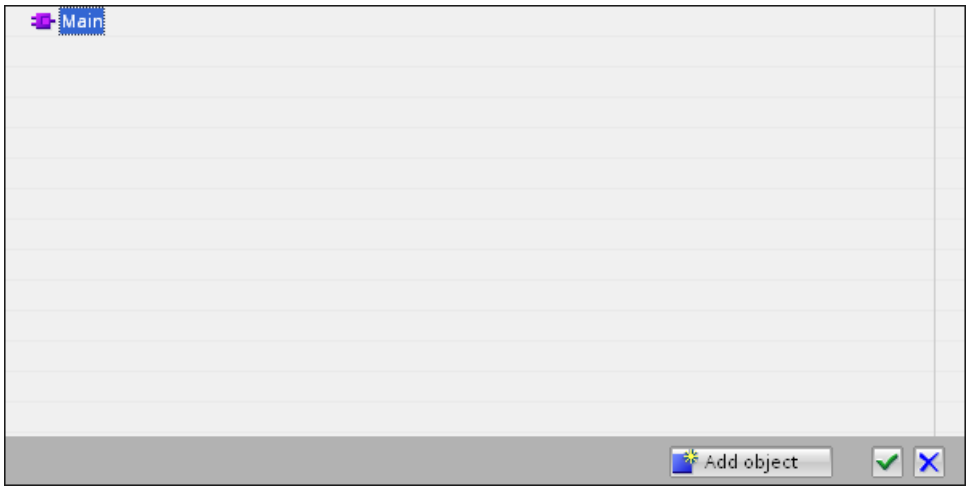


Figure 5-26 Creating the organization block for programming isochronous mode

   A dialog box for selecting organization blocks opens.

   - Select the "Synchronous Cycle" OB and confirm the selection with "OK".

     In the case of automatic number assignment, OB 61 will be generated and opened. The "Isochronous mode" area is selected in the Inspector window, and you can continue directly with the setting of the application cycle and delay time and start the programming of the OB in the instruction section.

5. Add other IO devices as required in the network view and adapt the configuration and the isochronous mode settings.
6. To retrieve information about calculated bandwidths or to adapt the send clock, select the subnet and navigate to the corresponding area of the domain management in the Inspector window.

Programming isochronous mode

The user program must be set up accordingly in order to operate your plant in isochronous mode. To do this you have to create a "Synchronous Cycle" program block (OB 6x) in an IO module (see above). You access the isochronous I/O via a process image partition, i.e., the addresses of isochronous modules must be in a process image partition.
You have to program accesses to the isochronous IO with the instructions SYNC_PI and SYNC_PO in the isochronous mode interrupt OB.

You call the instruction SYNC_PI at the start of OB 6x, provided you have selected the automatic setting for the delay time. You call the instruction SYNC_PO at the end of the OB 6x.

5.6 Device replacement without exchangeable medium

Definition

IO devices which have no slot for exchangeable medium (e.g. ET 200SP, ET 200MP) or IO devices which support the PROFINET functionality "Device replacement without exchangeable medium/PG" can be replaced without having an exchangeable medium with saved device names inserted and without having to assign the device name with the PG. The new IO device is given a device name by the IO controller and not by the exchangeable medium or the PG.

To assign the device name, the IO controller uses the configured topology and the neighborhood classifications established from the IO devices.

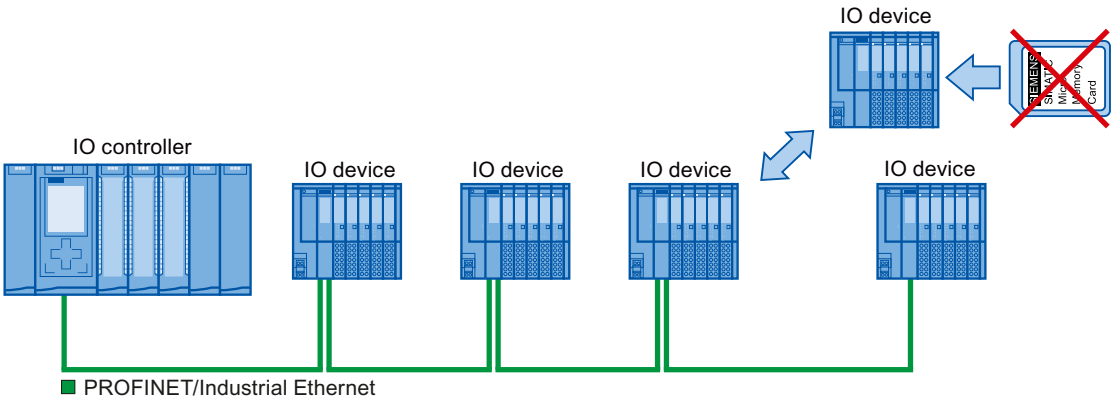


Figure 5-27 Device replacement without exchangeable medium

Note

When you exchange a device, make sure that the PROFINET cable is again inserted into the correct port, as it is configured in STEP 7.

Otherwise, the system will not run.

Advantages

With the Device replacement without exchangeable medium/PG PROFINET functionality, you can profit from the following advantages:

- After the replacement of the IO device, it automatically obtains its device name from the IO controller. You no longer have to assign device names with the PG or exchangeable medium.
- You can save on the storage medium for the IO device that replaces the removed one.
- Simple device name allocation with series machines that have the same configuration and set topology. It is no longer necessary to assign device names via exchangeable medium/PG.

5.6.1 Device replacement without exchangeable medium/PG function

Neighborhood

Neighborhood is the physical relationship between two ports of adjacent PROFINET devices. A PROFINET device is connected in this case through one of its ports over a physical Ethernet line to a specific port of the second PROFINET device in close proximity (neighbors).

Both terminal devices, for example, IO controllers and IO devices with a port, and network components, for example, switches, IO controllers and IO devices with multiple ports, are considered PROFINET devices.

Failure and replacement of an IO device

The following example describes device replacement without exchangeable medium in the case of failure of an IO device.

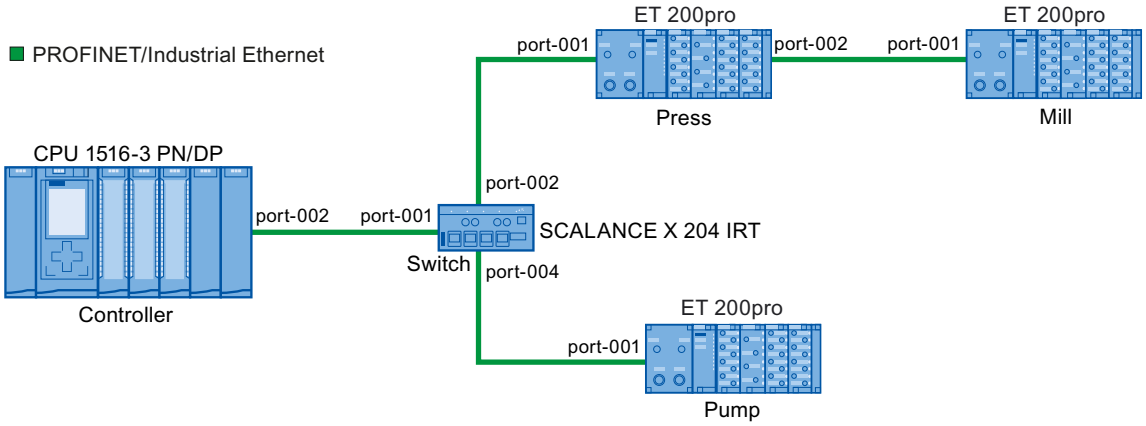


Figure 5-28 Example configuration of device replacement without exchangeable medium

For the device replacement, the following information is available to the IO controller:

PROFINET device	Device alias
Controller	"port-001.Switch"
Switch	"port-002.Controller", "port-001.Press", "port-001.Pump"
Press	"port-002.Switch", "port-001.Mill"
Mill	"port-002.Press"
Pump	"port-004.Switch"

The IO device with the device name "Mill" fails in this example:

Requirements

The PROFINET device replacing the removed one has no device name.

Principles of name assignment

The failure of the "Mill" IO device is considered here.

1. The IO controller queries the device name of the replaced IO device.
2. The IO controller detects that the IO device with the device alias "port-002.Press" does not have a device name.
3. The IO controller assigns the device name "Mill" to the replaced IO device via the device alias "port-002.Press" of the failed IO devices.

Note

If you insert a device with the Device replacement without exchangeable medium/PG PROFINET functionality at a different location than the configuration, a different device name is then assigned to the device.

Reset a wrongly inserted device to delivery state before you use it again.

5.6.2 Replacing an IO device without exchangeable medium

Introduction

Replacement of IO devices is sometimes frequently required in automation systems. The IO devices are generally assigned a device name by either inserting an exchangeable medium or via the programming device. The CPU identifies the IO device by using these device names.

Under certain circumstances, replacing an IO device can be done without inserting an exchangeable medium or without the PG.

Requirements

- The topology of the PROFINET IO system with the respective IO devices must be configured.

  By configuring the topology, the neighbor relationships of all the PROFINET devices located in the PROFINET IO system are announced to the PROFINET IO system or the IO controller. From the neighbor relationships specified by the set topology and the actual neighbor relationships established by the real PROFINET devices, the IO controller can identify the replaced IO device without a name and assign to it the configured name and the IP address and then again list it in the user data traffic.

- The affected IO devices in the automation system must support device replacement without exchangeable medium.

  If the individual IO devices in the automation system do not support device replacement without exchangeable medium, a corresponding alarm is output for the IO device.

Note

Use only new IO devices as replacements or restore configured IO devices to their delivery state.

Activating/deactivating device replacement without exchangeable medium

The "Device replacement without exchangeable medium" function is activated in the IO controller by default.

To deactivate device replacement without exchangeable medium, follow these steps:

1. In the device or network view of the STEP 7, select the PROFINET interface in the corresponding IO controller.
2. In the interface properties under "Advanced settings > Interface options", clear the "Support device replacement without exchangeable medium" check box.

To reactivate device replacement without exchangeable medium, you must select the "Support device replacement without exchangeable medium" check box again.

5.7 Saving energy with PROFIenergy

Saving energy with PROFIenergy

PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. Through this, the process should only be provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.

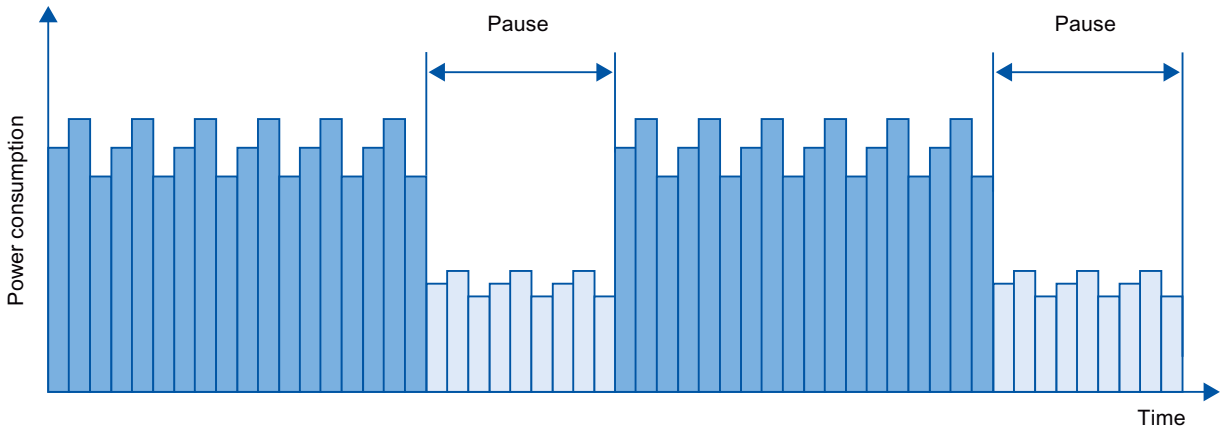


Figure 5-29 Energy savings during pauses with PROFIenergy

Basic information

Turning off the PROFINET devices or the power modules occurs through special commands in the user program of the PROFINET IO controller. No additional hardware is needed; the PROFIenergy commands are directly interpreted by the PROFINET devices.

Principle of operation

At the beginning and end of pauses, the system manager enables or disables the pause function of the system; then the IO controller sends the PROFIenergy command "Start_Pause" / "End_Pause" to the PROFINET device. The device interprets the contents of the PROFIenergy command and turns on / off.

Through other PROFIenergy functions, device information can be accessed during pauses. The user can use this information in order to punctually transfer the "Start_Pause" / "End_Pause" command.

PROFIenergy instructions for IO controllers

Two instructions are needed for controlling and monitoring the PROFIenergy functions

The instruction PE_START_END allows you to easily activate and deactivate the idle state of PROFINET devices. This occurs by means of an incoming edge or outgoing edge. The instruction PE_START_END provides a simple interface for implementing the PROFIenergy commands Start_Pause and End_Pause.

The instruction PE_CMD allows you to transmit all PROFIenergy commands, including Start_Pause and End_Pause. The other commands can be used, for example, to query the current status of the PROFINET device or the behavior during the pauses. The instruction PE_CMD is a convenient means for handling all PROFIenergy functions.

PROFIenergy instruction for I-devices

The instruction PE_I_DEV allows you to also implement PROFIenergy on I-devices. The instruction receives PROFIenergy commands on the I-device and forwards these to the user program for processing. After processing the command, the user program calls the PE_I_DEV instruction again in order to send the acknowledgement to the IO controller. For these replies, each command offers you a helper instruction that supplies the reply data to the instruction.

The instructions can be found in the "Instructions" task card of the STEP 7 program editor.

An application example can be found on the Internet (http://support.automation.siemens.com/WW/view/en/41986454) in the Service and Support portal.

Configuration and programming

The functions can be comfortably integrated into existing systems. No configuration is required for the use of PROFIenergy. However, amendments to the user program are required:

- Before the "Start_Pause" command, you must ensure that your system is brought into a condition that is suitable for a pause.
- A sequential control system for the beginning of the pause of the devices and for the punctual restarting of the device on break must be programmed (depending on the required startup times that the respective PROFINET device demands).
- The error messages of the PE_CMD instruction must be evaluated, and the required reaction must be programmed (for example, cancellation or continuation of further commands on lower-level PROFINET devices).

Note

In the case of the ET 200S distributed I/O system, you have to configure the application of PROFIenergy in STEP 7. You configure PROFIenergy by selecting the "Use energy saving for this potential group" check box in the PM-E DC24V/8A RO power module.

5.8 Docking systems

Using alternating IO devices ("alternating partners") during operation in a docking station

The following figure shows an automation cell with a docking station and several docking units.

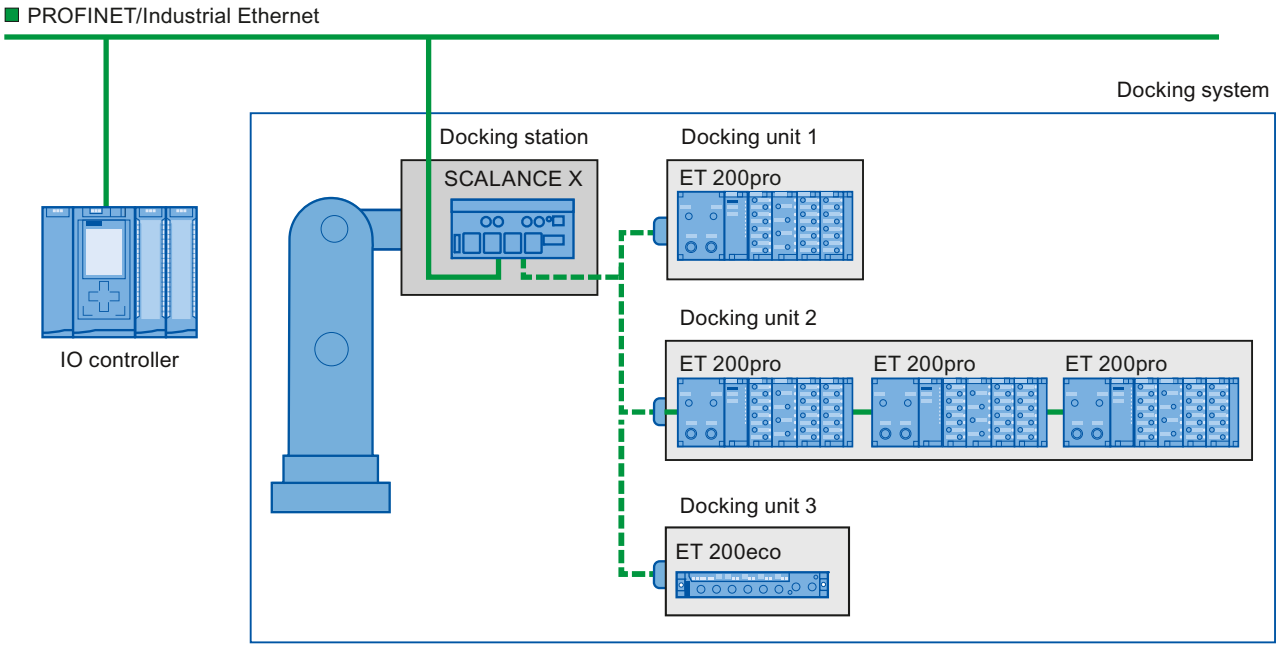


Figure 5-30 Alternating IO devices (partner ports) in a docking system

Area of application for alternating IO devices during operation

You can use the PROFINET function "Alternating IO devices during operation" ("alternating partners"), for the tool changeover for robots, for example.
Typical tools include:

- Welding guns
- Positioning tools for manufacturing parts

Requirements for interconnecting alternating partner ports during operation

You can interconnect IO devices with alternating partner ports during operation in the following situations:

- The alternating IO device (docking unit) has no IRT communication configured.
- The PROFINET interface is connected to the Ethernet subnet.
- The PROFINET devices support topology configuration.
- The IO controller, the alternating IO devices (docking unit) and the switch (docking station) on which the alternating IO devices are to be operated support this feature.

Note

Unique IP address

Each docking unit of a docking system must be configured with a unique IP address in a shared project and operated on the same IO controller as all other docking units of the system.

Applicative conditions

The following points should be observed when implementing a docking system with alternating IO devices during operation:

- The IO devices of all docking units must be deactivated by default in the configuration.
- At any time, only one docking unit can be active, i.e., only the IO devices of one docking unit can be activated. All IO devices of other docking units must be deactivated or become deactivated before the IO devices of a docking unit can be activated. You activate an IO device with the "D_ACT_DP" instruction.
- A physical connection to this docking unit and its IO devices must be created in order to activate a docking unit. The IO devices are then switched on (power on). At the same time, all the IO devices of this docking unit must be activated in the user program with the "D_ACT_DP" instruction.

Note

Automatic deactivation in "Startup" mode of the CPU

If the CPU is in "Startup" mode, IO devices of a docking system that alternate during operation are deactivated automatically.

- After the feedback "IO device activated", you can access the IO device by means of direct I/O access.
- Call the "D_ACT_DP" instruction to activate and deactivate the IO device as close as possible to the start of the OB 1 cycle.

Note

Number of alternating IO devices during operation ("alternating partner port") - number of docking units

If you wish to achieve the shortest possible tool changeover times, you must observe the following points that are dependent on the CPU or the CP that is being used:

- Only those IO devices that have been configured with the PROFINET function "Prioritized startup" can start up in an optimized fashion. The number of IO devices with configuration for this PROFINET function is restricted.
- Only a limited number of IO devices can be activated at the same time.
  This number depends on the available "D_ACT_DP" resources. A docking unit should not contain more than the corresponding number of IO devices.
  If more IO devices are operated in a docking unit, the IO devices must be activated one after the other, which takes correspondingly longer.

Example: An S7-CPU 1516-3 PN/DP can operate a maximum of 32 IO devices with prioritized startup and can simultaneously activate 8 IO devices by means of "D_ACT_DP".

Therefore, for a scheduled optimum use, a docking unit should include no more than 8 IO devices and no more than 32 IO devices should be used in all the alternating docking units.

5.8.1 Configuring docking systems

Configuring docking systems

The possible connections to the individual IO devices must be configured in STEP 7.

Procedure in STEP 7

1. Configure your system as usual, but do not yet configure the topological interconnections of the individual PROFINET devices.
2. Navigate to the "Topology view" tab.
3. Select the port which you want to operate with alternating partners during operation.
4. Navigate to the "Properties" tab of the inspector window and select "Port interconnection" in the area navigation.
5. Under "Partner port", select the "Alternative partners" option.
6. Select the desired partner ports: To do this, click "<Add alternative partners... and choose a partner port. Repeat this process until all required partner ports are connected.

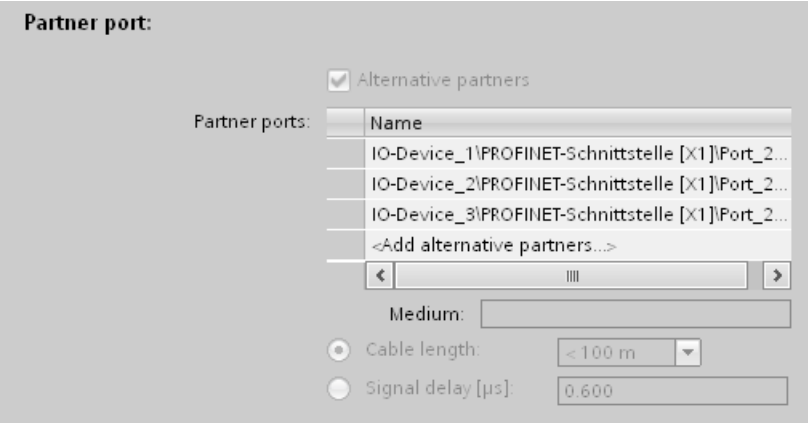


Figure 5-31 Configuring docking systems in STEP 7

Tip: You can also use drag-and-drop operation to connect alternative partner ports in the topology view.

Result

You have interconnected the respective port with one or more alternating IO devices. The connections with the individual alternating partner ports during operation are shown in the topology view by a green, dashed line.

Multiple IO devices as a docking unit ("Alternating partner port")

A docking unit may also consist of several IO devices connected in series. If you use IO devices connected in series as a docking unit, ensure that the topology of the IO devices is configured. A docking unit consisting of two IO devices connected in series (Tool_3_1 and Tool_3_2) is shown at the bottom right in the figure below.

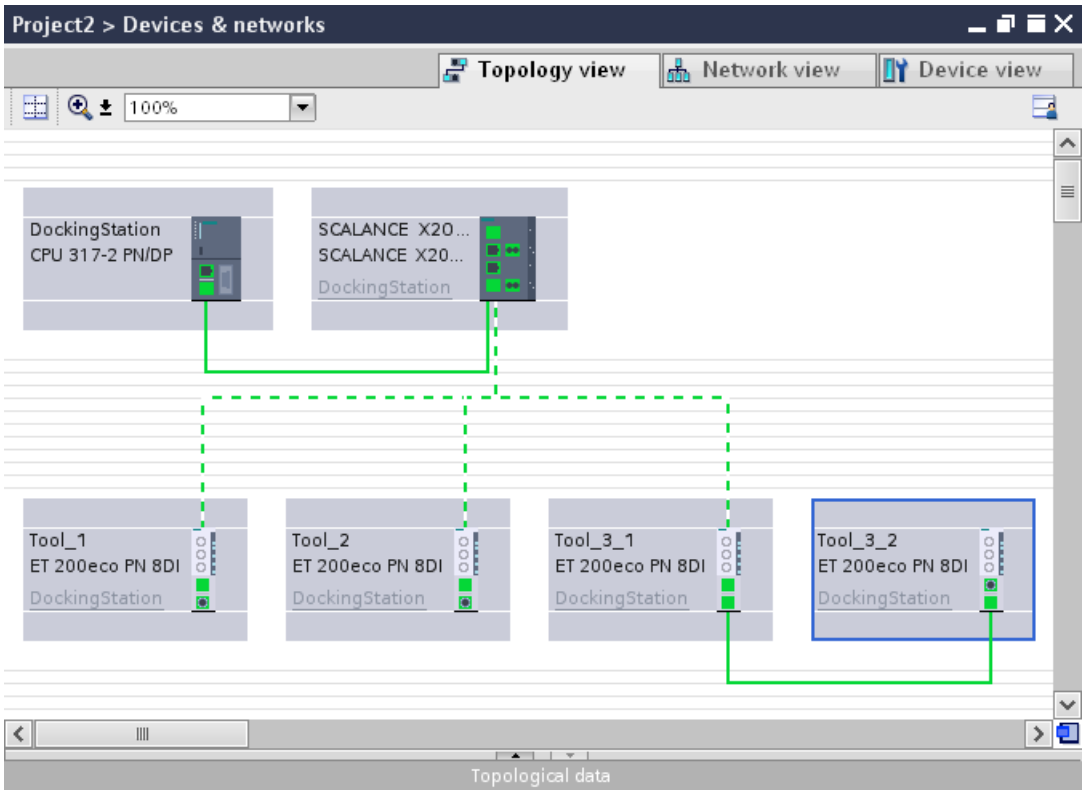


Figure 5-32 Docking system in the topology view of STEP 7

Restriction in the interconnection

The interconnection with a partner port is not possible in the following cases:

- The partner port does not have a suitable type of cable. In this case, a media convertor from the catalog must be inserted.
- The partner port is blocked (deactivated).
- The two ports that are to be interconnected belong to the same interface (it is only possible to interconnect the ports from different interfaces in a station).
- The two ports that are to be interconnected belong to different Ethernet subnets.

Deleting interconnections

Select the port of the alternating partner and remove the interconnection with the "Remove" button.

5.9 Accelerating startup

5.9.1 Options for accelerating the startup of IO devices

The time needed for the startup of IO devices depends on various factors and can be reduced in different ways. You can achieve a significant reduction in the startup time using the "Prioritized startup" function.

Dependencies

The length of the startup time for an IO device (distributed I/O) with the "Prioritized startup" PROFINET function depends on the following factors:

- IO devices (distributed I/O)
- IO structure of the IO device (distributed I/O)
- Modules of the IO device (distributed I/O)
- IO controller
- Switch
- Port setting
- Cabling
- Configured RT class of the IO device

Note

Startup time and RT class of the IO device

An IO device with IRT communication requires longer than an IO device with RT communication for the accelerated startup.

The longer startup for IRT is due to the necessity of synchronizing the IO device before the communication can be set up.

Note

IWLAN and prioritized startup

PROFINET devices which are connected via access points to PROFINET IO do not support the "Prioritized startup" PROFINET function.

Further acceleration

To achieve the shortest possible startup time, you need to implement the following measures:

- Correct port settings on the IO device
- Optimizing the cabling of the ports
- Measures in the user program (for docking systems only)

These steps will accelerate the startup of IO devices even without the "Prioritized startup" PROFINET function. However, you can only achieve the fastest startup times of about 500 ms by combining all the measures with "Prioritized startup".

Note

Startup time up to 8 s

In the following situation, despite prioritized startup, a startup time of up to 8 s may occur:

On a docking point, multiple physical IO devices dock as an IO device with a certain device name and a certain IP configuration (for example, docking point for automatic transport system).

5.9.2 Prioritized startup

Definition

Prioritized startup refers to the PROFINET function for accelerating the startup of IO devices in a PROFINET IO system with RT communication. It shortens the time that the respective configured IO devices require in order to reach the cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

Advantages

The PROFINET functionality "prioritized startup" enables PROFINET IO applications in which machine parts or tools and their IO devices have been permanently replaced. Waiting times of several seconds between the scheduled processes of the restart are reduced to a minimum by this optimization. This accelerates the production process with alternating IO devices (PROFINET functionality "docking systems"), e.g. in tool changer applications, and enables a greater throughput in production.

The PROFINET functionality "prioritized startup" also offers a considerable increase in performance for applications where a quick startup time of the IO devices after "power on" or after station failure / station return is required, or when activating IO devices.

Area of application

You can use prioritized startup, for example, for changing tools for robots in the automotive industry. Typical tools are, for example:

- Welding guns
- Positioning tools for the manufacture of car body parts

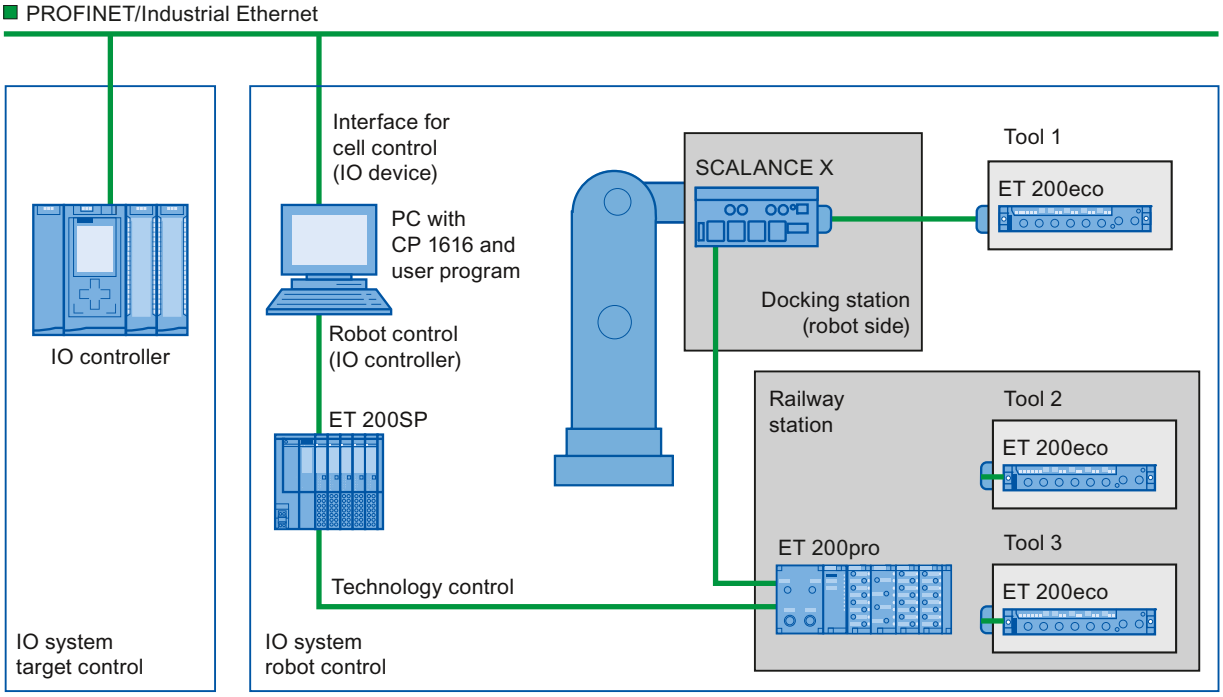


Figure 5-33 Example configuration of a tool changer: Tools 1-3 configured with "Prioritized startup".

5.9.3 Configuring prioritized startup

Requirements

You can enable the "Prioritized startup" PROFINET function for the IO devices (distributed I/O) only in the following cases:

- The IO controller used can prioritize selected IO devices during startup.
- The IO device used supports prioritization.

Procedure

1. Select the IO device in the network view or device view for which you wish to accelerate startup.
2. Open the IO device properties in the Inspector window.
3. Select "PROFINET interface > Advanced options > Interface options".
4. Select the "Prioritized startup" check box.

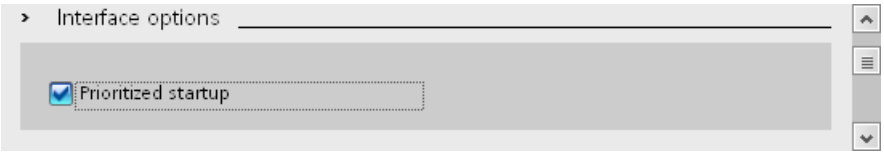


Figure 5-34 Configuring prioritized startup in STEP 7

5. Download the configuration to the IO controller.

Note

Prioritized startup after a startup for the first time

A prioritized startup of the IO device is always available to you after the first configuration of this IO device in the very first startup of the PROFINET IO system. Even in the case of spare parts or a reset to factory settings, the first startup is a standard startup for the respective configured IO devices.

Note

Number of IO devices (distributed I/O) with prioritized startup

You can only start up a maximum number of IO devices with the "Prioritized startup" PROFINET functionality within one PROFINET IO system. This maximum number depends on the IO controller used.

5.9.4 Optimizing port settings for accelerated startup

Optimizing port settings on the IO device and IO controller

The transfer medium and the duplex option are checked during startup of the IO device for control unit cabling.

These checks require time, but with specific presets of these options you can save the time the check requires. Make certain that the settings made correspond to the actual conditions (using the correct cables).

Optimizing port settings for accelerated startup

To optimize port settings for accelerated startup, follow these steps:

1. Select the ports of the IO controller or the partner port of the corresponding IO device.
2. Navigate to "Port options > Connection" in the Inspector window.
   Select the setting "TP 100 Mbps full duplex" under "Transmission rate/duplex"
3. Clear the "Enable autonegotiation" check box.

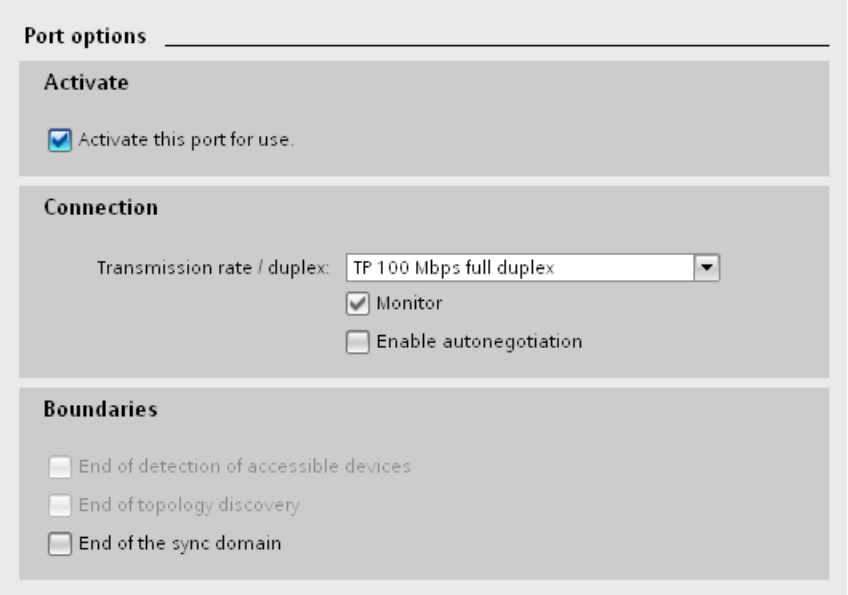


Figure 5-35 Optimizing port settings for accelerated startup in STEP 7

These settings are automatically applied during topology configuration for the partner port.

5.9.5 Optimizing the cabling for accelerated startup

Requirements

You have made the following settings for the port in question to accelerate the startup time of the IO device:

- Fixed transmission rate
- Autonegotiation deactivated

The time for negotiating the transmission rate during startup is saved.

If you have disabled autonegotiation, you must observe the cabling rules.

Properties of ports

PROFINET devices have the following two types of ports:

Type of port	PROFINET devices
Switch port with crossed pin assignment	For IO devices: Port 2 For S7-CPUs with two ports: Ports 1 and 2
Terminal device port with normal pin assignment	For IO devices: Port 1 For S7-CPUs with one port: Port 1

Crossed pin assignment means that the pin assignment for the ports for sending and receiving between the respective PROFINET devices is inverted internally.

Validity of the cabling rules

The cabling rules described in the following paragraph apply exclusively for the situation in which you have specified a fixed port setting in STEP 7.

Rules for cabling

You can connect several IO devices in series using patch cables. To do this, connect port 2 of the IO device (distributed I/O) with port 1 of the next IO device. The following graphic provides an example with two IO devices.

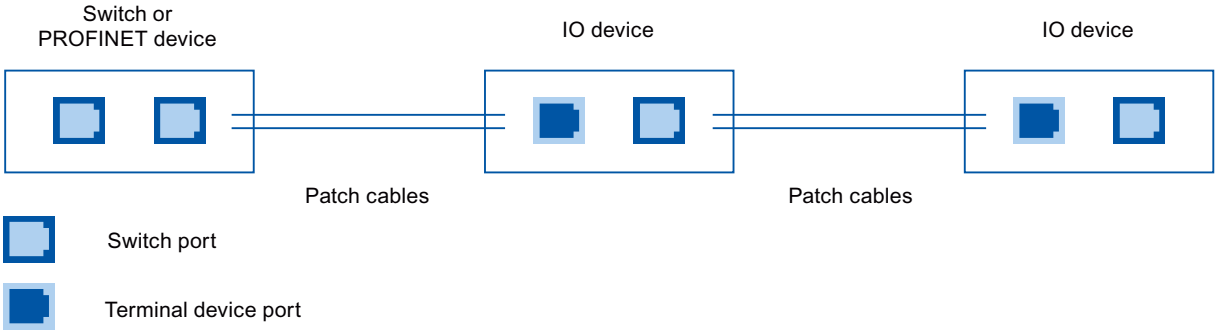


Figure 5-36 Optimized cabling for accelerated startup

5.9.6 Optimizing the user program for accelerated startup

Introduction

You can make certain changes in the user program to accelerate the startup for IO devices of docking systems that alternate during operation.

Making the required changes to the user program

To accelerate the startup by making changes to the user program, follow these steps:

1. Call the "D_ACT_DP" instruction to activate and deactivate the IO device at the start of the OB 1 cycle.

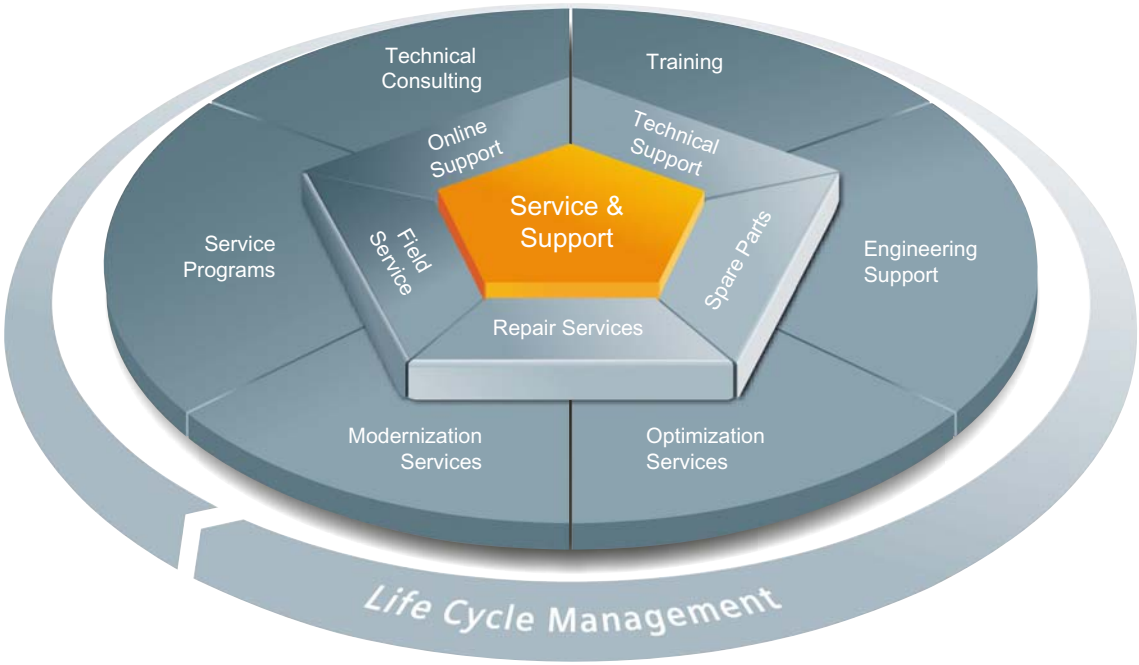
   If the IO device is replaced, the device that is no longer required must be deactivated and the new device must be activated.

2. If you control the "Power ON" command of the IO devices via the application, then start the activation of the IO devices via the corresponding call of the "D_ACT_DP" instruction as near to the same time as possible. The IO device has to be physically connected for this.

3. You access the IO device using direct access commands after the "D_ACT_DP" instruction has provided the feedback "IO device activated".

Service & Support

A



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Glossary

API

API (Application Process Identifier) is a parameter, the value of which specifies the IO data processing process (application).

The PROFINET standard IEC 61158 assigns profiles to specific APIs (PROFIdrive, PROFIsave), which are defined by the PROFINET user organization.

The standard API is 0.

Application

An application is a program that runs directly on the MS-DOS/Windows operating system. An application on the PG is STEP 7, for example.

See also User program

AR

AR (Application Relation) is an addressing level for diagnostic data records.

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Backplane bus

The backplane bus is a serial data bus for module intercommunication and the distribution of the necessary power to the modules. Bus connectors interconnect the modules.

Bus

A bus is a transfer medium that interconnects several devices. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

Communication Cycle and Reservation of Transmission Bandwidth

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

Communication processor

Communication processors are modules used for point-to-point and bus connections.

Configuring

Selecting and putting together individual components of an automation system or installing necessary software and adapting it for a specific application (for example, by configuring the modules).

Consistent data

Data which belongs together in terms of content and must not be separated is known as consistent data.

For example, the values of analog modules must always be handled as a whole, that is, the value of an analog module must not be corrupted as a result of reading out at two different points in time.

CP

-> Communication processor

CPU

Central **P**rocessing **U**nit - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

DCP

DCP (**D**iscovery and Basic **C**onfiguration **P**rotocol). Enables the assignment of device parameters (for example, the IP address) using manufacturer-specific configuration/programming tools.

Default router

The default router is used when data has to be forwarded via TCP/IP to a partner located outside the local network.

Determinism

Determinism means that a system responds in a predictable (deterministic) manner.

Device

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

Device name (PROFINET device name)

In the PROFINET IO environment, the device name is a unique identifier for the PROFINET IO interface of a device.

Diagnostic error interrupt

Modules capable of diagnostic operations report detected system errors to the CPU by means of diagnostic interrupts.

See also CPU

Diagnostics

-> System diagnostics

Diagnostics buffer

The diagnostics buffer represents a backup memory in the CPU, used to store diagnostic events in their order of occurrence.

DP master

A master which behaves in accordance with EN 50170, Part 3, is known as a DP master.

See also Master

DP slave

A slave operated on PROFIBUS with PROFIBUS DP protocol and in accordance with EN 50170, Part 3 is referred to as DP slave.

See also Slave

DPV1

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol.
The DPV1 functionality is integrated in IEC 61158/EN 50170, Volume 2, PROFIBUS.

Duplex

Half duplex: One channel is available for alternating exchange of information.

Full duplex: Two channels are available for simultaneous exchange of information in both directions.

Ethernet

Ethernet is an international standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET device that are necessary for its configuration in XML format.

I-device

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller, for example, as intelligent preprocessing unit of sub-processes. In its role as an IO device, the I-device is accordingly integrated into a "higher-level" IO controller.

Industrial Ethernet

Industrial Ethernet is a guideline for installing an Ethernet in an industrial environment. The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

Interrupt

An interrupt is an event that causes the operating system of an S7-CPU to automatically call an assigned organization block (interrupt OB) in which the user can program the desired reaction.

Interrupt, diagnostics

-> Diagnostic error interrupt

IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique on that network. The IP address is made up of 4 decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by dots.

The IP address is made up of the following components:

- Address of the network
- Address of the device (generally called the host or network node).

IRT

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

LAN

Local Area Network - a local network to which multiple computers within a company are connected. The LAN therefore has a limited geographical span and is only available to the company or institution.

Line depth

Designates the number of external switches or integrated switches interconnected in series.

MAC address

Worldwide unique device identification for all Ethernet devices. It is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

Every PROFINET device is assigned a worldwide unique device identifier at the factory. This 6-byte long device identifier is the MAC address.

Maintenance Required / Maintenance Demanded

A "Maintenance required" system alarm can be defined for different wear parameters and an inspection of a component can be recommended, for example, when a certain number of operating hours has elapsed.

The "Maintenance demanded" alarm is sent when the part involved needs to be replaced within a foreseeable period.

(Example printer: The maintenance demanded alarm is sent when the ink/printer cartridges have to be replaced immediately.)

Master

Higher-level, active participant in the communication/on a PROFIBUS subnet.
It has rights to access the bus (token), sends data and requests it.

Media redundancy

The so-called **M**edia **R**edundancy **P**rotocol (MRP) enables the configuration of redundant networks. Redundant transmission links (ring topology) ensure that an alternating communication path is made available if a transmission link fails. The PROFINET devices that are a part of this redundant network form an MRP domain.

Micro Memory Card (MMC)

Micro Memory Cards are memory media for CPUs and CPs. Their only difference to the SIMATIC memory card is the smaller size. The S7-1500 CPUs use SIMATIC memory cards.

MPI

The multipoint interface (**M**ulti **P**oint **I**nterface,MPI) represents the programming device interface of SIMATIC S7. It enables multiple devices (programming devices, text-based displays, OPs) to be operated simultaneously by one or more CPUs.
Each device is identified by its unique (MPI) address.

Network

A network consists of one or more interconnected subnets with any number of devices.
Several networks can exist alongside each other.

OB

-> Organization block

OPC

OPC (OLE for Process Control) refers to a standard interface for communication in automation technology.

Operating mode

Operating modes known to SIMATIC S7 automation systems: STOP, STARTUP, RUN

Organization block

Organization blocks (OBs) form the interface between the CPU operating system and the user program. The order in which the user program is executed is defined in the organization blocks.

Parameter

1. Tag of a STEP 7 code block:
2. Tag used to set one or several characteristics of a module

In delivery state, every module has practical basic settings, which can be modified by configuration in STEP 7.

There are static and dynamic parameters

PG

-> Programming device

PLC

-> Programmable logic controller

Prioritized startup

Prioritized startup denotes the PROFINET functionality for accelerating the startup of IO devices operated on a PROFINET IO system with RT and IRT communication. It reduces the time that the correspondingly configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

Process image

The process image is part of CPU system memory. At the start of cyclic program execution, the signal states of the input modules are transferred to the process image of the inputs. At the end of cyclic program execution, the process image of the outputs is transferred to the output modules as signal state.

See also System memory

PROFIBUS

Process **F**ield **Bus** - European Fieldbus standard.

PROFIBUS device

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485) or optical (polymer optical fiber, POF) interface.

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O = fast, real-time capable, cyclic data exchange. From the perspective of the user program, the distributed IOs are addressed in exactly the same way as the centralized IOs.

PROFIBUS users organization

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINETstandard. Additional information can be found on the Internet.

PROFIenergy

Function for energy saving in the process, for example, during pause times by briefly switching off the entire system via standardized PROFIenergy commands.

PROFINET

Open component-based industrial communications system based on Ethernet for distributed automation systems. Communications technology promoted by the PROFIBUS users organization.

PROFINET device

A PROFINET device always has a PROFINET interface (electrical, optical, wireless). A lot of devices also have a PROFIBUS DP interface to connect PROFIBUS devices.

PROFINET IO

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

PROFINET IO Controller

Device used to address the connected IO devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

PROFINET IO Device

A distributed field device that is assigned to one of the IO controllers (e.g. remote IO, valve terminals, frequency converters, switches)

PROFINET IO System

PROFINET IO controller with assigned PROFINET IO devices.

Programmable logic controller

Programmable logic controllers (PLCs) are electronic controllers whose function is stored as a program in the control unit. The structure and wiring of the device does not therefore depend on the controller's function. A programmable logic controller is structured like a computer. It consists of a CPU with memory, input/output modules and an internal bus system. The IOs and the programming language are oriented to the requirements of the control technology.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

Proxy

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link, for example. The IE/PB link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

Real-time

Real-time means that a system processes external events within a defined time.

Real-time communication

Group error for RT and IRT.

PROFINET uses its own real-time channel (RT) rather than TCP/IP for communication of time-critical IO user data.

Router

A router interconnects two subnets. A router works in a similar way to a switch. With a router, however, you can also specify which communication devices may communicate via the router and which may not. The communication devices on various sides of a router can only communicate with one another if you have explicitly enabled communication between these devices via the router. Real-time data cannot be exchanged beyond subnet boundaries.

RT

PROFINET IO with real-time communication (RT) is the optimal transmission method for time-critical applications in factory automation. PROFINET IO frames have priority over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology.

Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Send clock

Period between two consecutive intervals for IRT or RT communication.
The send clock is the shortest possible transmit interval for exchanging data.

For IRT, any multiples of 125 µs can be set as "uneven" send clocks in addition to the "even" send clocks (250 µs, 500 µs, 1 ms, 2 ms, 4 ms) in the range from 250 µs to 4 ms: 375 µs, 625 µs to 3.875 ms.

With "uneven" send clocks, the following is valid for all PROFINET IO devices:

- Update time = send clock
- It is not possible to extend IRT using RT devices

SIMATIC

The term denotes Siemens AG products and systems for industrial automation.

SIMATIC NET

Siemens Industrial Communication division for Networks and Network Components.

SIMATIC PC Station

A "PC station" is a PC with communication modules and software components within a SIMATIC automation solution.

SIMATIC Memory Card (SMC)

-> Micro Memory Card (MMC)

Slave

A slave can only exchange data after being requested to do so by the master.

SNMP

The network management protocol SNMP (**S**imple **N**etwork **M**anagement **P**rotocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the MIB (**M**anagement **I**nformation **B**ase). This information allows a network management system to run detailed network diagnostics.

STEP 7

STEP 7 is an engineering system and contains programming software for the creation of user programs for SIMATIC S7 controllers.

Subnet

All the devices interconnected by switches are nodes of the same network or subnet. All the devices in a subnet can communicate directly with each other.

All devices in the same subnet have the same subnet mask.

A subnet is physically restricted by a router.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

Sync domain

All PROFINET devices to be synchronized with IRT via PROFINET IO must belong to a sync domain.

The sync domain consists of exactly one sync master and at least one sync slave. An IO controller or switch generally handles the role of the sync master.

Non-synchronized PROFINET devices are not part of a sync domain.

System diagnostics

System diagnostics refers to the detection, evaluation, and signaling of errors that occur within the automation system, for example, programming errors or module failures. System errors can be indicated by LEDs or in STEP 7.

TCP/IP

The Ethernet itself is only a transport system for data - similar to a highway, which is a transport system for people and goods. The actual data transport is performed by so-called protocols - similar to cars and trucks, which transport people and goods on the highway.

The two basic protocols TCP (**T**ransmission **C**ontrol **P**rotocol) and IP (**I**nternet **P**rotocol) - TCP/IP for short - perform the following tasks:

1. The data is broken down into packets at the sender.
2. The packets are transported over the Ethernet to the correct recipient.
3. At the recipient, the packets are reassembled in the correct order.
4. Corrupt packets continue to be sent until they are received correctly.

Most higher-level protocols use TCP/IP to perform their duties. **H**yper **T**ext **T**ransfer **P**rotocol (HTTP), for example transfers documents written in **H**yper **T**ext **M**arkup **L**anguage (HTML) in the **W**orld **W**ide **W**eb (WWW). This technique is what enables you to view web pages in your Internet browser in the first place.

Topology

Network structure. Commonly used structures:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

Topology configuration

All the interconnected ports of the PROFINET devices in the STEP 7 project and their relationships to each other.

Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ω (AWG 22). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ45 connector system.

Update time

An IO device / IO controller in the PROFINET IO system is supplied cyclically with new data from the IO controller / IO device within this time interval. The update time can be configured separately for each IO device and determines the interval at which data is sent from the IO controller to the IO device (outputs) as well as from the IO device to the IO controller (inputs).

User program

In SIMATIC, we distinguish between the CPU operating system and user programs. The user program contains all instructions, declarations and data by which a system or process can be controlled. The user program is assigned to a programmable module (for example, CPU, CM) and can be structured in smaller units.

WAN

A network that extends beyond LAN boundaries and enables, for example, intercontinental network communication. Legal rights do not belong to the user but to the provider of the communication network.

XML

XML (Extensible Markup Language) is a flexible, easy to understand and easy to learn data description language. Information is exchanged using readable XML documents. These include continuous text supplemented by structure information.

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SIMATIC

S7-1500 / ET 200MP / ET 200SP CM PtP - Configurations for point-to-point connections

Function Manual

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Service & Support A

01/2013

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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Preface

Purpose of the documentation

This documentation provides important information on configuring and commissioning the point-to-point communication modules for the S7-1500 (ET 200MP) and ET 200SP.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7 V12

Validity of the documentation

This documentation is valid for all point-to-point communication modules of the S7-1500 (ET 200MP) and the ET 200SP.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 as well as for interface modules of distributed I/O systems, such as the IM 155-5.

Please also observe notes labeled as follows:

Note

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to their low pollutant content. For environmentally compliant recycling and disposal of your old device, please contact a company certified for the disposal of electronic waste.

Additional assistance

- Information about the technical support (http://www.siemens.com/automation/support-request) available can be found in the appendix to this documentation.
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com/).

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Guide to documentation 1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP and ET 200SP systems consists of the respective system manual, function manuals and product manuals.

Furthermore, the STEP 7 V12 information system (online help) offers you assistance in configuring and programming your automation system.

Overview of documentation on the topic of point-to-point communication

The table below includes additional documentation which amends this description.

Subject	Documentation	Important contents
System	S7 -1500 Automation System () system manual ET 200MP distributed I/O system () system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual	• Application planning • Installing • Connecting • Addressing • Commissioning • Maintenance
CPU storage concept	Function manual Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101)	• Setup • Principle of operation • Use
STEP 7 V12	STEP 7 Professional V12 online help	• Configuring • Programming

Subject	Documentation	Important contents
Communication	Function manual Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Basics of serial communication • Data transmission functions • Diagnostic functions
	Device manual CM PtP RS232 BA communication module (http://support.automation.siemens.com/WW/view/en/59057152) Device manual CM PtP RS422/485 BA communication module (http://support.automation.siemens.com/WW/view/en59057390) Device manual CM PtP RS232 HF communication module (http://support.automation.siemens.com/WW/view/en/59057160) Device manual CM PtP RS422/485 HF communication module (http://support.automation.siemens.com/WW/view/59061372) Device manual CM PtP communication module (http://support.automation.siemens.com/WW/view/en/59061378)	• Product overview • Connecting • Assigning parameters • Programming • Diagnostics
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	For S7-1500, ET 200MP, ET 200SP: • Diagnostic evaluation Hardware/software
Setup	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
PROFINET	Function manual PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)	• Basics • Functions • Diagnostics

SIMATIC Manuals

The latest manuals of SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) and can be downloaded free of charge.

Introduction 2

2.1 Overview of the communication modules

Automation systems encompass a wide range of components. These also include communication modules. A simple possibility of data exchange is provided by serial communication via point-to-point connections.

Customizing to a wide range of communication partners is possible by setting the communication parameters at a lower layer of the OSI layer model (see chapter Transmission security (Page 16)).

Communication through point-to-point connection with S7-1500, ET 200MP and ET 200SP takes place exclusively by means of communication modules (CM) with serial interfaces.

SIMATIC S7 offers a number of modules that provide the physical interface and fundamental protocol mechanisms for this purpose.

- RS232: An interface that can coordinate the communication between the partners through additional accompanying signals.
- RS422/RS485: An interface that allows longer lines through the use of differential voltages as transmission technology and also enables structures with more than 2 devices through a bus structure (RS485).

Instructions that carry out the coordination between the CPU and CM (Communication Module) are available to transfer data from the CPU to the respective modules. They inform the user program about a successful transfer or the receipt of new data (in systems without a SIMATIC CPU users have to program the function of these instructions themselves).

The function and use of the PtP communication modules is described in this function manual.

Overview of components and order numbers

Tabular overview of communication modules and their application suitability

Communication module	S7-1500	ET 200MP	ET 200SP	Order number
CM PtP RS232 BA [1]	X	X	-	6ES7540-1AD00-0AA0
CM PtP RS422/485 BA	X	X	-	6ES7540-1AB00-0AA0
CM PtP RS232 HF [2]	X	X	-	6ES7541-1AD00-0AB0
CM PtP RS422/485 HF	X	X	-	6ES7541-1AB00-0AB0
CM PtP (ET 200SP)	-	-	X	6ES7137-6AA00-0BA0

[1] BA = Basic

[2] HF = High Feature

Overview of components and interfaces

Tabular overview of communication modules and their functions.

Communication module	Interface	Protocols					Connection technology	
		Freeport	3964(R)	Modbus Master	Modbus Slave	USS-Master	D-Sub 9-pin	D-Sub 15-pin
CM PtP RS232 BA	RS232	X	X	-	-	X	X	-
CM PtP RS422/485 BA	RS422	X	X	-	-	X	-	X
	RS485	X	-	-	-	X	-	X
CM PtP RS232 HF	RS232	X	X	X	X	X	X	-
CM PtP RS422/485 HF	RS422	X	X	X	X	X	-	X
	RS485	X	-	X	X	X	-	X
CM PtP (ET 200SP)	RS232	X	X	X	X	X	ET 200SP BaseUnit 1)	
	RS422 2)	X	X	X	X	X		
	RS485	X	-	X	X	X		

1) BaseUnit with terminals instead of D-Sub; assignment depending on physical transmission properties

2) The CM PtP communication module can also be used for multipoint connection in RS422 mode

Overview of components and data transmission rates

The communication modules can send and receive data with different data transmission rates. The table below shows the assignment to the individual communication modules.

Communication module	Data transmission rate in bps										
	300	600	1200	2400	4800	9600	19200	38400	57600	76800	115200
CM PtP RS232 BA	X	X	X	X	X	X	X	-	-	-	-
CM PtP RS422/485 BA	X	X	X	X	X	X	X	-	-	-	-
CM PtP RS232 HF	X	X	X	X	X	X	X	X	X	X	X
CM PtP RS422/485 HF	X	X	X	X	X	X	X	X	X	X	X
CM PtP (ET 200SP)	X	X	X	X	X	X	X	X	X	X	X

Overview of components and receive buffer size

Each communication module has a buffer to temporarily store received frames. The table below shows the assignment of the maximum size of an individual frame as well as the size of the memory for the individual communication modules.

Module	Receive buffer size KB	Max. frame length KB	Bufferable frames
CM PtP RS232 BA	2	1	255
CM PtP RS422/485 BA	2	1	255
CM PtP RS232 HF	8	4	255
CM PtP RS422/485 HF	8	4	255
CM PtP (ET 200SP)	4	2	255

Accompanying signals and data flow control

- Software data flow control with XON/XOFF

  The Freeport protocol supports data flow control with XON/XOFF via the RS232 and RS422 interfaces.

- Hardware data flow control with RTS/CTS

  The Freeport protocol supports data flow control with RTS/CTS via the RS232 interface.

- Automatic operation of accompanying signals

  The RS232 accompanying signals can be controlled with the Freeport, Modbus master and Modbus slave protocols by means of the RS232 interface. (Only available if hardware data flow control is not activated.)

Protocols of the communication modules

You may set up a communication connection with different protocols, depending on the communication modules used:

- Freeport: Transmission of ASCII character strings without specified protocol format
- 3964(R): Communication between programmable logic controllers (master/master communication)
- USS: Communication between a programmable logic controller and a drive (master/slave communication) Communication is tailored to the drive technology requirements. The communication module can only be master.
- Modbus RTU: Communication between programmable logic controllers (master/slave communication) The communication module can be the master as well as the slave.

2.2 Overview of the processing steps

Point-to-point connection

The system provides various networking options for the exchange of data between two or more communication partners. The simplest form of data interchange is via a point-to-point connection between two communication partners.

The communication module (CM) forms the interface between a programmable logic controller and a communication partner. Data is sent in serial mode via point-to-point connection with the communication module.

Configuring / parameter assignment

Configuring the communication module includes the arrangement of the communication module in the device configuration of STEP 7 V12 as well as the settings of the specific protocol parameters in the properties dialog of the communication module (static configuration).

Programming

Programming includes the program-specific connection of the communication module to the corresponding CPU by means of the user program. You program the communication module with STEP 7 V12.

Communication between CPU, communication module and a communication partner takes place through instructions. A number of instructions are available for the S7-1500 automation system that you can use to initiate and control communication in the user program as well as influence the configuration for runtime (dynamic configuration).

For more information, please refer to Overview of instructions (Page 13) and the STEP 7 V12 online help.

2.3 Overview of instructions

Note

CPU quantity structures

The point-to-point instructions communicate with the communication modules by reading or writing data records.
When using the instructions, you should therefore check the quantity structure of the CPU for reading and writing data records.
If multiple instructions need to read or write data records simultaneously on a CPU, there may need to be a gap between the calls of each instruction by the user program.

Overview of the instructions

The communication protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules.

The instructions form the software interface between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place across several cycles.

The instructions are part of STEP 7 V12. The instructions are available in the "Instructions" task card under Communication > Communication processor.

The corresponding instruction descriptions are available in the information system. They apply to all listed communication modules if they support the required function.

Table 2- 1 Instructions for PtP

Instruction	Meaning
Port_Config	The instruction Port_Config allows you to dynamically assign basic interface parameters.
Send_Config	The instruction Send_Config (send configuration) allows you to dynamically assign serial send parameters of a port.
Receive_Config	The instruction Receive_Config (receive configuration) allows you to dynamically assign serial receive parameters of a port.
P3964_Config	The instruction P3964_Config (protocol configuration) allows you to dynamically configure the parameters of the 3964(R) procedure.
Send_P2P	The instruction Send_P2P allows you to send data to a communication partner.
Receive_P2P	The instruction Recveive_P2P allows you to receive data from a communication partner.
Receive_Reset	The instruction Receive_Reset allows you to clear the receive buffer of the communication module.
Signal_Get	The instruction Signal_Get allows you to read the RS232 accompanying signals.
Signal_Set	The instruction Signal_Set allows you to set the RS232 accompanying signals.

Instruction	Meaning
Get_Features	The instruction Get_Features allows you to read the extended functions supported by the communication module.
Set_Features	The instruction Set_Features allows you to activate the extended functions supported by the communication module.

Table 2- 2 Instructions for USS

Instruction	Meaning
USS_Port_Scan	The instruction USS_Port_Scan allows you to communicate by means of the USS network.
USS_Drive_Control	The instruction USS_Drive_Control allows you to swap data with the drive.
USS_Read_Param	The instruction USS_Read_Param allows you to read parameters from the drive.
USS_Write_Param	The instruction USS_Write_Param allows you to change parameters in the drive.

Table 2- 3 Instructions for Modbus

Instruction	Meaning
Modbus_Comm_Load	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU. .
Modbus_Master	The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

Basics of serial communication 3

3.1 Serial data transmission

During serial data transmission, the individual bits of a character of information to be transmitted are sent successively in a defined sequence.

Bidirectional data traffic - operating mode

In the context of bidirectional data traffic, we distinguish between two operating modes for the communication module:

- Half-duplex operation

  The data is exchanged between the communication partners in both directions alternately. In half-duplex operation one communication partner is sending and the other communication partner is receiving at the same time. In the process one line is alternately used for sending or receiving.

- Full-duplex operation

  The data is exchanged between one or more communication partners in both directions simultaneously, which means you can send and receive data at the same time. This process requires one line for sending and one line for receiving.

Asynchronous data transmission

Serial data transmission is performed asynchronously with communication modules. The so-called time base synchronism (a fixed timing code used in the transmission of a fixed character string) is only upheld during transmission of a character. Each character to be sent is preceded by a synchronization impulse, also called start bit. The length of the start-bit transmission determines the clock pulse. The end of character transmission is formed by one or two stop bits.

Declarations

In addition to start and stop bits, additional declarations must be made between the sending and receiving partners before serial transmission can take place. These include:

- Data transmission rate
- Frame start and end criteria (e.g., character delay time)
- Parity
- Number of data bits (7 or 8 bits/characters)
- Number of stop bits (1 or 2)

3.2 Transmission security

Transmission security plays an important role in the transmission of data and in the selection of the transmission procedure. Generally speaking, the more layers of the reference model are applied, the higher the transmission security.

Classification of existing protocols

The figure below illustrates how the protocols of the communication module fit into the reference model.

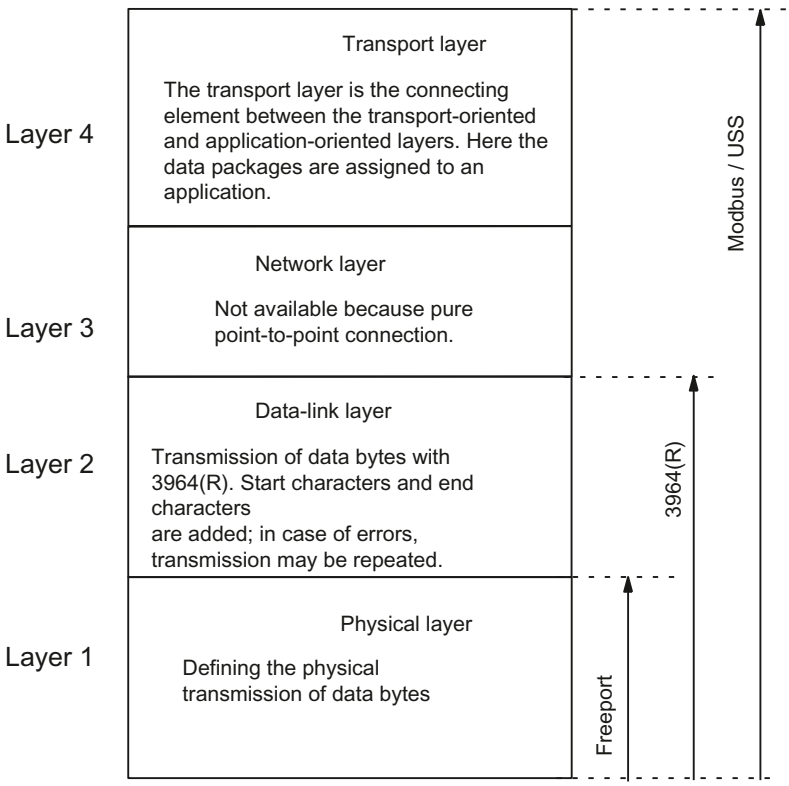


Figure 3-1 Classification of the existing protocols of the communication module in the reference model

Transmission security with Freeport

Transmission security when using Freeport:

- When data is sent with Freeport, there are no data security measures other than the use of a parity bit. This means data transmission with Freeport is very efficient, but data security is not guaranteed. A certain degree of data security can be achieved through parameter assignment of the frame start and frame end conditions.
- Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, there is no guarantee that these errors are still detected.
- To increase transmission security, you can, for example, implement a checksum, a frame length specification, or configurable end conditions. These measures must be implemented by the user.
- A further increase in data security can be achieved by means of acknowledgment frames in response to send or receive frames. This is the case with high-grade protocols for data communication (ISO 7-layer reference model).

Transmission security with 3964(R)

The parity bit is used to increase data security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, these errors can no longer be reliably detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

Two different procedures for data transmission can be used, either with or without a block check character:

- Data transmission without block check character: 3964

  Transmission security is achieved by means of a specified frame structure, frame breakdown, and frame repetitions.
- Data transmission with block check character: 3964R

  The high degree of transmission security is achieved by means of a specified frame structure and breakdown, frame repetitions, as well as inclusion of a block check character (BCC).

In this manual, the term 3964(R) is used when descriptions and notes refer to both data transmission modes.

Transmission integrity for Modbus and USS

The parity bit is used to increase transmission security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, this error can no longer be clearly detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

The CRC (cyclic redundancy check) is additionally used with Modbus. With this method additional redundancy in the form of a so-called CRC value is added for each data block of the user data before data transmission. This is a check value calculated by using a specific procedure that can be used to detect any errors that may occur during transmission.

A BCC (block check character) is additionally used with USS. The block check character is formed during the receipt and is compared with the received BCC after the entire frame has been read in. If these two characters do not match, the frame is not evaluated. (If a character is incorrectly transmitted, an error is reliably detected. If an even number of characters are incorrectly transmitted, an error can no longer be reliably detected.)

3.3 RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 BA
- CM PtP RS232 HF
- CM PtP (ET 200SP)

In RS232 mode, data is sent via two lines. A separate line is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

RS232 signals

In addition to the TXD (interface transmits; Transmitted Data), RXD (interface receives; Received Data) and GND (Ground; isolated) signals, the communication module provides the following RS232 signals when using RS232 hardware:

DCD	(input)	Data Carrier detect; Carrier signal when connecting a modem. The communication partner signals that it recognizes incoming data.
DTR	(output)	Data terminal ready; DTR set to "ON": Communication module switched on, ready for operation DTR set to "OFF": Communication module not switched on, not ready for operation
DSR	(input)	Data set ready; DSR set to "ON": Communication partner signals readiness for operation DSR set to "OFF": Communication partner not switched on, not ready for operation
RTS	(output)	Request to send; RTS set to "ON": Communication module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communication module not ready to send
CTS	(input)	Clear to send; Communication partner can receive data from the communication module (response to RTS = ON of the communication module) CTS set to "ON": Signals readiness to receive to the communication partner CTS set to "OFF": Signals "Not ready to receive" to the communication partner
RI	(input)	Ring Indicator; Incoming call when connecting a modem

After power on of the communication module, the output signals are in the OFF state (inactive).

You configure the operation of the DTR/DSR and RTS/CTS control signals in the user interface of the communication module.

The RS232 signals cannot be influenced in case of:

- configured data flow control "Hardware RTS always switched"

  (corresponds to automatic operation of the accompanying signals)
- configured data flow control "Hardware RTS always ON"

  (corresponds to hardware flow control with RTS/CTS)
- configured data flow control "Hardware RTS always ON, ignore DTR/DSR"

For more information on this topic, refer to chapter Handshake procedure (Page 23).

3.4 RS422 mode

The following communication modules support RS422 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS422 mode, data is transmitted via two line pairs (four-wire operation). A separate line pair is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

All communication partners must be capable of simultaneous operation of a sender and receiver unit.

The data can be exchanged simultaneously between one or several communication partners. In RS422 multipoint mode, only one slave may send data at any given time.

Interface operating modes

The following table is a summary of the interface operating modes for the various communication modules and protocols.

The communication module can be used in the following topologies in RS422 mode:

- Link between two devices: Point-to-point connection
- Link between several devices: Multipoint connection
  (only available with CM PtP (ET 200SP))

Operating mode	Description
Full duplex (RS422) four-wire operation (point-to-point connection)	Both devices have the same priority in this operating mode.
Full duplex (RS422) four-wire operation (multipoint master)	The communication module can be used as multipoint master.
Full duplex (RS422) four-wire operation (multipoint slave)	The communication module can be used as multipoint slave.

The following applies for a multipoint master/slave topology in RS422 mode:

- The master's sender is interconnected with the receivers of all slaves.
- The slaves' senders are interconnected with the master's receiver.
- Only the receiver of the master and the receiver of one slave have a default setting. All other slaves operate without default settings.

3.5 RS485 mode

The following communication modules support RS485 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS485 mode, data is transmitted via one line pair (two-wire operation). The line pair is available alternately for the send and receive directions. It is possible to either send or receive (half duplex). On completion of a send operation, operation is immediately switched to receive mode (ready to receive). Send mode is reset again as soon as a new send job is received.

RS485 mode

The following table is a summary of the interface operating modes for the various communication modules and protocols.

Operating mode	Description
Half duplex (RS485) two-wire operation	Operating mode for point-to-point connection or multipoint connection (multipoint) in two-wire operation. The communication module can be the master as well as the slave.

If you operate the Freeport in RS485 mode (half duplex, two-wire operation), you must make provisions in the user program to ensure that only one device sends data at any given time. If more than one device sends data at the same time, the frames are corrupted.

Modbus automatically ensures that only one device is sending.

Changeover times for RS485 communication module in half duplex mode

A maximum time of 0.1 ms is set for the changeover between sending and receiving.

3.6 Handshake procedure

Introduction

Handshaking controls the data flow between two communication partners. The use of the handshaking method prevents data loss during transmission if the devices are operating at different speeds.

We can basically distinguish between the following methods:

Table 3- 1 Overview of methods and interfaces

Method	RS232	RS422	RS485
Software data flow control XON/XOFF	X	X	-
Hardware data flow control (RTS/CTS)	X	-	-
Automatic operation of accompanying signals	X	-	-

Software data flow control

Software data flow control is implemented as follows on the communication module:

- XON/XOFF
  - As soon as the communication module has been set to the "XON/XOFF" operating mode by means of parameter assignment, it sends the XON character, thereby allowing the communication partner to send data.
  - On reaching the configured maximum number of frames, or 16 characters ahead of receive buffer overflow, the communication module sends the XOFF character, thereby requesting that the communication partners stop sending. If the communication partner nonetheless continues to send data, an error message is generated if the receive buffer overflows. Data received in the last frame is discarded.
  - As soon as a frame has been fetched by the CPU and the receive buffer is ready to receive data again, the communication module sends the XON character.
  - If the communication module receives the XOFF character during sending, it cancels the current send operation until it receives a XON again from its communication partner. If no XON is received within a specific configurable time, send operation is canceled and a corresponding error message is output.

Note

You can configure the characters for XON and XOFF (any ASCII character).

During parameter assignment of the XON/XOFF software data flow control, user data may not contain any of the configured XON or XOFF characters.

Hardware data flow control

Note

The DTR/DSR signals do not have to be wired for "Hardware RTS always ON, ignore DTR/DSR" parameter assignment.

If "Hardware RTS always ON" is configured, it is imperative that you fully wire the interface signals used. Make sure that the local RTS (out) is connected with the CTS (in) of the communication partner and the local CTS is connected with the RTS of the communication partner. Accordingly, the local DTR must be connected with the DSR of the communication partner and the local DSR with the DTR of the communication partner.

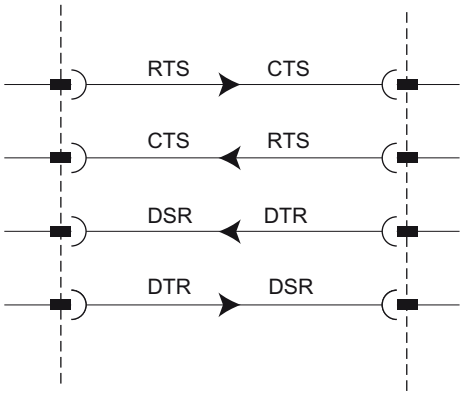


Figure 3-2 Wiring of the interface signals

- Hardware RTS always ON, ignore DTR/DSR
  - As soon as the communication module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it outputs the RTS = ON signal to the communication partner to indicate its ready state.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
- Hardware RTS always ON

  The "Hardware RTS always ON" mode corresponds to the "Hardware RTS always ON, ignore DTR/DSR" mode. However, you also need to wire DTR and DSR.
  - As soon as the communication module has been set set to an operating mode with "Hardware RTS always ON" through parameter assignment, it sets DTR = ON and RTS = ON to signal its general ready state to the communication partner.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
  - A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

Automatic operation of accompanying signals

- **Hardware RTS always switched**

  "Hardware RTS always switched" is implemented as follows on the communication module:

  – As soon as the communication module is set to the operating mode with "Hardware RTS always switched" through parameter assignment, it sets the line RTS to OFF and DTR to ON (communication module ready for operation).

    It is not possible to send frames until the DSR line is set to ON. No data is sent via the RS232C interface as long as DSR is set to OFF. A send job is canceled and a corresponding error message is generated.

  – When a send job is pending, RTS is set to ON and the configured RTS ON delay starts. On expiration of the data output time, the system checks whether the communication partner has set CTS to ON. If so, the data is sent via the RS232 interface.

  – If the CTS line is not set to ON within the RTS ON delay, or if CTS changes to OFF during transmission, the send job is aborted and an error message is generated.

  – Once the data has been sent and the configured clear RTS OFF delay has elapsed, the RTS line is set to OFF. The system does not wait for CTS to change to OFF.

  – It is always possible to receive data via the RS232 interface. There will be no reaction if there is a danger of the receive buffer of the communication module overflowing.

  – A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

  Note

  Set the "RTS ON delay" in such a way that the communication partner is able to enter the ready to receive state before the time elapses.

  Set the "RTS OFF delay" in such a way that the communication partner is able to receive the last characters of the frame completely before RTS is set to OFF and the send request is canceled.

  Note

  When automatic operation of the RS232 signals is configured, RTS and DTR cannot be controlled by means of the corresponding instruction!

Time diagram

The figure below shows the chronological sequence of a send job with configured data flow control "Hardware RTS always switched":

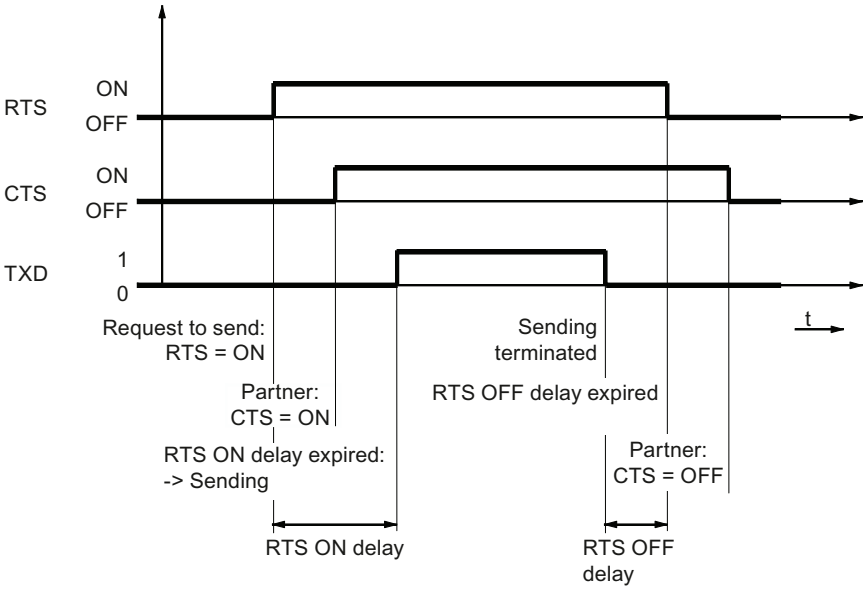


Figure 3-3 Time diagram for Hardware RTS always switched

Additional information

Note

Operation of DTR/DSR or RTS/CTS is accepted by the communication module with the following settings:

- Hardware RTS always ON, ignore DTR/DSR
- Hardware RTS always ON
- Hardware RTS always switched

Configuring / parameter assignment 4

4.1 Configuring / parameter assignment of a communication module

The following sections contain explanations on the following protocols and their parameters:

- Communication using Freeport (Page 30)
- Communication using 3964(R) (Page 38)
- Communication using USS (Page 42)
- Communication through Modbus RTU (Page 46)

This information is required to carry out the parameter assignment and subsequently programming of the communication in accordance with the used protocol.

Configuration and parameter assignment are carried out in the device view of STEP 7 and in the properties dialog of the communication module. Some configurations can also be changed during runtime by means of the corresponding "Config" instructions (Port_Config, Send_Config, Receive_Config, P3964_Config).

Procedure for setting up point-to-point communication

The procedure does not depend on the communication module used.

1. Configure an S7-1500 design with CPU and communication module in the device view of the STEP 7 V12 hardware editor.
2. You assign the parameters of the communication module interface (protocol, protocol parameters, addresses) in the "General" area of the "Properties" tab.

Additional information

Information about programming the communication is available in the section Programming - communication using instructions (Page 53).

4.2 Communication using Freeport

4.2.1 Data transmission with Freeport

Introduction

Freeport is a freely programmable frame-based protocol that is also known as ASCII protocol.

The Freeport protocol controls data transmission by means of a point-to-point connection between the communication module and a communication partner. The Freeport protocol contains the physical layer (Layer 1).

The Freeport protocol supports sending and receiving of messages with any structure (all characters from 00H through FFH (for character frames with 8 data bits) or from 00H through 7FH (for character frames with 7 data bits)).

The frame start and end criteria must be configured both for the send and the receive direction. The start and end criteria can be configured differently.

Instructions are available for communication with a communication partner (see Programming - communication using instructions (Page 53)).

4.2.2 Sending data with Freeport

Specifying settings for sending

To send a message, the partner must be informed of the start and end of the message. These settings can be set fixed in the hardware configuration or be adjusted during runtime by using the instruction Send_CFG. You can select one of the following options or also combine them:

- Send break before frame start

  You can specify that an additional Break is sent at the beginning of each message transmission on expiration of the RTS ON delay time.
  The duration of the "Break" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- Send idle line

  You can specify that an additional "Idle Line" signal is output at the start of each message transmission.
  The duration of the "Idle Line" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- RTS ON delay

  You can configure the time that has to expire after the RTS (Request to send) before the actual data transmission starts (RS232 only).

- RTS OFF delay

  You can configure the time that has to expire after transmission has been completed before the RTS signal is deactivated (RS232 only).

- Send up to and including the end delimiter

  You can configure the number of end delimiters (1 or 2) and their value.

  All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the delimiter, even if the specified data length is longer.

- Number of appended characters

  Input of the number of appended characters. Sending takes place up to the configured length. The end delimiter(s) is/are appended automatically. Depending on the number of end delimiters, one to five characters more than the number specified at the instruction are sent to the partner.

Note

If you combine "Send break before frame start", "Send idle line" and "RTS ON delay", these are processed in the order "RTS ON delay", "Send break before frame start" and "Send idle line".

4.2.3 Receiving data with Freeport

Specifying the message start

For data transmission with Freeport, you can choose between several different start criteria. The start criterion defines when a frame starts. Once a criterion that indicates the start of the message is met, the data stream is scanned for message end criteria. Here you select the settings that correspond to the properties of the sending communication partner.

Two different methods are available for detecting the message start:

- Start on any character

  Any character can be used to define the start of the message (default).

  This means that the first character sent at the start of communication, or after the frame end has been detected, will be identified as the first character of a message.

- Start on special condition

  The start of the message is detected based on the following specified conditions.

  – After detection of a line break

    The frame start is not accepted unless a break has been received beforehand, in other words, it is compulsory for the partner to send a break before sending a frame.

  – After detection of an idle line

    The frame start is not accepted until the configured idle line duration has expired. This procedure requires a minimum interval between two frames.

  – After receipt of a start character

    The frame start is detected when the configured start character is identified.

  – After detection of one or several start sequences

    The frame start is detected when the configured string with a length of up to five characters is identified. You can configure up to 4 start sequences. The start sequences that are up to 5 characters long can also contain "don't care characters".

Example:

Table 4- 1 Configured start conditions

Start condition	1st character	2nd character	3rd character	4th character	5th character
1	0x68	xx	xx	0x68	xx
2	0x10	0xaa	xx	xx	xx
3	0xdc	0xaa	xx	xx	xx
4	0xe5	xx	xx	xx	xx
:					

The following message has been received: 68 10 aa 68 bb 10 aa 16

The evaluation of the start criteria begins with the receipt of the first character 0x68.
The 2nd and 3rd characters are free.
When the 4th character (second 0x68) is received, the first start condition is met and further evaluation of the message begins.

Specifying the message end

You can choose from several different end criteria for data transmission using the Freeport protocol. The end criterion defines the point at which a frame has been received completely.

Configurable end criteria are:

- Recognize message end by message timeout
- Recognize message end by response timeout
- After character delay time elapses (default)
- After receipt of a fixed frame length
- After receipt of a maximum number of characters
- Read message length from message
- After receipt of an end sequence

Message timeout

When data is received, the end of frame is detected on expiration of the configured time for transferring a frame. Time measurement starts after the start criterion has been met.

Response timeout

The response time is used to monitor the response behavior of the communication partner. If a valid frame start is not recognized after the completion of a send job, the send job is acknowledged with a corresponding message.

The actual end criterion has to be configured additionally.

Expiration of character delay time

When data is received, the frame end is detected when the configured maximum time between successive characters is exceeded (character delay time). The value is specified in bit times.

In this case, the character delay time must be set in such a way as to ensure that it expires between two consecutive frames. However, it should be of sufficient length to exclude incorrect identification of the end of the frame whenever the communication partner performs a transmission pause within a frame.

Fixed frame length

When data is received, the end of the frame is identified after the configured frame length has been reached.

An error message is output and the frame is discarded if the character delay time expires (if activated) before the fixed frame length has been reached.

Please note the following if the frame length of the received characters does not match the fixed configured frame length:

- All characters received after the fixed configured frame length has been reached will be discarded until a new start criterion is detected.
- An error message is output and the frame is discarded if another (activated) end criterion is met before the fixed frame length has been reached.

Maximum number of characters

When receiving data, the end of the frame is recognized after the declared number of characters have arrived.

This setting can be combined with the "Character delay time" settings. The frame received is also assessed as free of error if another end condition occurs, regardless of whether the maximum number of characters has been reached.

Please note the following if the frame length of the received characters does not match the configured maximum frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- If a different (activated) end criterion is met before the configured maximum number of characters has been reached, this "frame part" is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

Note

If no further end criterion is activated, the fixed frame length and maximum number of characters will respond in the same way.

Message length in the message

When data is received, the frame end is detected when the frame length sent with the received frame has been reached.

The following parameters define the characters to be used for evaluation of the message length:

- **Offset of length field in message**

  In the message, the value defines the position of the character that is to be used to determine the message length.

  You can set values from 0 to 4095 characters, depending on the buffer size.

- **Size of length field**

  This value specifies the number of characters as of the first evaluation position to be used to determine the message length.

  You can set values of 1, 2 and 4 characters.

- **Number of characters not counted in length specification**

  Number of characters appended to the frame without counting towards the frame length. This value defines the number of bytes at the end of the frame which should not be included in the evaluation of the message length.

  You can set values from 0 to 255 characters.

Example:

Parameter assignments for "Message length in the message"

Offset of length field in message:	3rd byte ("2" has to be configured as offset)
Size of length field:	1 byte
Number of characters not counted in length specification:	3 bytes

Message					Number of characters not counted in length specification		
Start character	Address	Length field			Checksum	End delimiter	
Byte 1	Byte 2	Byte 3	Byte ...	Byte X	Byte X+1	Byte X+2	Byte X+3

End sequence

When data is received, the end of the frame is identified when the configured end sequence (max. 5 characters) is received. The end sequence which is up to 5 characters long can also contain "don't care characters". The received data is applied by the CPU, including the end sequence.

If you are working with the end sequence, transmission is not code-transparent and you must exclude the presence of end code in the user data.

4.2.4 Code transparency

Code transparency

Code-transparent means that any character combinations can occur in the user data without the end criterion being recognized.

The code transparency of the procedure depends on the selection of the configured end criterion and flow control:

- With specified end sequence or using XON/XOFF flow control
  - Not code-transparent
- End criterion character delay time, fixed frame length, maximum frame length, message timeout, or response timeout and message length in the message
  - Code-transparent

4.2.5 Receive buffer

Receive buffer of the module

The communication modules have a receive buffer that stores the received frames temporarily until they are transmitted to the CPU. The receive buffer is implemented as a ring buffer, which means the frames are transmitted to the CPU in the order in which they were received until the receive buffer is full. If additional frames are received once the buffer is full, the oldest frame is overwritten. If "Prevent overwriting" was configured, a corresponding message is generated when the receive buffer is full. All further frames are rejected until the receive buffer is ready to receive new ones.

During the parameter assignment, you can specify whether the receive buffer should be deleted during startup. You can also specify the range of values (1 to 255) for the number of buffered receive frames.

The receive buffer of the module may have a size of up to 8 KB, depending on the communication module used (see chapter Introduction (Page 9)). The frame has a maximum length of 4 KB. This means that each communication module is capable of buffering at least two frames.

If you always want to transfer the last frame received to the CPU, you must set the value "1" for the number of buffered frames and deactivate overwrite protection.

Note

If continuous reading of the received data in the user program is interrupted for a certain time, you may find when the receive data is requested again, that the communication module first sends older frames before the CPU receives the most recent one. At the time of interruption, the old frame had already been transmitted from the receive buffer of the communication module and prepared for transmission to the CPU.

4.3 Communication using 3964(R)

4.3.1 Data transmission with 3964(R) procedure

Introduction

The 3964(R) procedure controls point-to-point data exchange between the communication module and a communication partner. and contains both the physical layer (layer 1) and the link layer (layer 2).

Instructions are available for communication with a communication partner (see Programming - communication using instructions (Page 53)).

4.3.2 Control characters

Introduction

During data transmission, the 3964(R) procedure adds control characters to the information data (link layer). The communication partner can use these control characters to check whether it has received all data completely and without errors.

Control characters of the 3964(R) procedure

The 3964(R) procedure evaluates the following control characters:

STX	Start of Text	Beginning of the character string to be transmitted	02H
DLE	Data Link Escape	Data transmission changeover	10H
ETX	End of Text	End of the character string to be transmitted	03H
NAK	Negative Acknowledge	Negative acknowledgment	15H
BCC	Block Check Character (only with 3964R)	Block check character	

BCC is formed and monitored automatically in the communication module. The block check character is not transmitted as frame content to the CPU.

Note

If the DLE character is transmitted as an information character within a frame, it is sent twice (DLE duplication) to distinguish it from the DLE control character during connection establishment and termination. The receiver reverses the DLE duplication.

Priority

With the 3964(R) procedure, one communication partner must be assigned a higher and the other a lower priority. If both partners start to establish a connection at the same time, the partner having lower priority will cancel its send job.

4.3.3 Block check character

Block check character

With the 3964R transfer protocol, data security is enhanced by sending an additional block check character (BCC = Block Check Character).

The block check character is the even longitudinal parity (EXOR logic operation of all data bytes) of a sent or received block. Its calculation begins with the first byte of user data (first byte of the frame) after the connection establishment, and ends after the DLE ETX character at connection termination.

Note

With DLE duplication, the DLE character is included twice in the BCC calculation.

4.3.4 Sending data with 3964(R)

Connection establishment for sending

The 3964(R) procedure sends the STX control character to set up the connection. If the communication partner responds with the DLE character before the acknowledgment delay time expires, the procedure switches to send mode.

If the communication partner answers with NAK or any other character (except for DLE or STX), or the acknowledgment delay time expires without a response, the procedure tries to set up the connection again. After the configured number of unsuccessful setup attempts, the procedure cancels the connection setup and sends the NAK character to the communication partner. The communication module outputs a corresponding error message.

Sending data

If the connection is successfully established, the user data contained in the output buffer of the communication module is sent to the communication partner with the selected transmission parameters (a DLE recognized in the user data is doubled during the send job). The communication partner monitors the time intervals between the incoming characters. The interval between two characters must not exceed the character delay time. Monitoring of the character delay time starts immediately after the connection has been established.

If the communication partner sends the NAK character during an active send operation, the procedure cancels the block and repeats it as described above, beginning with connection establishment. If a different character is sent, the procedure first waits for the character delay time to expire and then sends the NAK character to set the communication partner to idle state. Then, the procedure restarts sending with the connection setup STX.

Connection termination during sending

Once the contents of the buffer have been sent, the procedure appends the DLE and ETX characters and (only with 3964R) the block checksum BCC as the end identifier, and then waits for an acknowledgment character. If the communication partner sends the DLE characters within the acknowledgment delay time, the data block has been received without errors. If the communication partner responds with NAK, any other character (except DLE), or with a corrupted character, or if the acknowledgment delay time expires without a response, the procedure restarts sending with the connection setup STX.

After the configured number of attempts to send, the procedure stops the process and sends an NAK to the communication partner. The communication module outputs a corresponding error message.

4.3.5 Receiving data with 3964(R)

Connection setup for receiving

In idle state, when there is no send job to be processed, the procedure waits for the communication partner to set up the connection.

A wait time is started (wait time = acknowledgment delay time - 10 ms, however, maximum of 400 ms) if no free receive buffer is available during the connection setup with STX. An error message is generated if no free receive buffer is available on expiration of this time. The procedure sends the NAK character and returns to the idle state. Otherwise, the procedure sends a DLE and receives the data as described above.

The acknowledgment delay time should be set to the same value at both communication partners.

If the procedure receives any character (except for STX or NAK) while in idle state, it waits for the character delay time (CDT) to expire and then sends the NAK character. The communication module outputs a corresponding error message.

Receiving data

After a successful connection establishment, the incoming receive characters are saved to the receive buffer. If two consecutive DLE characters are received, only one of these is saved to the receive buffer.

After connection has been established and after each receive character, the procedure waits for the next character during the character delay time. If this period expires before another character is received, an NAK is sent to the communication partner. The communication module outputs a corresponding error message. A retry is then expected.

If transmission errors occur during receiving (frame errors, parity errors, etc.), the procedure continues to receive data until the connection is terminated and then sends an NAK to the communication partner. A retry is then expected. If the block still cannot be received without errors after the specified number of transfer attempts, or if the communication partner does not start the retry within a block wait time of 4 seconds, the procedure cancels the receive operation. The communication module reports the first corrupted transfer and the final cancelation.

Connection setup for receiving

If the 3964 procedure detects a DLE ETX string, it terminates the receive operation and confirms a successfully received block by sending a DLE to the communication partner. In the case of a receive error, an NAK is sent to the communication partner. A retry is then expected.

The 3964R procedure terminates the receive operation after having detected the DLE ETX BCC string. It compares the received block check character BCC with the internally calculated longitudinal parity. If the BCC is correct and no other receive errors have occurred, the 3964R procedure sends a DLE and returns to the idle state. The communication module informs the control system that new receive data is available.

If the BCC is faulty or a different receive error occurs, an NAK is sent to the communication partner. A retry is then expected.

4.4 Communication using USS

4.4.1 Overview of USS communication

Position in the system environment

The following USS description refers to the use of the corresponding communication modules.

- CM PtP RS232 BA
- CM PtP RS422/485 BA
- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Introduction

The USS® protocol (Universal Serial Interface Protocol) is a basic serial data transmission protocol designed to meet the requirements of drive technology.

The USS protocol defines an access method based on the master-slave principle for communication via a serial bus. One master and up to 16 drives (slaves) can be connected to the bus. The individual drives are selected by the master using an address character in the frame. A drive can never send anything without first being initiated by the master. Therefore, direct data transmission between individual drives is not possible. Communication functions in half-duplex mode. The master function cannot be transferred.

Drive technology requires specific response times for the control tasks and therefore strict cyclical frame traffic:

The master continuously sends frames (job frames) to the drives and expects a response frame from each addressed drive.

A drive must send a response frame if

- it has a received a frame without errors and
- it was addressed in this frame.

A drive may not send if these conditions are not met or the drive was addressed in the broadcast.

The connection with the respective drives exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

frame structure

Each frame begins with a start character (STX), followed by the length specification (LGE) and the address byte (ADR). The data field comes after that. The frame ends with the block check character (BCC). The frame length includes the user data (quantity n), the address byte (ADR) and the data verification character (BCC).

STX	LGE	ADR	1	2	...	N	BCC

For single-word (16-bit) data, the high byte is sent first followed by the low byte. Correspondingly, with double-word data the high word is sent first, followed by the low word. The length of a frame is specified in bytes.

Data encryption

The data is encrypted as follows:

- STX: 1 byte, start of text, 02H
- LGE: 1 byte, contains the frame length as a binary number
- ADR: 1 byte, contains the slave address and frame type in binary code
- Data fields: One byte each, content depending on job
- BCC: 1 byte, block check character

Data transmission procedure

The master ensures cyclic data transmission in frames. The master addresses all slave devices one after another with a job frame. The nodes addressed respond with a response frame. In accordance with the master-slave procedure, the slave must send the response frame to the master after it has received the job frame. Only then can the master address the next slave.

Data field in the frame

The data field is divided into two areas: the parameter area (PKW) and the process data area (PZD).

STX	LGE	ADR	Parameter (PKW)	Process data (PZD)	BCC

- **Parameter area** (PKW)

  The PKW area handles parameter transmission between two communication partners (e.g., controller and drive). This involves, for example, reading and writing parameter values and reading parameter descriptions and the associated text. The PKW interface generally contains jobs for operation and display, maintenance and diagnostics.

- **Process data area** (PZD)

  The PZD area consists of signals that are required for automation:

  – Control words and setpoints from the master to the slave

  – Status words and actual values from the slave to the master

  The contents of the parameter area and process data area are defined by the slave drives.

  For additional information on this, refer to the drive documentation.

4.4.2 Overview of functions

Transmission sequence

The instructions process the data transmission cyclically with up to 16 drive slaves. Only one job is active for each drive at any one time.

Performance features:

- Creation of data storage areas for communication, depending on the bus configuration
- Execution and monitoring of PKW jobs
- Monitoring of the complete system and troubleshooting
- Communication with the CPU
- Access to the drive functions
- Reading the drive parameters
- Writing the drive parameters

4.5 Communication through Modbus RTU

4.5.1 Overview of modbus communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the electrical RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which the entire communication is triggered by only one master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only this slave address responds to the command (exception: broadcast frames to slave address 0 which are not acknowledged by the slaves).

The procedure used is a code-transparent, asynchronous half-duplex procedure. Data transmission is carried out without handshake.

Position in the system environment

The following Modbus description refers to the use of the corresponding communication modules.

- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Function of the coupling

With the corresponding communication modules and the related instructions, you can establish a communication connection between a remote Modbus control system and a SIMATIC S7.

The GOULD-MODBUS protocol in RTU format is used for transmission.

Function codes 01, 02, 03, 04, 05, 06, 08, 15 and 16 are used for communication between a communication module operated as a Modbus slave and a master system (see Function Codes (Page 50)).

If a SIMATIC S7 communication module is operated as a Modbus master, function codes 11 and 12 are also available.

SIMATIC S7 as a Modbus slave

The master has the initiative for transmission, the communication module works as a slave.

frame traffic from slave to slave is not possible.

The instruction Modbus_Slave makes the data available on a SIMATIC data area in accordance with the mapping specification or stores them.

SIMATIC S7 as a Modbus master

As master, the communication module initiates transmission and, after outputting a request frame, it waits for the configured response monitoring time for a response frame from the slave. If the slave does not respond, the master repeats the request in accordance with the configuration before it outputs an error message.

frame structure

The data exchange "Master-Slave" and/or "Slave-Master" begins with the **slave address**, followed by the **function code**. Then the data are transferred. The structure of the data field depends on the function code used. The CRC check is transmitted at the end of the frame.

ADDRESS	FUNCTION	DATA	CRC-CHECK
Byte/Word	Byte	n byte	2 byte

ADDRESS	Modbus slave address • Standard address: 1 to 247 (bytes) • Extended station address: 1 to 65535 (word)
FUNCTION	Modbus Function Codes (Page 50)
DATA	frame data: Management and net data depending on the function code
CRC-CHECK	frame checksum

Slave address

The slave address can be range from 1 to 247 (byte) or 1 to 65535 (word). The address is used to address a defined slave on the bus.

Broadcast Message

The master uses slave address 0 to address all slaves on the bus.

Broadcast messages are only permitted in conjunction with writing Function codes 05, 06, 15 and 16.

A broadcast message is not followed by a response frame from the slave.

Data Field DATA

The data field DATA is used to transfer the function code-specific data such as:

- Bytecount, Coil_Startaddress, Register_Startaddress; Number_of_Coils, Number_of_Registers, ...

  For details, see "Function Codes (Page 50)".

CRC-Check

The end of the frame is identified by means of the CRC 16 checksum consisting of 2 bytes. It is calculated by the following polynominal: $x^{16} + x^{15} + x^2 + 1$.

The low byte is transmitted first, followed by the high byte.

End of frame

The end of frame is recognized when no transmission takes place during the time period required for the transmission of three and a half characters (3.5 times character delay time) (see Modbus Protocol Reference Guide).

This end of frame TIME_OUT therefore depends on the data transmission rate and is indicated in bit times (35 bit times are fix coded internally; further bit times can be configured in addition at the instruction).

The Modbus frame received from the connection partner is evaluated and formally checked after the end of frame TIME_OUT is received.

Exception responses

On recognition of an error in the request frame from the master, for example, register address illegal, the slave sets the highest value bit in the function code of the response frame.

This step is followed by transmission of a byte exception code that describes the cause of the error.

A detailed description of the meaning of the above-mentioned parameters is available in the "GOULD MODICON Modbus Protocol" (not part of this documentation).

Exception code frame

The exception code frame from the slave has the following structure:

- for example, slave address 5, function code 5, exception code 2

Response frame from the slave EXCEPTION_CODE_xx:

05H	Slave address
85H	Function code
02H	Exception code (1...7)
xxH	CRC checksum "Low"
xxH	CRC checksum "High"

On receipt of an exception code frame by the driver, the current job is completed with error.

The following error codes are defined in accordance with the Modbus specification:

Error code	Meaning in accordance with Modbus specification	Cause - Short Description *
1	Illegal function	Illegal function code
2	Illegal data address	Slave has illegal data address
3	Illegal data value	Slave has illegal data value
4	Failure in Associated Device	Slave has internal error
5	Acknowledge	Function is carried out
6	Busy, Rejected message	Slave is not ready to receive
7	Negative acknowledgement	The function cannot be carried out.
* Check slave for further details.		

RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 HF
- CM PtP (ET 200SP)

For more information on RS232 mode, see the chapter RS232 mode (Page 19).

For information on hardware data flow control and on automatic operation of the accompanying signals, refer to the Handshake procedure (Page 23) chapter.

RS422/485 mode

The following communication modules support RS422/485 mode:

- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

For more information on RS422/485 mode, see the chapters RS422 mode (Page 21) and RS485 mode (Page 22).

4.5.2 Function Codes

Used function codes

The function code defines the meaning of the frame. It also defines the structure of a frame.

The following function codes are supported by the communication module:

Function code	Function in accordance with MODBUS specification	Range
01	Read Coil Status	1 to 2000 bit/request
02	Read Input Status	1 to 2000 bit/request
03	Read Holding Registers	1 to 124/125 bit/request (124 at extended station address)
04	Read Input Registers	1 to 124/125 bit/request (124 at extended station address)
05	Force Single Coil	1 bit/request
06	Preset Single Register	1 word/request
08 *	Loop Back Test	Read slave status or reset event counter in the slave
11 *	Fetch Communications Event Counter (only master)	-
15	Force Multiple Coils	1 to 1968 bits/request
16	Preset Multiple Registers	1 to 123 bit/request

* Diagnostic information for slave communication

Modbus function code 00 sends a broadcast message to all slaves (without slave response).

Assignment of the Modbus addresses to the SIMATIC addresses

The table below shows the assignment of the Modbus addresses to the SIMATIC addresses.

Modbus				S7-1500	
FC [1]	Function	Declaration	Address area	Declaration	CPU address
01	Read bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.6
02	Read bits	Input	10001 - 19999	Process image of inputs	I0.0 - 1248.6
03 [2]	Read words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU
04	Read words	Input	30001 - 39999	Process image of inputs	IW0 to IW19996
05 [2]	Write bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.7
06	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU
15	Write bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.6
16 [2]	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU

1) FC = function code

2) The value of the HR_Start_Offset determines whether data areas or bit memory address areas can be addressed with the FCs 03, 05 and 16 in the SIMATIC CPU.

Programming - communication using instructions 5

5.1 Overview of point-to-point programming

Data exchange using Freeport or 3964(R) communication

You must make the send data available in data blocks or in the bit memory address area in the user program of the corresponding CPU. A receive buffer is available in the communication module for the receive data. A corresponding data block is set up in the data block.

In the user program of the CPU, the instructions Send_P2P and Receive_P2P carry out the data transfer between the CPU and the communication module. The receive buffer can be deleted with the instruction Receive_Reset.

Dynamic configuration by means of the user program

As an alternative to or in addition to the parameter assignment of the communication module interface described in chapter Configuring / parameter assignment of a communication module (Page 29), it may be advisable in certain application areas to set up the communication dynamically, i.e., program-controlled by a specific application.

All configurations carried out in the properties dialog of the communication module can also be changed during runtime by means of the corresponding "Config" instructions (Port_Config, Send_Config, Receive_Config, P3964_Config).

Program calls for point-to-point communication - sequence

The figure below shows the function of the point-to-point instructions for communication between the user program and communication partner.

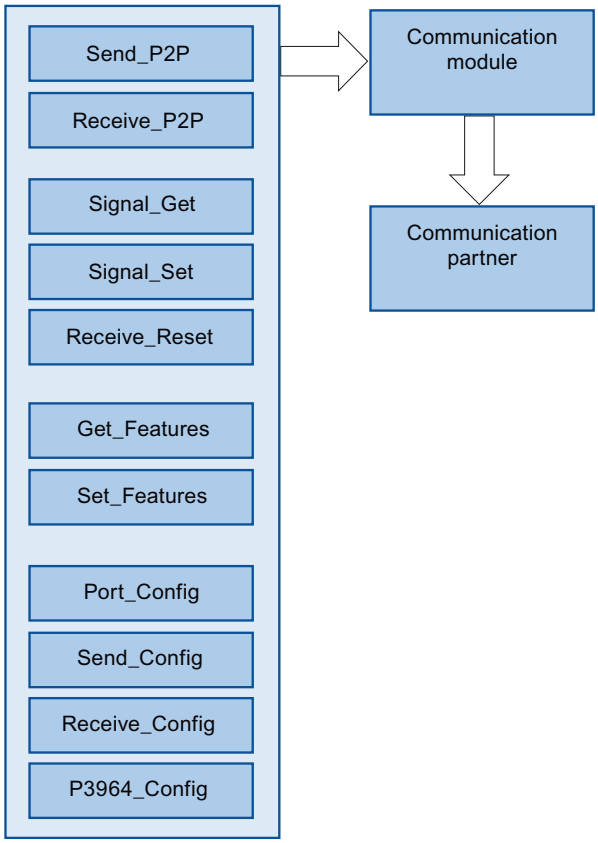


Figure 5-1 Program sequence

PtP instructions

- Instructions for dynamic parameter assignment
  - Port_Config

    You can use the Port_Config instruction (port configuration) to configure basic interface parameters, such as the data transmission rate, parity and data flow control dynamically through your user program.
  - Send_Config

    With the instruction Send_Config (send configuration) you can configure serial send parameters, such as RTS ON-/RTS OFF delay, dynamically for a point-to-point communication interface.
  - Receive_Config

    The instruction Receive_Config (receive parameter assignment) allows you to dynamically assign serial receive parameters to a communication module.

    This instruction configures the conditions that specify the start and the end of a received message.
  - P3964_Config

    The instruction P3964_Config (configure protocol) can be used to dynamically configure protocol parameters of the procedure 3964(R), such as character delay time, priority and block check using your program.
- Instructions for data exchange (communication)
  - Send_P2P

    The instruction Send_P2P (send point-to-point data) can be used to send data to the communication partner.

    Call up the instruction Send_P2P to send data using the Freeport protocol. You have to call the instruction cyclically until you receive a corresponding acknowledgement at the output parameters of the instruction.

    Note: During parameter assignment of the XON/XOFF data flow control, user data may not contain any of the configured XON or XOFF characters. Default settings are DC1 = 11H for XON and DC3 = 13H for XOFF.
  - Receive_P2P

    The instruction Receive_P2P (receive point-to-point data) can be used to pick up the messages received in the communication module from a communication partner.

    Call the instruction Receive_P2P cyclically to receive data using the Freeport protocol. The instruction indicates at the NDR parameter if new received data is available.

    To signal the start and end of a message transmission, you need to define criteria in the Freeport protocol which identify the start and end of the message.
  - Receive_Reset

    The instruction Receive_Reset (delete receive buffer) allows you to clear the receive buffer of the communication module.

- Instructions for operation of the RS232 signals
  - Signal_Get

    With the Signal_Get instruction (get RS232 signals) you can read the current states of the RS232 signals.
  - Signal_Set

    With the instruction Signal_Set (get RS232 signals), you can set the states of the RS232 signals DTR and RTS.
- Instructions for advanced functions
  - Get_Features

    You can use the instruction Get_Features (get extended functions) to get information on the Modbus support and on generating diagnostic alarms.
  - Set_Features

    If supported by the module, you can use the instruction Set_Features (set extended functions) to activate the generation of diagnostic alarms.

Procedure for setting up Freeport or 3964(R) communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions Send_P2P and Receive_P2P and drag-and-drop them into a network of the Main (OB1).
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

Additional information

You can find a list of available instructions in chapter Overview of instructions (Page 13).

Information about the instructions is available in the info system of STEP 7 V12.

5.2 Overview of USS programming

Program calls for USS communication - sequence

The figure below shows the function of the USS instructions for communication between user program and USS drive. (The instructions Send_P2P, Receive_P2P and the Config instruction are required downstream).

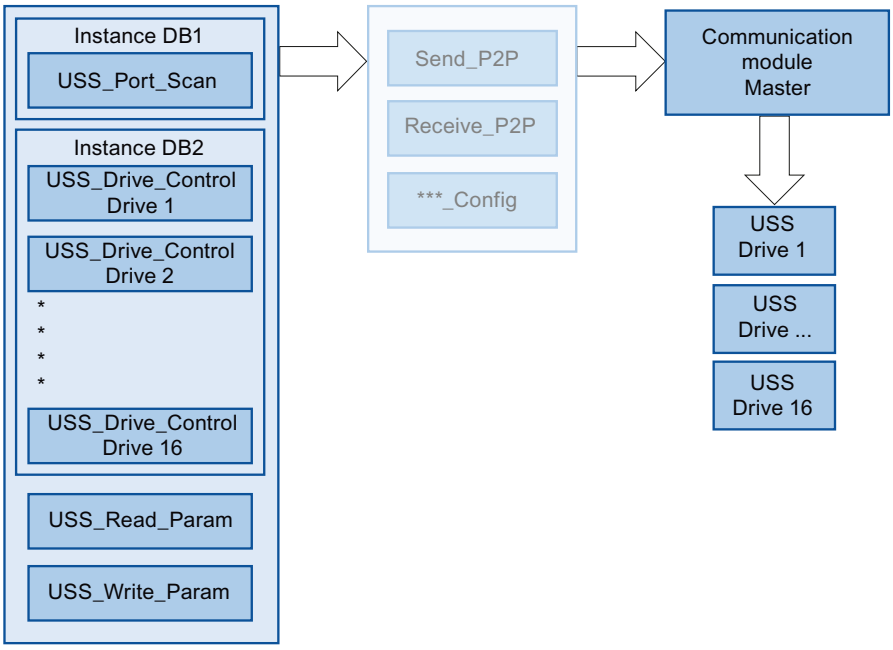


Figure 5-2 Program sequence

USS instructions

- USS_Port_Scan:

  The instruction USS_Port_Scan allows you to communicate via a communication module with up to 16 drives using a USS network (must be called cyclically).

  The instruction USS_Port_Scan controls the communication between CPU and the drives by means of the PtP communication port. A communication with the drive is processed every time you call this function. The instruction USS_Port_Scan is required once:

  Since most drives features a configurable internal function that monitors the integrity of the communication based on a timeout, the instruction USS_Port_Scan should be called from a time-controlled OB.

- USS_Drive_Control:

  The instruction USS_Drive_Control allows you to prepare the send data for a drive and to display the receive data.

  The inputs and outputs of the instruction correspond to the states and operating functions of the drive. The instruction USS_Drive_Control must be called once for each drive. Only one common instance DB is required for all calls of the instruction USS_Drive_Control for a USS network. Interconnect all calls of the instructions USS_Drive_Control for a USS network with the same instance DB.

  The instruction USS_Drive_Control should be called from the cyclic Main (OB1) of the main program.

- USS_Read_Param:

  The instruction USS_Read_Param allows you to read parameters from the drive.

  You use the USS_Read_Param instruction to read the operating parameters of the drive that control the internal drive functions.

  The instruction USS_Read_Param should be called from the cyclic Main (OB1) of the main program.

- USS_Write_Param:

  The instruction USS_Write_Param allows you to change parameters in the drive.

  The instruction USS_Write_Param should be called from the cyclic Main (OB1) of the main program.

Procedure for setting up USS communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project tree for the CPU, select the "Program blocks" folder and open the desired time-controlled OB by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instruction USS_Port_Scan and drag-and-drop it into a network of a time-controlled OB.

   The instruction USS_Port_Scan allows you to communicate by means of the USS network.
3. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
4. From the "Instructions" task card, "Communication" area select the instructions for USS communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction USS_Drive_Control is used for data exchange with the drive.
   - The instruction USS_Read_Param is used for reading parameters from the drive.
   - The instruction USS_Write_Param is used for changing parameters in the drive.
5. Configure the instructions in accordance with your specifications.
6. Download the hardware configuration and the user program to the CPU.

Additional information

You can find a list of available instructions in chapter Overview of instructions (Page 13).

Information about the instructions is available in the info system of STEP 7 V12.

5.3 Overview of Modbus programming

Program calls for Modbus communication - sequence

The figure below shows the function of the Modbus instructions for communication between user program and Modbus device. (The instructions Send_P2P, Receive_P2P and the Config instruction are required downstream).

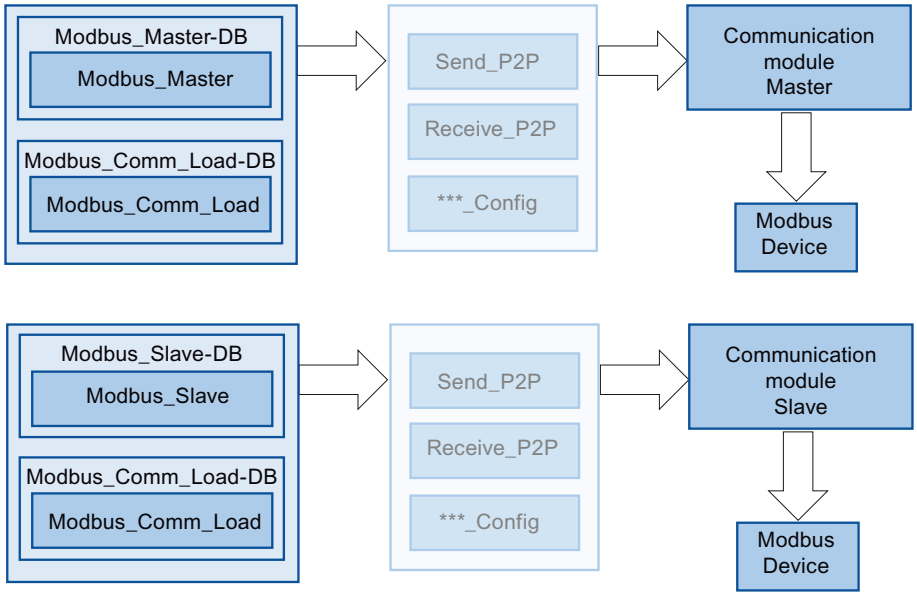


Figure 5-3 Program sequence

Modbus instructions

- Modbus_Comm_Load:

  The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU.

  You have to run Modbus_Comm_Load to set up PtP port parameters, such as data transmission rate, parity and flow control. Once you have configured the interface for the Modbus RTU protocol, it can only be used by the instruction Modbus_Master or the instruction Modbus_Slave .

- Modbus_Master:

  The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.

  The CPU can be used as Modbus RTU master device with the Modbus_Master instruction for communication with one or several Modbus slave devices.

- Modbus_Slave:

  The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

  The CPU can be used as Modbus RTU slave device with the Modbus_Slave instruction for communication with one Modbus master device.

Note

Alternative use of Modbus_Slave and Modbus_Master

A communication module can be operated either as master or as slave.

Procedure for setting up Modbus communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions for Modbus communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction Modbus_Comm_Load configures the port of the communication module for Modbus communication.

     The Modbus_Comm_Load must be called in Main (OB1) until DONE (or ERROR) is reported.
   - The instruction Modbus_Master is used for the Modbus master functionality.
   - The instruction Modbus_Slave is used for the Modbus slave functionality.
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

Additional information

You can find a list of available instructions in chapter Overview of instructions (Page 13).

Information about the instructions is available in the info system of STEP 7 V12.

Startup and Diagnostics 6

6.1 Startup characteristics

Operating mode transitions

After the communication module starts up, all data between the CPU and the communication module is exchanged by means of instructions.

CPU STOP During a running data transmission communication module - CPU, both a send and a receive job is aborted.

CPU RUN Send and receive operation is ensured in the RUN state of the CPU.

With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

From the view of the communication module, there are no further operating states/operating state transitions.

6.2 Diagnostic functions

Introduction

The diagnostic functions of the communication module allow errors that have occurred to be located quickly. The following diagnostic options are available to you:

Diagnostics by means of the display elements of the communication module	The indicators provide information on the operating mode or the possible error states of the communication module. The indicators provide an initial overview of any internal or external errors and interface-specific errors. For more information refer to the device manual of the corresponding communication module.
Diagnostics via the STATUS output of the instructions	Instructions have a STATUS output for error diagnostics; it provides information about communication errors between the communication module and the CPU. You can evaluate the STATUS parameter in the user program (it is active for exactly one cycle).
Diagnostic error interrupt	The communication module can trigger a diagnostic error interrupt on the CPU assigned to it. The communication module makes diagnostic information available. The analysis of this information is made via the user program or by reading the CPU diagnostics buffer.

6.3 Error messages

Overview of error messages - PtP

The error messages are output at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Remedy
0x0000	No error	-
RECEIVE status and error codes		
0x0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
0x0095	frame end identified based on "Message timeout"	-
0x0096	frame end identified based on expiration of the "Character delay time"	-
0x0097	The frame was aborted because the maximum response time was reached.	-
0x0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
0x0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
0x7000	Block idle	-
0x7001	Initial call for a new frame: Data transmission initiated	-
0x7002	Interim call: Data transmission running	-
0x8085	Invalid length	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
0x8088	The specified length exceeds the range set in the receive buffer. Note: If the data type STRING has been specified at the BUFFER parameter, this error code will also appear if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
RECEIVE status and error codes		
0x8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)

Error code	Description	Remedy
Error message codes of the special functions		
0x818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following numbers are valid: 0-2047
0x8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
0x8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostic error interrupt". The following are valid: Diagnostic error interrupt deactivated or diagnostic error interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
0x81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
0x81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).
0x81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
0x81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
0x81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
0x81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
0x81A7	Invalid valid for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF(XOFFCHAR). Valid range of values: 0...255

Error code	Description	Remedy
0x81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint slave) (3) • Half duplex (RS485) two-wire mode (4)
0x81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
0x81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
0x81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
0x81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
0x81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.

Error code	Description	Remedy
Error codes of the "Receive configuration"		
0x81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
0x81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Receiving data with Freeport (Page 32)).
0x81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
0x81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
0x81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
0x81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
0x81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1024/2048/4096 (Byte) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
0x81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
0x81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1-65535 (bit times)
0x81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
0x81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.

Error code	Description	Remedy
0x81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
0x81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
0x81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
0x81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
0x81D2	"Hardware RTS always ON": Send command aborted due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
0x81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
0x81D5	Transmission aborted due to parameter changes, detected wire break, or because CPU in STOP	Check the parameter assignment, for wire break, and the CPU status.
0x81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end characters and the frame of the communication partner.
0x81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
0x81D8	Transmission attempt rejected because module is not configured	Configure the module.
Error codes of the receive configuration		
0x81E0	Frame aborted: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
0x81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
0x81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
0x81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
0x81E4	Frame aborted: The total length of "Offset in the message + size of the length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of the length field, and number of characters not counted.
0x81E5	Frame aborted: Break	Receive line to partner is interrupted. Reconnect or switch on partner.

Error code	Description	Remedy
0x81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
0x81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
0x81E9	Modbus CRC error (only communication modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
0x81EA	Modbus frame too short (only communication modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
0x81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (Byte) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
0x81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
0x81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
Error codes of the receive configuration		
0x8201 1)	BUFFER is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
0x8225	BUFFER points to an optimized memory area greater than 1 kB or BUFFER points to an optimized memory area and the receive length is greater than the area addressed by BUFFER.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 kByte • Non-optimized area: 4 kByte Note: If the pointer points to an optimized memory area, do not send more than 1 kByte.
0x8229 1)	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes, general		
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter You will find more detailed information on error causes in the RDREC.STATUS static parameters and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You will find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC.
0x8282	Module not available	Check the input at the parameter PORT and ensure that the module can be reached.

Error code	Description	Remedy
Error codes of the receive configuration		
0x82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1-255
0x82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
0x8301 1)	BUFFER is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
0x8322	Range length error when reading a parameter	Check the input at the BUFFER parameter
0x8324	Range error when reading a parameter	Check the input at the BUFFER parameter
0x8328	Setting error when reading a parameter	Check the input at the BUFFER parameter
Error codes of the send configuration		
0x8328 1)	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
0x8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
0x833A	The designation of the data block at the BUFFER parameter refers to a data block which is not loaded.	Check the input at the BUFFER parameter
0x8351	Invalid data type	Check the input at the BUFFER parameter
0x8352 1)	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
0x8353 1)	Receive_Conditions does not point to a structure of the type Receive_Conditions	Check the pointer to Receive_Conditions
Error codes 3964(R) protocol		
0x8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1-65535 (ms)
0x8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1-65535 (ms)
0x8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
0x8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
0x8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1-255

Error code	Description	Remedy
0x8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1-255
0x8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
0x8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
0x8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before this (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x838A	Runtime error: Logical error during receiving. Another character (other than DLE, ETX) was received after receipt of DLE.	Check whether the partner DLE in the frame header and in the data string is always in duplicate or the connection is released with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.
0x838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
0x838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
0x838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
0x838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
0x8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.

1) Only with instructions for S7-300/400 CPUs

Overview of error messages - Modbus

Error code	Description	Remedy
0x0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
0x8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
0x8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
0x8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
0x8184	Invalid value for "Response timeout".	Select a valid value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1-65535 (ms)
0x8280	Negative acknowledgment when reading module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_Config.RDREC.STATUS, Receive_Config.RDREC.STATUS or RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_Config.WRREC.STATUS, Receive_Config.WRREC.STATUSor WRREC.STATUS , and in the description of the SFB WRREC.
0x8282	Module not available	Check the input at the parameter PORT and ensure that the module can be reached.

Error code	Description	Remedy
Configuration error - Modbus_Slave		
0x8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address range; 1-65535 at extended address area (0 is reserved for broadcast)
0x8187	Invalid value at the MB_HOLD_REG parameter	Select a suitable value for the holding register at the MB_HOLD_REG parameter.
0x8188	Invalid operating mode or broadcast (MB_ADDR = 0) and parameter MODE ≠ 1	Select the value 1 for MODE in broadcast operating mode or select a different operating mode.
0x818C	The pointer to an MB_HOLD_REG area must be a data block or a flag area.	Select a valid value for the pointer to the MB_HOLD_REG area.
0x8280	Negative acknowledgment when reading module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC.
0x8452 1)	MB_HOLD_REG is not a pointer to a DB or a flag area	Check the pointer MB_HOLD_REG
0x8453 1)	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the pointer MB_HOLD_REG
0x8454 1)	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the pointer MB_HOLD_REG
0x8455 1)	MB_HOLD_REG points to a write-protected DB	Check the pointer MB_HOLD_REG
0x8456 1)	Error during instruction execution. The cause of the error is shown in the static parameter STATUS.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.

Error code	Description	Remedy
Configuration error - Modbus_Master		
0x8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
0x8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address range; 1-65535 at extended address area (0 is reserved for broadcast)
0x8188	Invalid operating mode or broadcast (MB_ADDR = 0) and parameter MODE ≠ 1	Select the value 1 for MODE in broadcast operating mode or select a different operating mode.
0x8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master in the Info system
0x818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master in the Info system
0x818B	Invalid valid for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (flag or DB address). See description Modbus_Master in the Info system
0x818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
0x818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the pointer DATA_PTR
0x8280	Negative acknowledgment when reading module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS, Receive_P2P.WRREC.STATUS or Receive_Reset, and in the description of the SFB WRREC.

Error code	Description	Remedy
Communication errors - Modbus_Master and Modbus_Slave		
0x80 D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
0x80D2	"Hardware RTS always ON": Send command aborted due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
0x80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
0x80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
0x80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
0x80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.
0x80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
Communication error - Modbus_Master		
0x80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
0x8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communication modules that support Modbus)		
0x8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
0x8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.
0x8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
0x8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
0x8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
0x8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 0x0000 and 0x000A.

Error code	Description	Remedy
Protocol error - Modbus_Master (only communication modules that support Modbus)		
0x8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
0x8381	Response frame from Modbus Slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
0x8382	Response frame from Modbus Slave with the following error message: Invalid length	Select a suitable data length.
0x8383	Response frame from Modbus Slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
0x8384	Response frame from Modbus Slave with the following error message: Data value error	Check the request frame to the Modbus slave.
0x8385	Response frame from Modbus Slave with the following error message: The diagnostic value is not supported by the Modbus slave	Modbus slaves only support the diagnostic values 0x0000 and 0x000A.
0x8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
0x8387	A slave that was not requested answers	Check the response frame of the slave. Check the address settings of the slave.
0x8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
0x8828 [1)]	DATA_PTR points to a bit address which is not equal to n * 8	Check the pointer DATA_PTR
0x8852 [1)]	DATA_PTR is not a pointer to a DB or a flag area	Check the pointer DATA_PTR
0x8853 [1)]	DATA_PTR is not a pointer of type BOOL or WORD	Check the pointer DATA_PTR
0x8855 [1)]	DATA_PTR points to a write-protected DB	Check the pointer DATA_PTR
0x8856 [1)]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communication modules that support Modbus)		
0x8428 [1)]	MB_HOLD_REG points to a bit address which is not equal to n * 8	Check the pointer MB_HOLD_REG
0x8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a flag area	Check the pointer MB_HOLD_REG
0x8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the pointer MB_HOLD_REG
0x8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the pointer MB_HOLD_REG
0x8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the pointer MB_HOLD_REG
0x8456 [1)]	Error during call of SFC51	Call the Modbus_Slave instruction again

[1)] Only with instructions for S7-300/400CPUs

Overview of error messages - USS

Error code	Description	Remedy
0x0000	No error	-
0x8180	Length error in response of drive	Check the response frame of the drive.
0x8181	Data type error	Select a suitable data type. The following are valid: • Real • Word • Double word
0x8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
0x8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
0x8184	Checksum error in response of drive	Check the drive and the communication connection.
0x8185	Addressing error	Valid drive address range: 1 to 16
0x8186	Setpoint error	Valid setpoint range: -200 % to +200 %
0x8187	Incorrect drive number returned	Check the response frame of the drive.
0x8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6 words
0x8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
0x818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
0x818B	The drive does not respond.	Check the drive.
0x818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
0x818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
0x818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.

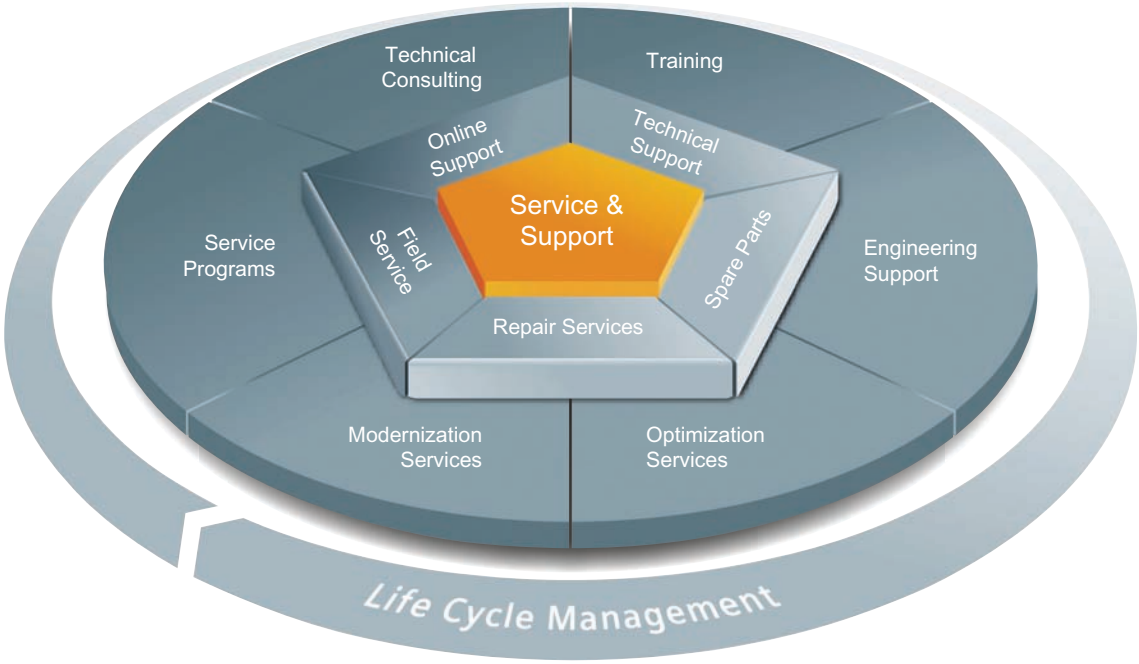
Error code	Description	Remedy
0x8280	Negative acknowledgment when reading module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT. parameter You will find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.

1) Only with instructions for S7-300/400 CPUs

Service & Support

A

A.1 Service & Support



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Our Field Service offers you services for commissioning and maintenance – to ensure that your machines and plants are always available.

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In every sector worldwide, plants and systems are required to operate with constantly increasing reliability. We will provide you with the support you need to prevent a standstill from occurring in the first place: with a worldwide network and optimum logistics chains.

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Downtimes cause problems in the plant as well as unnecessary costs. We can help you to reduce both to a minimum – with our worldwide repair facilities.

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During the service life of machines and plants, there is often a great potential for increasing productivity or reducing costs.

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Our service programs are select service packages for an automation and drives system or product group. The individual services are coordinated with each other to ensure smooth coverage of the entire life cycle and support optimum use of your products and systems.

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Examples of service programs:

- Service contracts
- Plant IT Security Services
- Life Cycle Services for Drive Engineering
- SIMATIC PCS 7 Life Cycle Services
- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

Benefits at a glance:

- Reduced downtimes for increased productivity
- Optimized maintenance costs due to a tailored scope of services
- Costs that can be calculated and therefore planned
- Service reliability due to guaranteed response times and spare part delivery times
- Customer service personnel will be supported and relieved of additional tasks
- Comprehensive service from a single source, fewer interfaces and greater expertise

Contact

At your service locally, around the globe: your partner for consultation, sales, training, service, support, spare parts... for the entire range of products from Industry Automation and Drive Technologies.

You can find your personal contact in our contacts database on the Internet (http://www.siemens.com/automation/partner).

Glossary

Automation system

An automation system is a programmable logic controller consisting of at least one CPU, various input and output modules, and operating and monitoring devices.

Communication module

Communication modules are used for point-to-point connections and bus links.

Configuring

Configuring refers to the configuration of separate modules of an automation system in the configuration table.

CPU

Central Processing Unit = Central module of the automation system that consists of the control and computing units, memory, system program, and interfaces to the I/O modules.

CTS

Clear to send. The communication partner is ready to receive data.

Cycle time

The cycle time is the time that the CPU requires to process the user program once.

Cyclic program processing

In cyclic program processing the user program runs in program loop, or cycle, that is constantly repeated.

Default setting

The default setting is a reasonable basic setting that can be used whenever no other value is specified.

Diagnostic events

Diagnostics events are, for example, module errors or system errors in the CPU that may be caused by a program error.

Diagnostic functions

The diagnostic functions cover the entire system diagnostics and include the recognition, interpretation and reporting of errors within the automation system.

Diagnostics buffer

Memory area in which detailed information on all diagnostics events is entered based on the order of their occurrence.

Hardware

Hardware is the entire physical and technical equipment of a automation system.

Module parameters

Module parameters are values with which the behavior of the module can be set.

Online/Offline

When you are online there is a data connection between the automation system and programming device, when you are offline there is no data connection between them.

Parameter assignment

Parameter assignment refers to the setting of a module's behavior.

Parameters

Parameters are values that can be allocated. There are two different types of parameters: block parameters and module parameters.

Point-to-point communication

In point-to-point communication the communication processor forms the interface between a programmable logic controller and a communication partner.

Procedure

Procedure refers to the process of a data transmission according to a specific protocol.

Protocol

All communication partners involved in data transmission must follow fixed rules for handling and implementing the data traffic. Such rules are called protocols.

Receive line initial state

The initial state of the receive line for RS422 and RS485 mode:

- enables break detection (wire break)
- ensures a defined level on the receive line while it is not sending.

RTS

Request to send. The communication module is ready to send.

Software

Software refers to the entirety of all programs that are used on a computing system. The operating system and user programs belong to this.

User program

The user program contains all instructions and declarations for processing the signals used for controlling a system or a process. In SIMATIC S7 the user program is structured and divided into small units, the blocks.

USS

The USS® protocol (universal serial interface protocol) defines an access method based on the master-slave principle for communication by means of a serial bus. The point-to-point connection is included as a subset in this protocol.

XON/XOFF

Software data flow control with XON/XOFF. You can configure the characters for XON and XOFF (any ASCII character). The user data may not contain these characters.

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SIEMENS

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SIMATIC

S7-1500
Web server

Function Manual

08/2013
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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation supports you in the operation of the Web server.

The Web server of the S7-1500 CPU offers, among other things, website access to diagnostic data and to process data of the CPU.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge in the field of automation technology
- Knowledge of the industrial automation system SIMATIC
- Experience of working with Windows-based computers
- Experience of working with STEP 7

Conventions

- This documentation contains illustrations of the Web server user interface. The user interface can deviate in details from the illustrations depending on the browser you use.
- The term "User-defined websites" used in the STEP 7 user interface refers to the "User pages" described in this documentation.

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Additional support

- The range of technical documentation for the individual SIMATIC products and SIMATIC systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Overview of additional documentation on the topic Web server

The table below includes additional documentation which supplements this description on the topic of Web servers.

Table 1- 1 Web Server documentation

Topic	Documentation	Most important contents
Overview information PROFINET	PROFINET (http://www.automation.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?InfoType=brochures&nodeKey=key_8097497) brochure	• Overview • Application examples • Hardware • Software
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	Configuring and programming with the engineering software
CPU	CPU 1511-1 PN (http://support.automation.siemens.com/WW/view/en/59402190)	• Block diagram • Wiring • Parameter assignment/addressing • Interrupts/diagnostic alarms • Technical specifications • Dimensional drawings
	CPU 1513-1 PN (http://support.automation.siemens.com/WW/view/en/59186494)	
	CPU 1516-3 PN/DP (http://support.automation.siemens.com/WW/view/en/59191914)	

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge on the Internet (http://support.automation.siemens.com).

General information 2

2.1 Properties of the Web server

Benefits of the Web server

The Web server lets you monitor and administer the CPU through authorized users by means of a network. This permits evaluation and diagnostics over long distances. Monitoring and evaluation is possible without STEP 7; all you need is a web browser. Make sure that you protect the CPU from being compromised through the use of different methods (e.g., limiting network access, using firewalls).

Activating the Web server

The Web server is deactivated in the delivery state of the CPU. This means that you must load a project in which the Web server is activated to enable access using the web browser.

Safety functions

The Web server provides the following security functions:

- Access via secure transmission protocol "https"
- User authorizations you can configure by means of user list
- Enabling for specific interfaces

Web browser

You need a web browser to access the HTML pages of the CPU.

The following web browsers have been tested for communication with the CPU:

- Internet Explorer (Version 8)
- Mozilla Firefox (Version 21)
- Mobile Safari (iOS5)

Note

Make sure HTTP caching is enabled in your browser when you access the CPU Web server by means of a communication processor (CP). Disabling HTTP caching in your browser can result in long access times and incomplete display.

Reading out information

You can read out the following information from the CPU with the Web server:

- Start page with general CPU information (Page 21)
- Identification information (Page 24)
- Content of the diagnostic buffer (Page 25)
- Module information (Page 26)
- Alarms (Page 33) (without acknowledgment option)
- Information about Communication (Page 35)
  - Important interface parameters
  - Display of the communication resources
- PROFINET- Topology (Page 37)
  - Display of the actual topology
  - Display of the set topology specified in configuration data
- User pages (Page 47)
- File browser (Page 71)

On the following pages you will find detailed information on the HTML pages.

Web access to the CPU via PG/PC, HMI devices and mobile terminal devices

Proceed as follows to access the Web server:

1. Use STEP 7 to download a project to S7-1500 in which the Web server is enabled.
2. Enable WLAN on the display device and establish a connection to the access point (e.g., SCALANCE W788-1RR or SCALANCE W784-1, etc.).
   If you are not working with WLAN, connect the display device (PG/PC, HMI, mobile terminal device, such as tablet PC or smartphone) with the CPU or a communication module using a PROFINET interface.
3. Open the web browser on the display device.
4. Enter the IP address of the CPU in the "Address" field of the web browser in the format: http://a.b.c.d or https://a.b.c.d (exemplary input: http://192.168.3.141).
   The CPU intro page opens. From the intro page you can navigate to additional information. Additional information on access using the secure transmission protocol "https" is available in the chapter Configuring the Web server (Page 11) in the section "Permit access only with HTTPS only".

For HMI devices operating with the preinstalled Windows CE operating system (V 5.x or earlier), the CPU information is processed in a browser especially developed for Windows CE. The information appears in a simplified format in this browser.

2.2 Configuring the Web server

Requirements

You have opened the properties dialog of the CPU in the STEP 7 project view.

Procedure

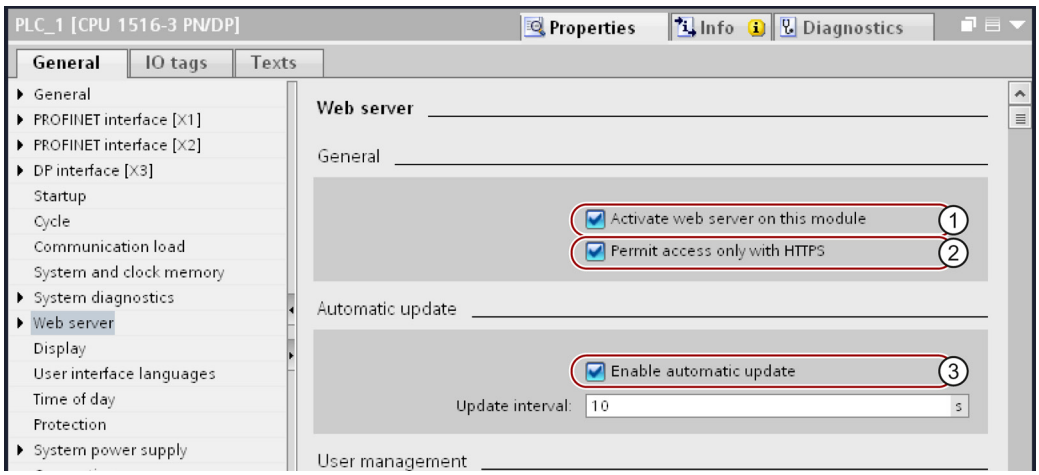


Figure 2-1 Web server settings in STEP 7

To use the full range of functions offered by the Web server, you need to make the following listed settings in STEP 7:

- ① Activating the Web server

  The Web server is disabled in the basic setting of a configured CPU; to enable the Web server, follow these steps:

  – Open the "Devices & Networks" view with a double-click in the STEP 7 project tree.

  – Select the required CPU in the device view, network view or topology view.

  – Navigate to the "Web server" area in the Inspector window properties, "General" tab.

  – Select the "Enable Web server on this module" check box.
  The following notice is output:

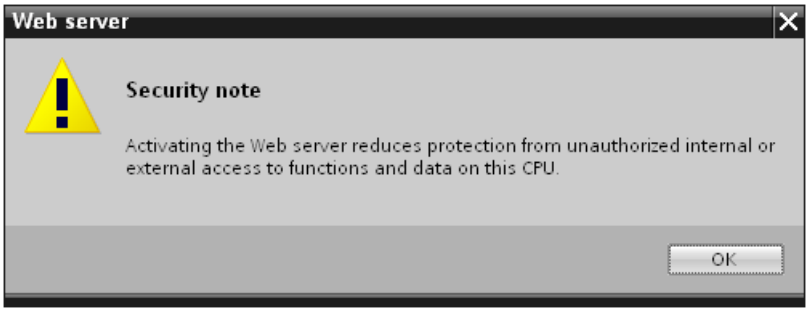


Figure 2-2 Security notice upon activation of the Web server in STEP 7

Note

When projects from deliveries are applied in which the Web server was already activated and configured on the module, this security notice is not shown.

- ② Permit access only with HTTPS

  The websites are transmitted by default via insecure connection and are not protected from attacks by third parties. If you always want to transmit websites and login information to the browser in encrypted form, enable the "Permit access only with HTTPS" option in the CPU properties. Note that the URL of the CPU starts with "https://" in this case.

  For error-free https access to the CPU, the following conditions must be met:

  – The current time is set on the CPU.
  – The IP address of the CPU is set (example: https://192.168.3.141).
  – A valid certificate is installed in the web browser.

    If no certificate is installed, a warning is output recommending that you do not use the page. To view this page, you must explicitly "Add an exception".

    A valid certificate (Certification Authority) is available for download from the "Intro" website, "Download certificate". Instructions for installing the certificate are available in the help system of your Web browser.

    Note

    To protect against manipulation from the outside, download the certificate only in an environment that is guaranteed not to be compromised. You have to download the certificate once for each display device you are going to use.

- Access protection
  The certificate establishes an encrypted connection that prevents wiretapping or distortion of the communication but does not provide access protection. This means you have to protect your CPU from unauthorized access with the corresponding configuration in the user administration.

- ③ Automatic updating

  Automatic updating is activated in the basic setting of a configured CPU.

  The following websites are updated automatically:

  – Start page
  – Diagnostic buffer
  – Module information
  – Messages
  – Information about communication
  – Topology

    Note

    The preset update interval is 10 seconds.
    Larger amounts of data or several http-/https connections increase the update time.

- **Setting the language for the web**

  Activate the project languages you want to use and then select up to two languages for the web. Assign one of the activated project languages to each of the languages for the web.

  You can find additional information in chapter Language settings (Page 17).

- **Amending user administration**

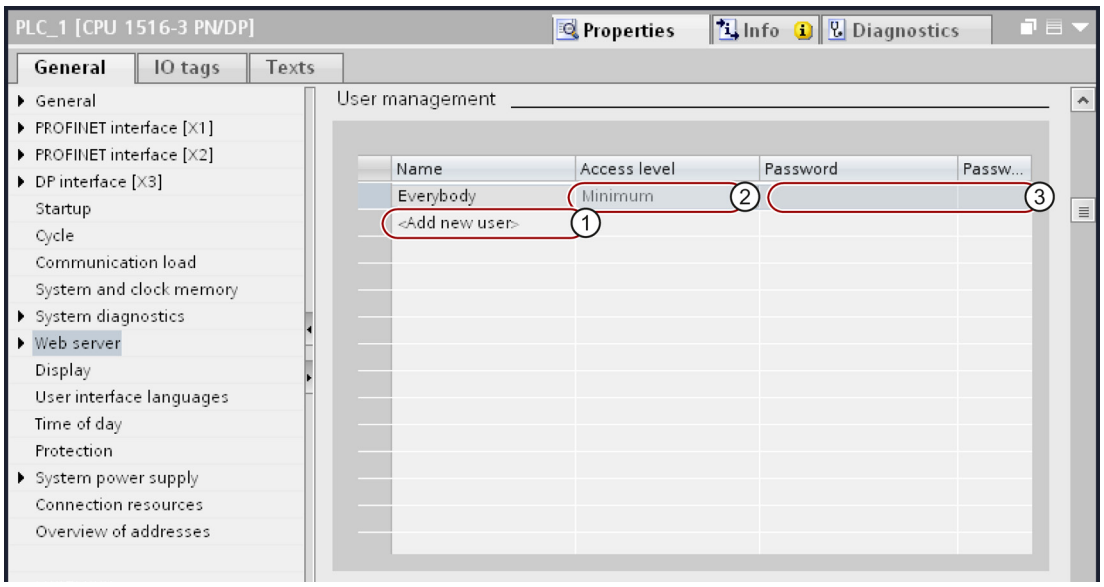


Figure 2-3 User administration in STEP 7

In STEP 7, you manage the user list in the area "Web server > User administration".

The user list provides the following options:

– ① Create user

– ② Specify access permissions

– ③ Assign passwords

Users only have access to the options that are permanently linked to the access permissions.

You can assign different user rights depending on the used CPU and firmware. Rights that your CPU does not support cannot be activated.

The available rights can be available for selection as follows in STEP 7:

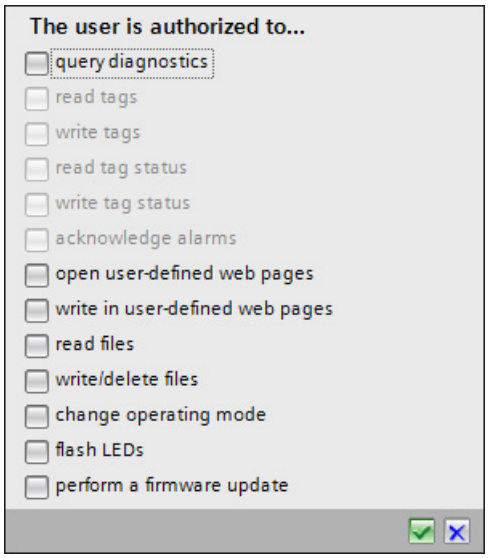


Figure 2-4 Assignment of user rights in STEP 7

If you are not logged in, you automatically access the Web server as the user "Everybody".

It does not matter in this case whether you have configured additional users.

User "Everybody"

A user with the name "Everybody" is preset in the user list; this user has minimum access rights. These are read-only access to the intro page and start page. The user "Everybody" is defined without a password. However, you can assign all access authorizations available in STEP 7 to this user.

You can create a maximum of 20 users and a user "Everybody".

Because the user "Everybody" is defined in STEP 7 without assignment of a password, be careful of the access authorizations which you assign to this user.
Certain authorizations, such as the possibility of changing the operating state, could represent a security risk.
For the assignment of security-relevant authorizations, we recommend that you configure a user and always assign a password in STEP 7.

Assign secure passwords to users during configuration. An example of a secure password is one which is only used for a single application, is more than 8 characters long, and consists of lower- and upper-case letters as well as symbols and numbers (?!+%$1234...). In addition, passwords based on common keyboard sequences or words from the dictionary should be avoided.
Change the password at regular intervals.

Whenever possible, select the option "Permit access only with HTTPS" as soon as you have assigned a password to at least one user.

- **User pages**

  In the "User pages" area you can download your own websites to the CPU and make available your own web applications by means of the web browser.

  You can find additional information, in chapter User pages (Page 47). It also includes references for creating user pages for the Web servers of the S7-300 or S7-1200 CPUs.

- **Activation of the Web server for specific interfaces**

  In the area "Overview of interfaces", you have the option to release or block access to the Web server.

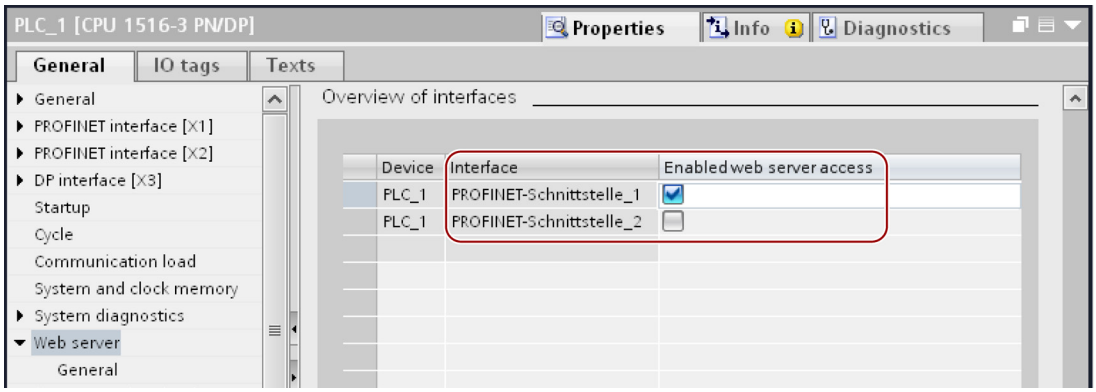


Figure 2-5 Activation of access to the Web server via the interfaces

2.3 Language settings

Introduction

The Web server provides messages and diagnostic information in the following languages:

- German (Germany)
- English (U.S.)
- French (France)
- Italian (Italy)
- Spanish (traditional sorting)
- Chinese (Simplified)
- Japanese

The two Asian languages can be combined as follows:

- Chinese with English
- Japanese with English

Requirements for the availability of the Asian languages

The following requirements must be met for the Chinese and Japanese languages:

- The corresponding support package for East Asian languages is installed on the display device (e.g., PC).
  For this purpose, activate the "Install files for East Asian languages" option in the "Regional and Language Options > Languages" tab of the Windows Control Panel.
- STEP 7 for Asian languages is installed on the programming device used to configure the CPU.

Note

Asian languages are not supported for SIMATIC HMI devices with Windows CE operating system.

Requirements for multilingual output of text

The following two language settings must be made in STEP 7 to permit that the Web server displays the different languages correctly:

- Set the Web server interface languages in the properties dialog of the CPU
- Assign one project language each to the selected languages

Note

The project languages you want to assign must be activated and the corresponding texts (translations) must be available in the project. The project languages selection is available in the project tree under "Languages & Resources".

Setting the language for the web

Once you have activated the Web server on your module, set up to two interface languages for the Web server and assign them a project language each from the drop-down list.

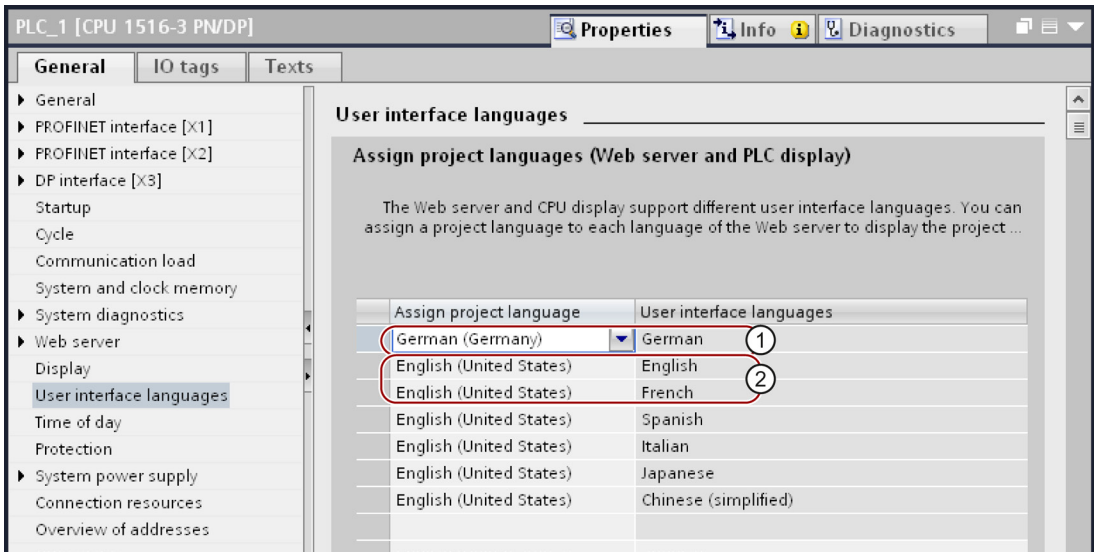


Figure 2-6 Language settings for the Web server in STEP 7

You can assign all relevant languages the same project language:

- ① Language for Web server: German, assigned project language: German,
- ② Language for Web server: English (U.S.), assigned project language: English (U.S.), Language for Web server: French, assigned project language: English (U.S.)

If you want to use French as second language for the Web server instead of English, English (U.S.) remains set as project language because of the selected assignment.

Reference

Additional information on how to set the project language in STEP 7, is available in the online help for STEP 7, keyword: "Selecting project languages".

See also

Configuring the Web server (Page 11)

2.4 Updating and storing information

Update status of the screen content

Automatic updating is activated in the basic setting. The preset update time is 10s.

You update the websites manually with the <F5> function key.

Disabling automatic updates for an individual website

Select the button Off to temporarily deactivate automatic updating of a website.

You reactivate automatic updates with the <F5> function key or the On button.

Note

If the CPU is subject to high load, for example, when processing a large number of PROFINET interrupts or extensive communication jobs, the update of websites may take a lot longer for the duration of such high CPU load.

Saving messages and diagnostic buffer entries

You can save messages and diagnostic buffer entries to a csv file for further processing in a spreadsheet calculation program or database program. Save the data by clicking the icon.

A dialog opens in which you can specify the file name and target directory.

Websites

3

3.1 Start page with general CPU information

Connecting to the Web server

Set up a connection to the Web server by entering the IP address of the configured CPU in the address bar of the web browser, for example, http://192.168.3.141 or https://192.168.3.141. The connection is set up and the "Intro" page opens.

The examples in the next section provide information about the different websites.

Intro

The figure below shows the first page (Intro) called by the Web server.

Figure 3-1 Welcome page of the Web server of the CPU 1516-3 PN/DP

Click the ENTER link to go to the Web server pages.

Note

Select the "Skip Intro" check box in order to skip the Intro. As of now, the Web server will take you directly to its start page. You can undo the setting "Skip Intro" by clicking the "Intro" link on the Start page.

Start page

Before the log in, the Start page offers information as shown in the figure below. The CPU image with LEDs returns the actual CPU status at the time of the data request.

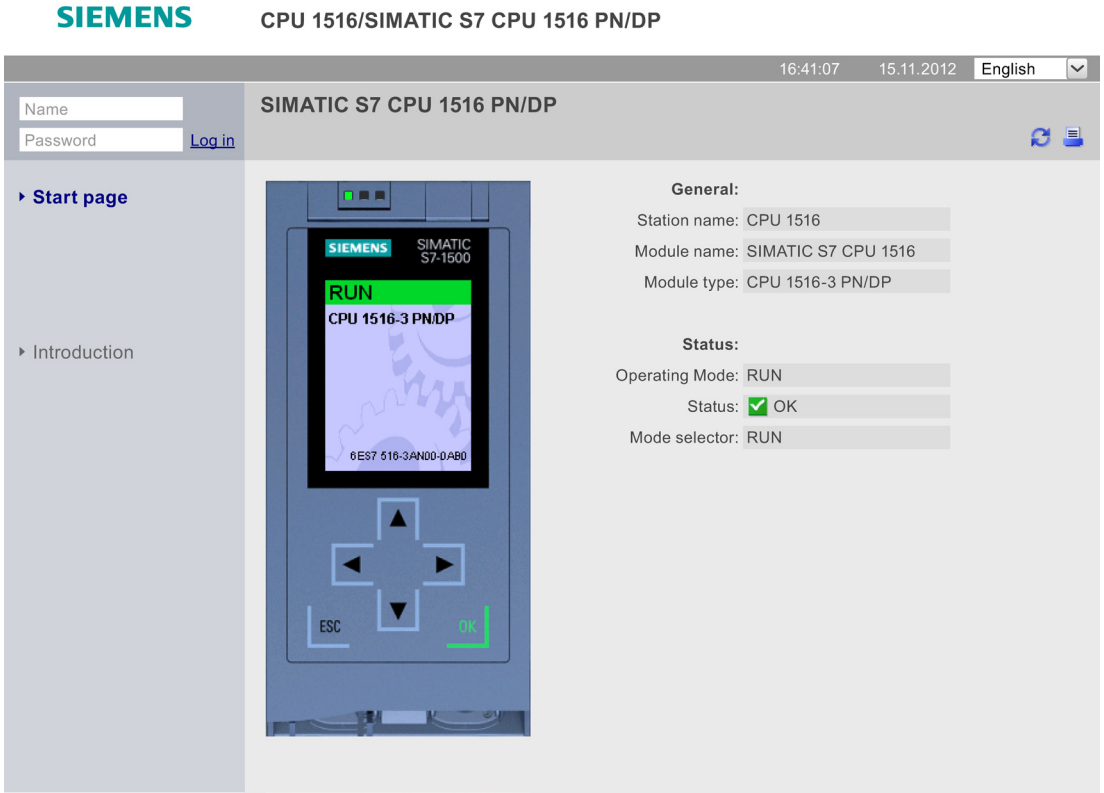


Figure 3-2 Start page before log in

Log in

You must be logged in in order to use the full functionality of the websites. Log in with a user name and password specified in the web configuration in STEP 7. You now have corresponding permissions to access the websites released for this user. If you have not configured a user, read-only access is granted to welcome and home pages by default.

Note

After carrying out your required actions, log out explicitly from the Web server by clicking "Logout" in order to minimize the risk of unauthorized external access.

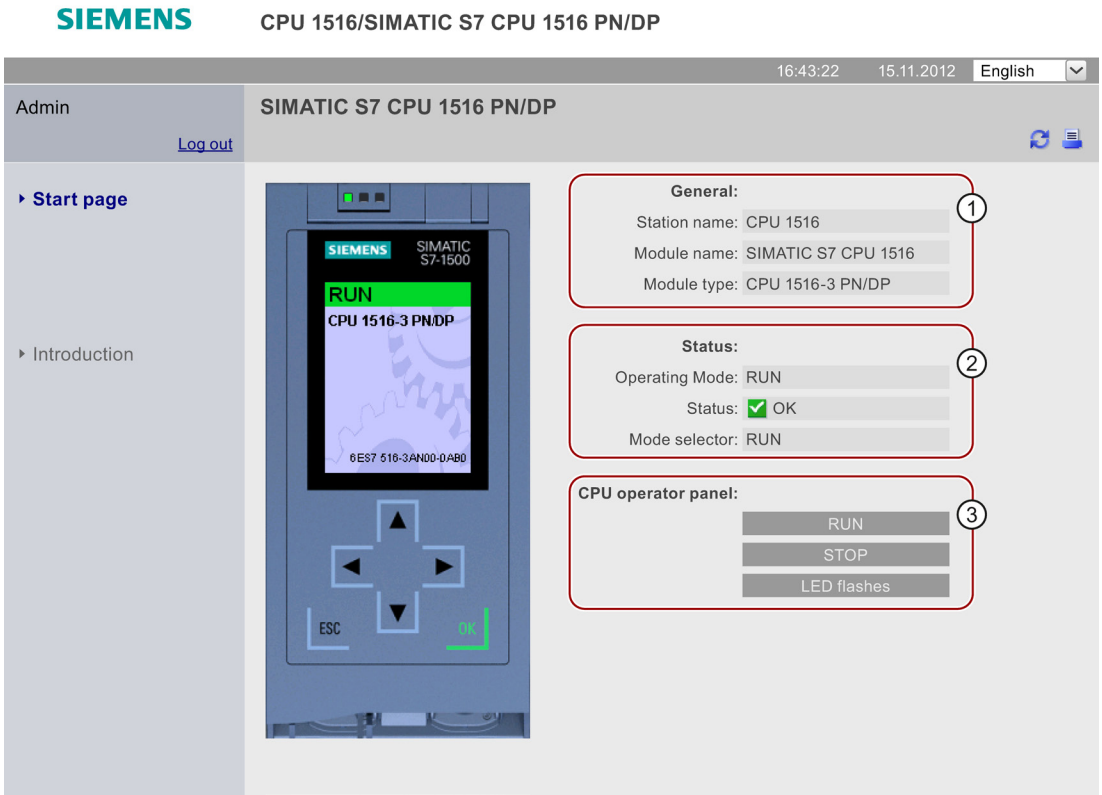


Figure 3-3 Start page after login

① "General"

"General" contains information about the CPU with whose web server you are currently connected.

② "Status"

"Status" contains information about the CPU at the moment of the query.

③ "CPU operator panel"

If you have the necessary access permissions, you can change the operating mode of the CPU ("RUN"/"STOP" fields) or have the LEDs flash ("LED flashes" field) in the section "CPU operator panel".

Reference

You can find additional information in the chapter Configuring the Web server (Page 11).

3.2 Identification

Characteristics

The CPU characteristics are available on the "Identification" website.

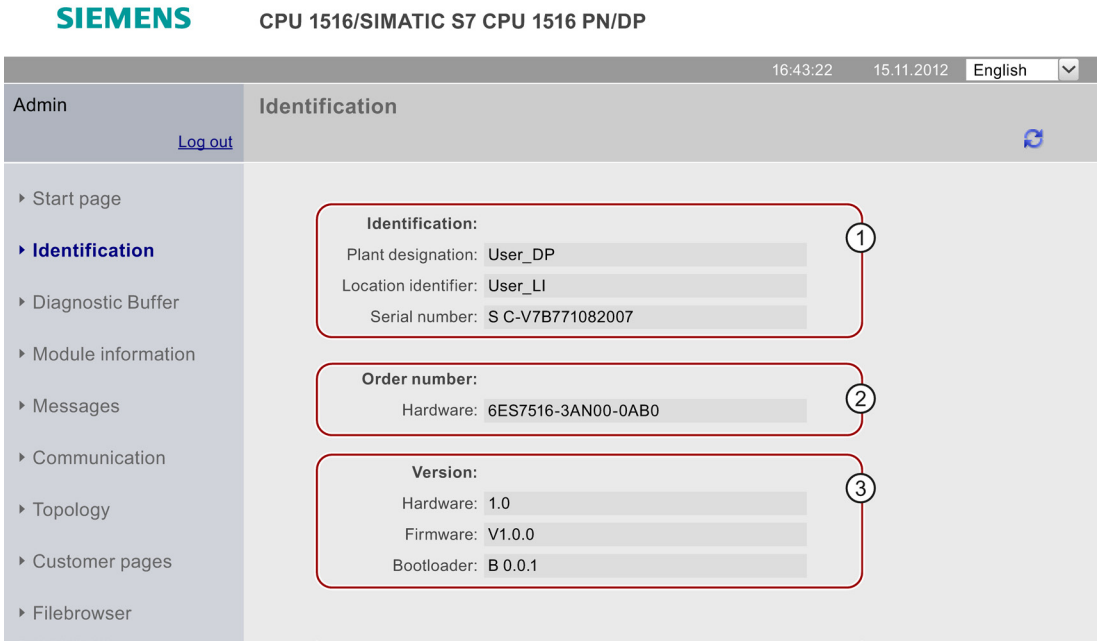


Figure 3-4 Identification

① "Identification"

The "Identification" info box contains the plant and location designation and the serial number. Plant and location designations can be configured in STEP 7 in the properties dialog box of the CPU, "General" tab.

② "Order number"

The "Order number" info box contains the order number for the hardware.

③ "Version"

You can find the hardware, firmware and bootloader versions in the "Version" info box.

3.3 Diagnostic buffer

Diagnostic buffer

The browser displays the content of the diagnostic buffer on the "Diagnostic buffer" website.

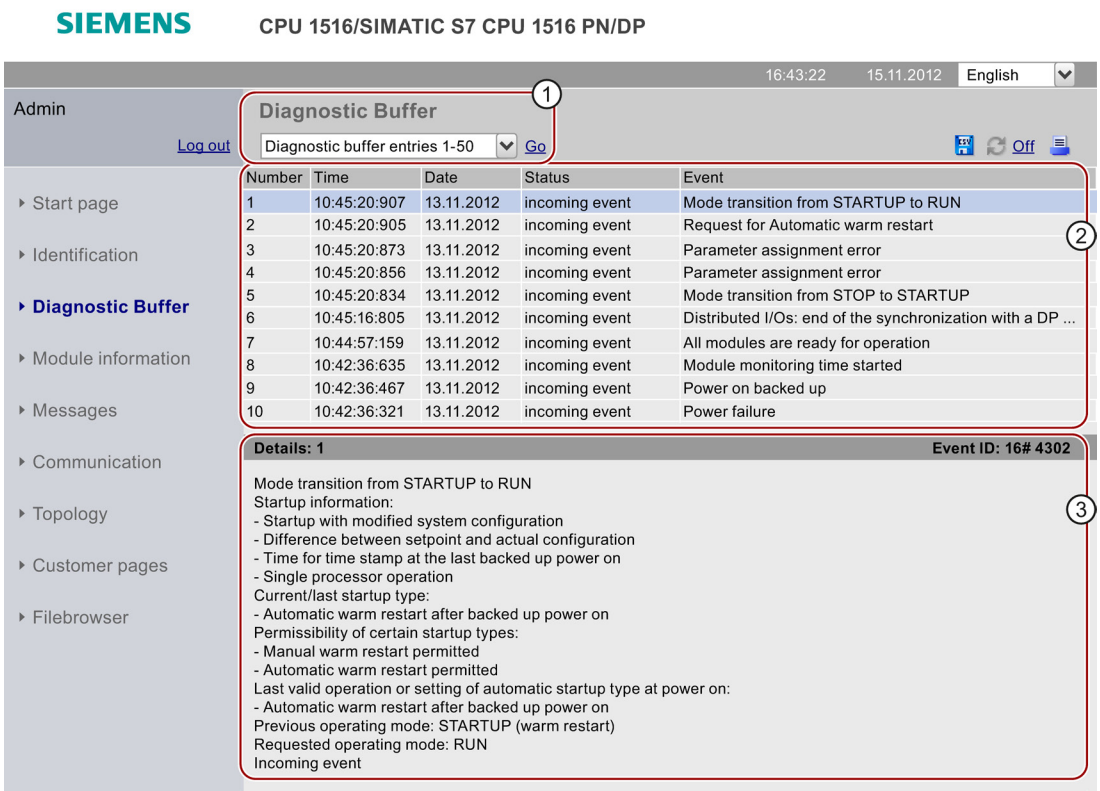


Figure 3-5 Diagnostic buffer

Requirements

The Web server is activated, languages are set, the text libraries are loaded and the project has been compiled and downloaded with STEP 7.

① "Diagnostic buffer entries 1-50"

The diagnostic buffer can save up to 3200 (CPU 1516) or 1000 messages (CPU 1513/1511). Select an interval for the entries from the drop-down list. Each interval comprises 50 entries.

② "Event"

The "Event" info box contains the diagnostic interrupts with date and time.

③ "Details"

This field outputs detailed information about a selected event. Select the corresponding event from the ② "Event" info field.

3.4 Module information

Requirements

- You have made the following settings in the project view, "Properties" tab:
  - Web server activated
  - Assigned a project language to the language in the Web server
- You have compiled and downloaded the project with STEP 7.

Module information

The state of a station is indicated by means of symbols and comments on the "Module information" website.

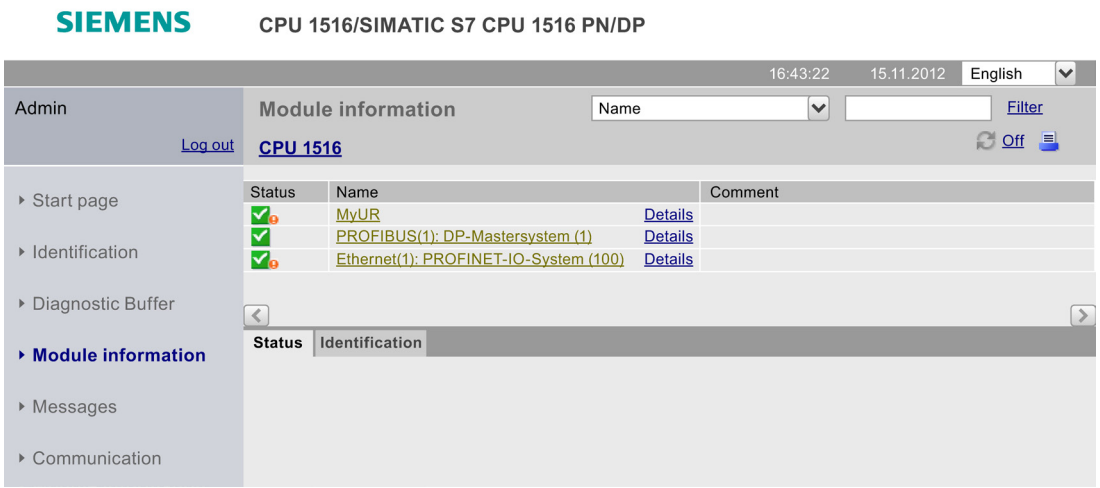


Figure 3-6 Module information

Meaning of the symbols in the "Symbol" column

Table 3- 1 Meaning of symbols

Symbol	Symbol color	Meaning
	green	Component is OK
	gray	Deactivated PROFIBUS slaves or PROFINET devices.
?	black	State cannot be determined • The "Status cannot be determined" is displayed during system diagnostics for all configured I/O modules and I/O systems after restart of the CPU. • However, this status can also be displayed temporarily during operation if a diagnostic interrupt burst occurs for all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	red	Component failed or is not reachable • "Not reachable" is displayed for e.g. a module that has been removed or a module that has been configured but does not exist.
	green	Maintenance required (Maintenance Required)
	yellow	Maintenance demanded (Maintenance Demanded)
	red	Error - component faulty or not available due to an incorrect type
	-	A module in a lower module level does not have the status "Component OK"

Navigation to further module levels

The status of individual components/modules/submodules is displayed when you navigate to the further module levels:

- To the next higher module level using the links in the display of the module levels
- To the next lower module level using the links in the "Name" column

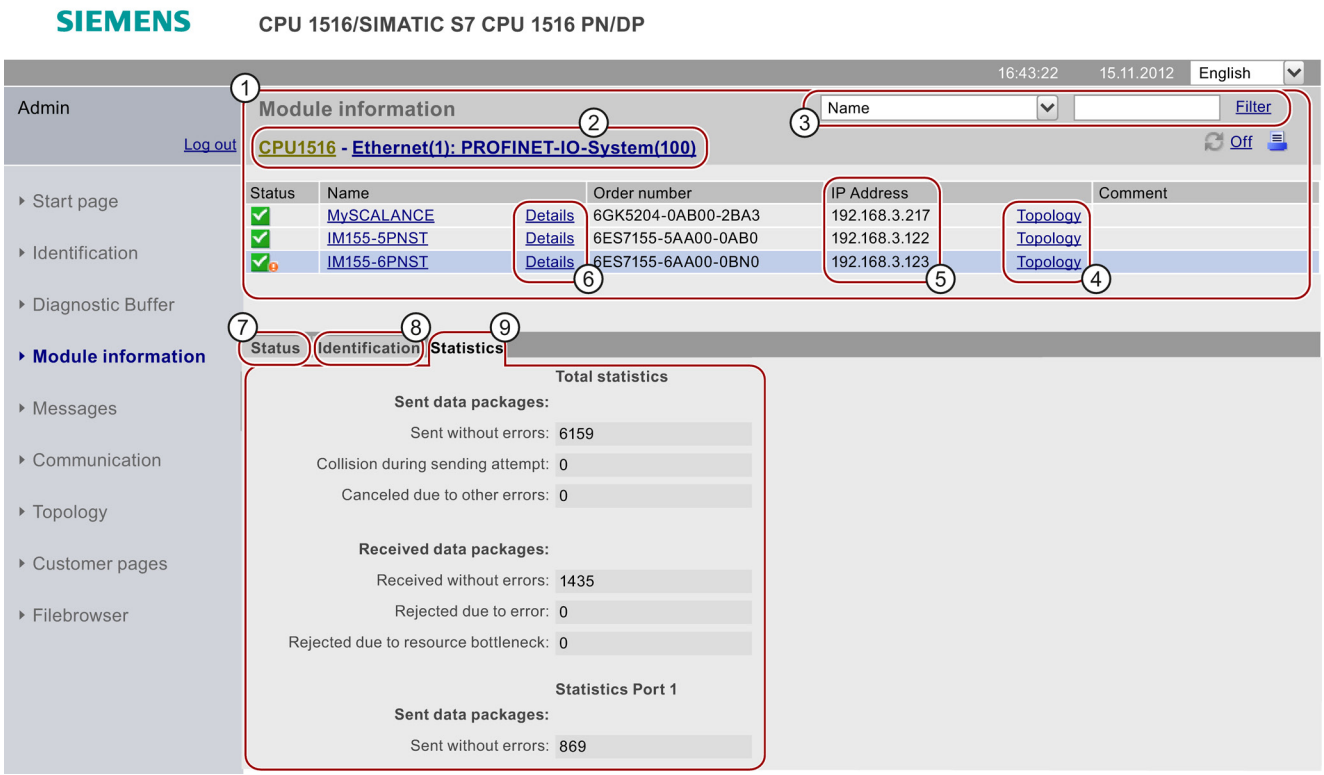


Figure 3-7 Navigation to further module levels

① "Module information"

Depending on the selected level, the table contains information about the rack, the DP master system, the PROFINET IO master system, about the devices, the individual modules, as well as the modules or submodules of the station.

② "Display of the module levels"

The links are used to access the "Module information" of the higher module levels.

③ "Filter"

You can search in the table by selecting specific criteria:

1. Select a parameter from the drop-down list:
   - Slot
   - Name
   - Order number
   - I-address
   - O-address
   - Comment
2. Enter the value of the selected parameter.
3. Click "Filter".

Note

The filter criteria are also retained when you update a page.

To deactivate the filter settings, click "Filter" again.

④ "Topology"

The two websites, "Topology" and "Module information", are linked. A click on "Topology" of the selected module automatically takes you to this module in the graphic view of the target topology on the "Topology" website. The module is displayed in the visible area of the "Topology" website. The device header of the selected module flashes for a few seconds.

⑤ "IP address"

If a link is available, you can use it to access this Web server of the configured device you selected.

⑥ "Details"

Further information about the selected module is provided in the "Status" and "Identification" tabs via the "Details" link.

⑦ "Status" tab

The tab contains information about the status of the selected module when a fault or alarm exists.

⑧ "Identification" tab

The tab contains data on the identification of the selected module.

Note

This tab displays only the data configured offline of the module.

⑨ "Statistics" tab

The tab is only displayed for PROFINET IO devices and includes the following information on communication statistics of the selected IO device:

- "Overall statistics - Data packets sent"

  The quality of the data transfer on the send line can be determined from the key data in this info box.

- "Overall statistics - Data packets received"

  The quality of the data transfer on the reception line can be determined from the key data in this info box.

- "Statistics port x - Data packets sent"

  The quality of the data transfer on the send line can be determined from the key data in this info box.

- "Statistics port x - Data packets received"

  The quality of the data transfer on the reception line can be determined from the key data in this info box.

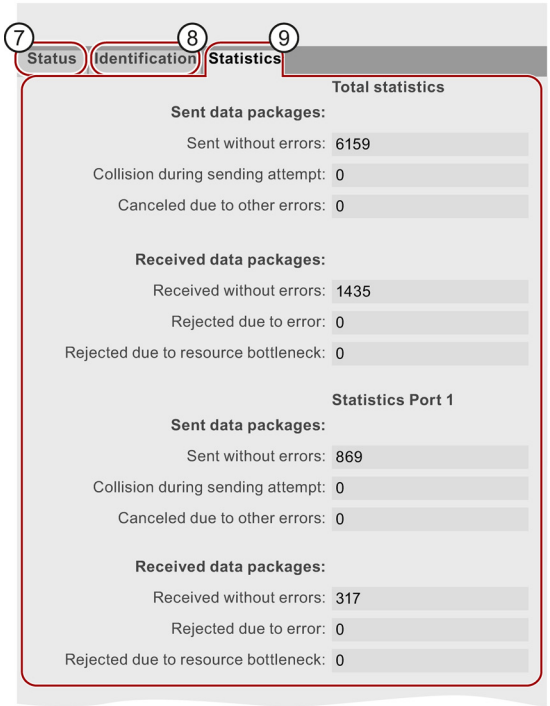


Figure 3-8 Tabs

Reference

You can find additional information in the "Statistics" tab, in the chapter Communication (Page 35).

Example: Module information - module

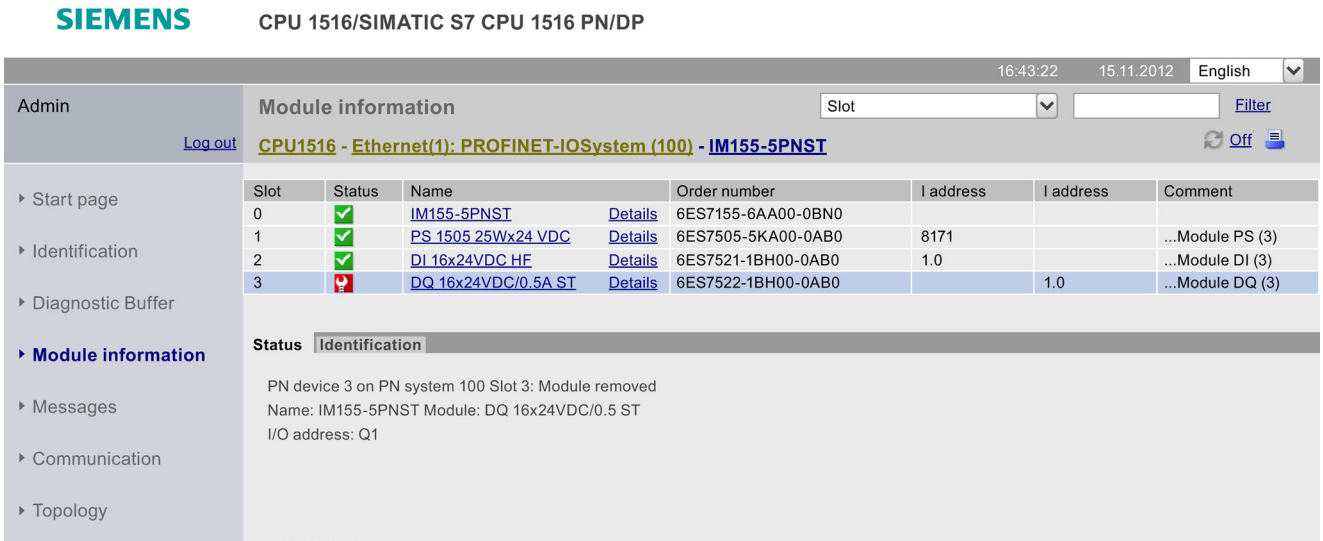


Figure 3-9 Example: Module information - module

Example: Module information - submodule

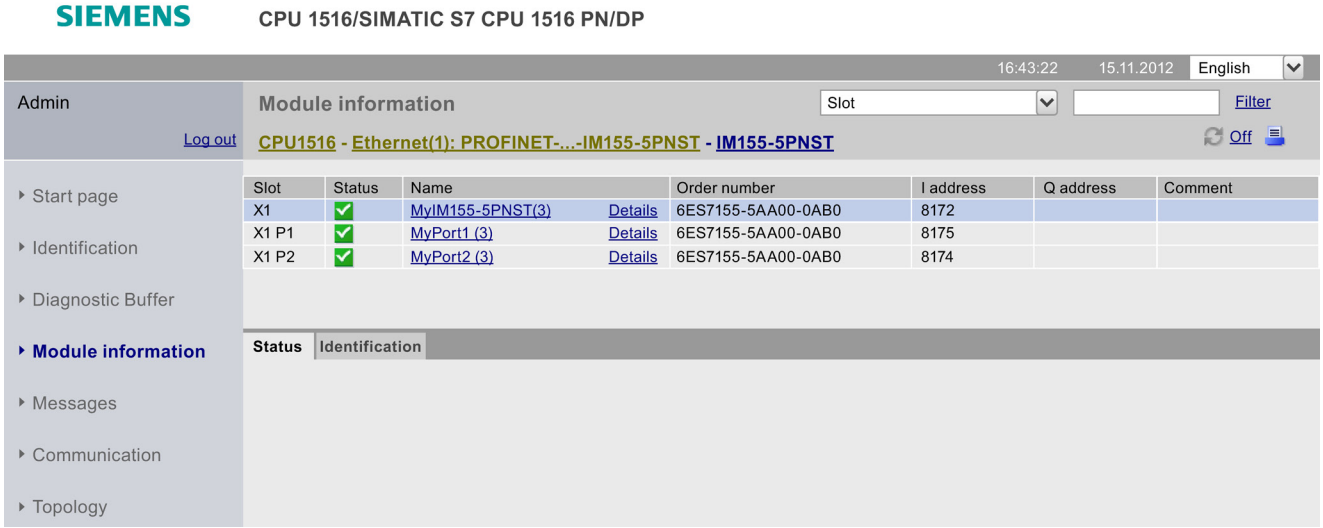


Figure 3-10 Example: Module information - submodule

Reference

You can find additional information on the "Module information" in the online help for STEP 7, keyword: "Module information".

3.5 Firmware update

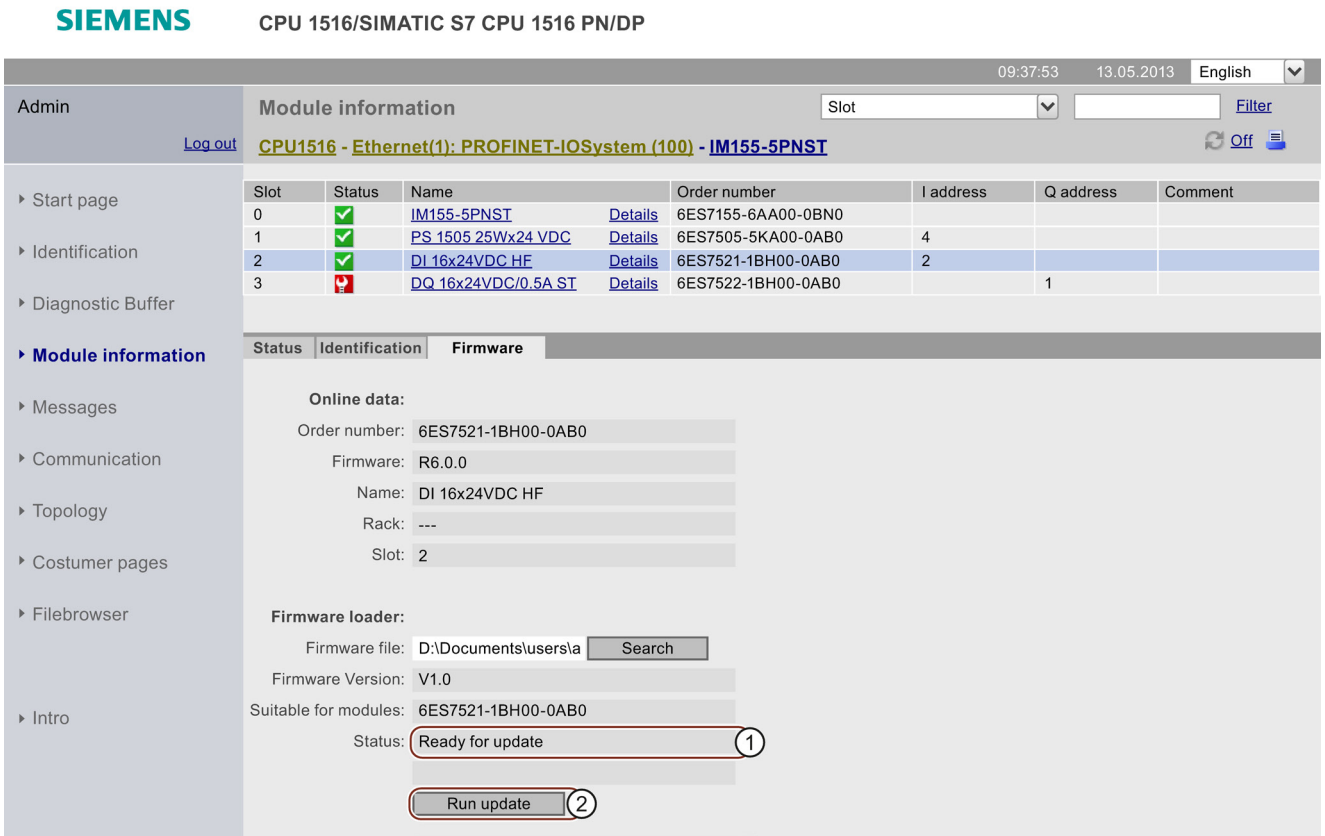
Introduction

You update the firmware as a user with the corresponding access rights on the "Module information" web page at the module level. Information on user administration is available in chapter Configuring the Web server (Page 11), paragraph "Amending user administration". You use an update file to update the firmware of the CPU, the CPU operator panel or the individual central or distributed modules. Note that all modules you want to update must be compatible with the TIA Portal as of V12.0.

Procedure

The following steps are required to perform a firmware update:

- Click on "Browse" in the Firmware Loader area.
- Select a file on your display device or a storage medium that holds the firmware update to be loaded. The available firmware updates are available on the Service&Support page on the Internet (http://support.automation.siemens.com).



① Status of the selected firmware file
② Button to execute the update

Figure 3-11 Module information, "Firmware" tab, "Ready for update" status

The Firmware Loader checks the file name of the selected firmware file and outputs the message "Firmware is not suitable" or "Ready for update" in the "Status" line.

- If the status is "Ready for update", click the "Run update" button. If the CPU is in RUN mode during the update, the following message is output:

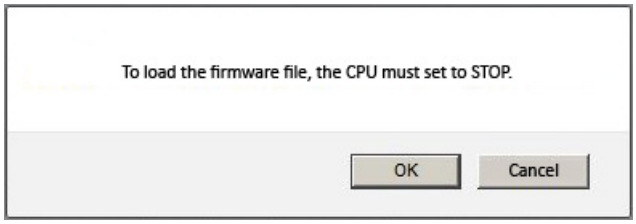


Figure 3-12 Message after clicking "Run update"

Acknowledge the message output by clicking on "OK". The CPU is set to STOP mode and the firmware update is executed.
If you click "Cancel", the CPU remains in the current mode and the firmware update is canceled.

- The current status of the firmware update is output during the update.
A message informs you about the order number and version ID of the updated firmware once the update is complete.
The CPU is automatically started when the mode selector switch of the CPU is in RUN and when you acknowledge the message with "OK".
If you click "Cancel", the CPU remains in STOP mode and you can run additional updates.

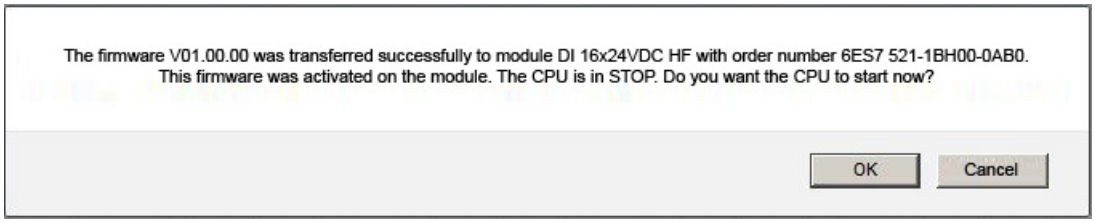


Figure 3-13 Message firmware successfully transferred

3.6 Alarms

Messages

To receive compact information on fault analysis, we recommend that you first read out the content of the message buffer. This is the most effective method to get an overview of the pending faults.

The browser displays the content of the message buffer on the "Messages" website.
The messages cannot be acknowledged on the Web server.

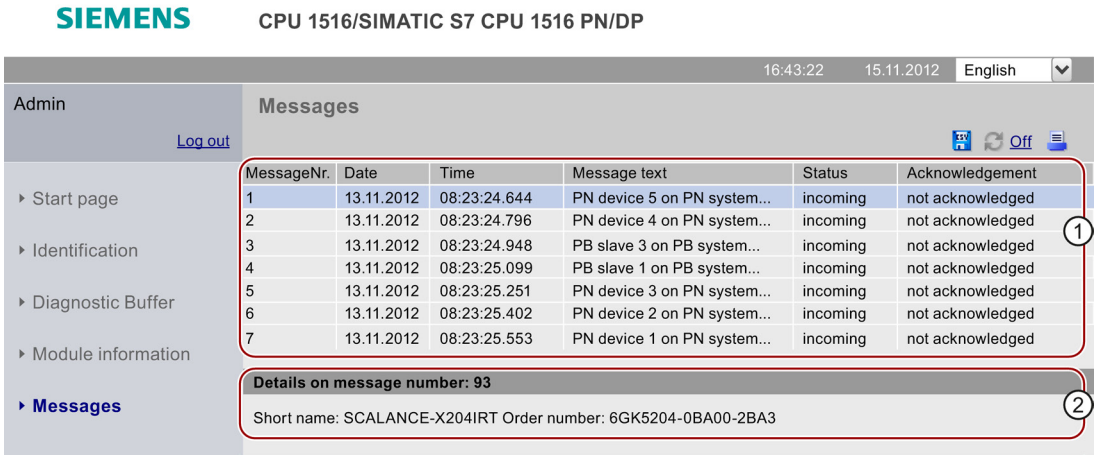


Figure 3-14 Messages

Requirements

The message texts were configured in the user-specific languages. For information about configuring alarm texts refer to STEP 7 and to the Service&Support pages (http://www.siemens.com/automation/service&support).

① "Messages"

CPU messages are displayed in chronological order in info box ②, including **date** and **time**.

The **message text** parameter is an entry which contains the message texts configured for the corresponding fault definitions.

Sorting

You can also view the individual parameters in ascending or descending order. For this purpose, click on one of the parameters in the column header:

- Message number
- Date
- Time (of the CPU)
- Message text
- Status
- Acknowledgment

The messages are returned in chronological order when you click the "Date" entry. Incoming and outgoing events are output at the **Status** parameter.

② "Details on message number"

You can view detailed message information in this info box. Select the corresponding message from the info field ②.

3.7 Communication

Overview

The "Communication" website provides more information about the following tabs:

- Parameters
- Resources

① "Parameters" tab

A summary of the information on the PROFINET interfaces of the selected CPU is available in the "Parameters" tab.

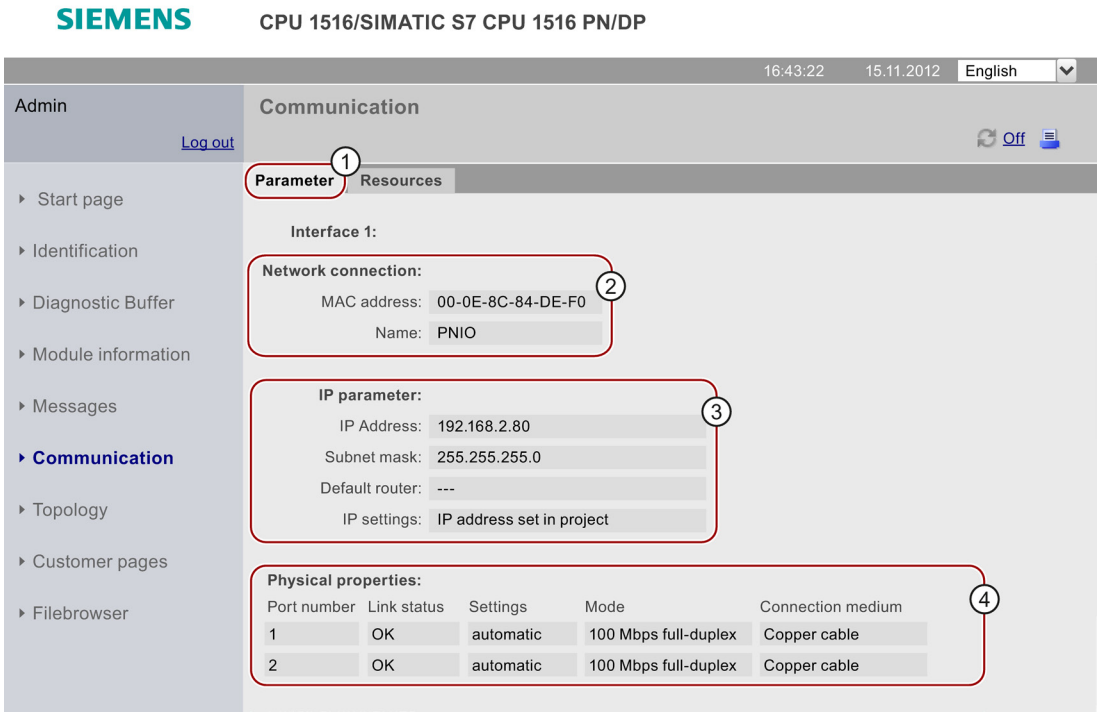


Figure 3-15 Parameters of the integrated PROFINET interface

② "Network connection"

The item "Network connection" includes information for identification of the integrated PROFINET interface of the corresponding CPU. The MAC address is located on the CPU above the respective PROFINET interface.

③ "IP parameters"

This parameter includes information on the configured IP address and number of the subnet in which the corresponding CPU is located.

④ "Physical properties"

In a communication window there is additional information on the interface layout in the field "Physical properties".
It includes information on:

- Port number
- Link status
- Settings
- Mode
- Connection medium

① The "Resources" tab

For information about the load of connections on resources, refer to the "Resources" tab.

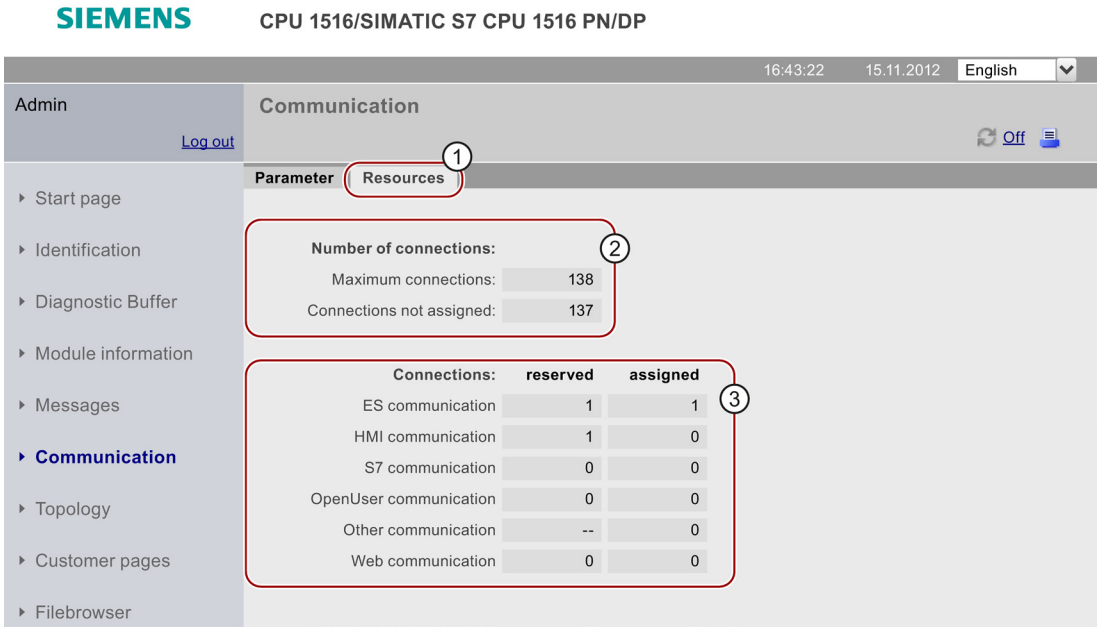


Figure 3-16 "Resources" tab

② Number of connections

The item "Number of connections" includes information on the maximum number of connections and the number of available connections.

③ Connections

The item "Connections" provides information on the number of connections reserved or used for ES, HMI, S7, OpenUser, web communication and other communication functions.

3.8 Topology

3.8.1 Introduction

Topology of the PROFINET devices

The "Topology" website provides information on the topological configuration and status of the PROFINET devices on your PROFINET IO system.

There are three tabs for the following views:

- Graphical view (target and actual topology)
- Tabular view (actual topology only)
- Status overview (excluding topological correlations)

The tabular view and status overview can be printed. Before printing, use the print preview of your browser and, if necessary, correct the format.

Set topology

Display of the PROFINET devices and connections of a PROFINET IO system configured in the topology view of STEP 7. The corresponding status of these devices is displayed.

The display includes neighboring PROFINET devices, provided their topological layout is configured as well. The status is not displayed.

This view identifies the topological assignment of PROFINET devices that have failed, the differences between the target and actual topology, and interchanged ports.

Note

The configured set topology is always displayed by default in the following scenarios:

- When the "Topology" website is called via the navigation bar
- When you change from the overview of PROFINET IO devices on the "Module information" website to the "Topology" website by means of the "Topology" link.

If a set topology was not configured, the actual topology is displayed.

Actual topology

Displays the actual topological layout of the "configured" PROFINET devices of a PROFINET IO system and the directly adjacent, non-configured PROFINET devices (display of the relations, provided these can be determined; but the status of these adjacent PROFINET devices is not displayed).

3.8.2 Graphical view

Requirements

For error-free operation of the topology, the following conditions must be met:

- You completed the Language settings (Page 17).
- In the Topology Editor of STEP 7, you configured the topological interconnection of ports (requirement for display of the set topology and the corresponding topological target connections).
- You compiled the project in STEP 7.
- The project is completely loaded.

Target and actual topology - graphical view

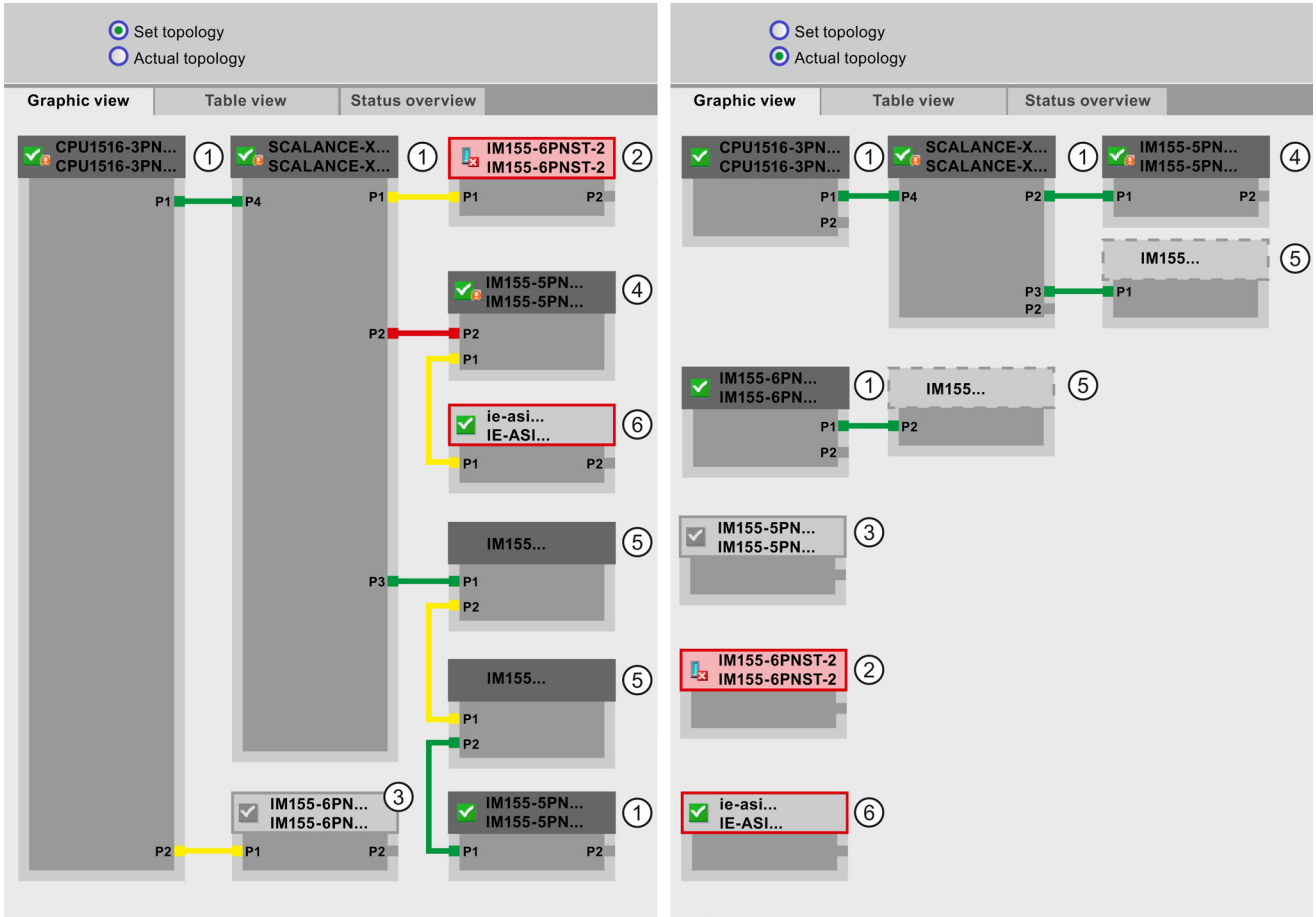


Figure 3-17 Graphical view - Target and actual topology

Meaning of the colored connections in the target/actual topology:

Table 3- 2 Meaning of the colored connections in the target/actual topology

Connection	Meaning	
	Set topology	Actual topology
green	The current actual connection matches the configured target connection.	Connections detected
red	Mismatch between the current actual connection and the configured target connection (e.g., port interchanged).	-
yellow	Connection diagnostics not possible. Causes: • Malfunction of communication with a device (e.g., cable was removed) • Connection to a passive component (e.g., switches or cables) • Connection to devices/PROFINET devices on a different IO controller or IO subsystem.	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed in dark gray. Connections indicate the ports used to connect the PROFINET devices of a station.

② Configured but inaccessible PROFINET devices

Configured but inaccessible PROFINET devices are indicated in pink color with red frame (e.g., device failure, cable disconnected).

③ Deactivated devices

All deactivated, configured PROFINET devices are displayed in light gray.

④ Interchanged ports

Interchanged ports are highlighted in red color in the set topology view. The actual topology view indicates the actually connected ports, while the set topology view displays the configured target connections.

⑤ PROFINET devices of a different PROFINET IO subsystem

- In the set topology:

  A PROFINET device of a different PROFINET IO subsystem is indicated by means of a green link (or red link for interchanged ports) if it is available on the bus and directly adjacent to an accessible configured PROFINET device ①. If the PROFINET device of a different PROFINET IO is inaccessible, it is identified by means of a yellow connecting line.
  The connection between two PROFINET devices which both belong to a different PROFINET IO subsystem cannot be identified and is always indicated in yellow color.

- In the actual topology:

  The PROFINET device of a different PROFINET IO subsystem is not displayed unless it is directly adjacent to a configured PROFINET device. The PROFINET device is shown in light gray with a dashed line around the device header.

The status of PROFINET devices of a different PROFINET IO subsystem is **not** displayed in the device header.

⑥ Displaying faulty neighbor relationships

Devices from which the relation data could not be read completely or with error are highlighted in light gray with a red frame.

Note

Displaying faulty neighbor relationships

If a device does not have the matching firmware, the relationships cannot be displayed correctly. This means a firmware update of the respective device is required in case a faulty neighbor relationship is displayed.

Views after changes to the configuration

- If a device fails, it remains at the same position in the "Set topology" view. This error state is indicated with a red border around the device header and the icon .
- If a device fails, it is displayed in the "Actual topology" view. This error state is indicated separately in the bottom area with a red border around the device header and the icon .

Link between the "Topology" and "Module information" websites

The two websites, "Topology" and "Module information", are linked. A click on the header of a selected module in the topology view automatically takes you to this module on the "Module information" website.

You can find additional information on this in the chapter Module information (Page 26).

Reference

Additional examples for graphical topology view are available in the chapter Examples for graphical topology views (Page 44).

3.8.3 Tabular view

Topology - tabular view

The "Tabular view" always shows the "Actual topology".

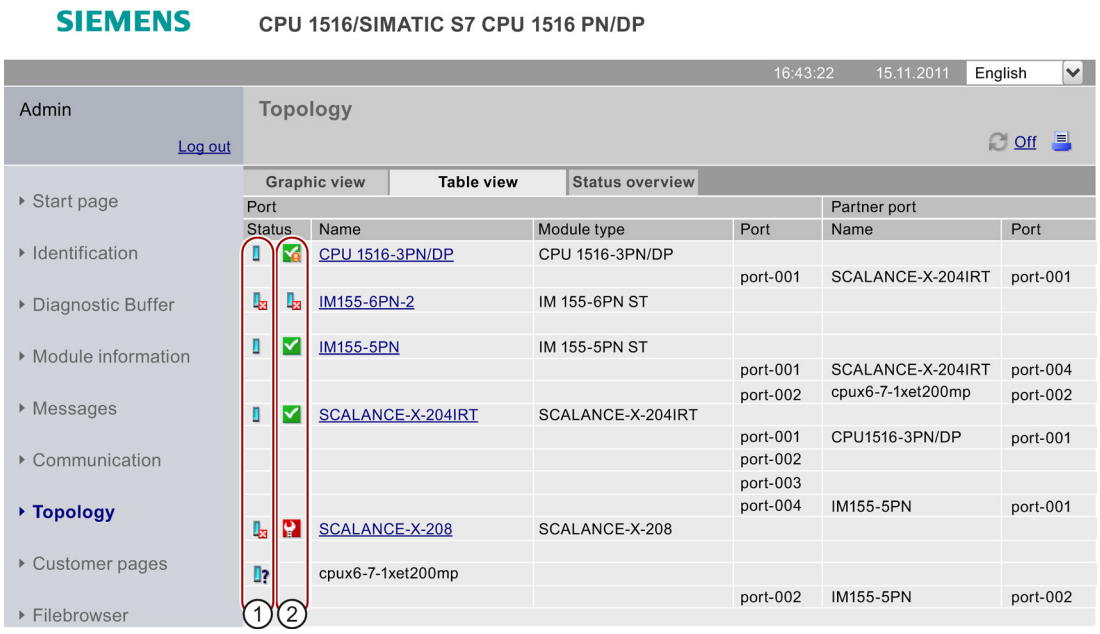


Figure 3-18 Topology - tabular view

① Meaning of the symbols relating to the status of the PROFINET devices

Table 3- 3 Meaning of the symbols relating to the status of the PROFINET devices

Symbol	Meaning
	Configured and accessible PROFINET devices
?	Unconfigured and accessible PROFINET devices
	Configured but inaccessible PROFINET devices
!	Devices for which neighbor relations cannot be determined, or for which the neighbor relationship could not be read out completely, or only with errors

② Meaning of the symbols relating to the module status of the PROFINET devices

Table 3- 4 Meaning of the symbols relating to the module status of the PROFINET devices

Symbol	Color	Meaning
	green	Component is OK.
	gray	Deactivated PROFIBUS slaves or PROFINET devices
?	black	State cannot be determined • For example, "Status cannot be determined" is always displayed while the CPU is in STOP mode, or during startup evaluation of "Report system error" for all configured I/O modules and I/O systems after a CPU restart. • However, this status can also be displayed temporarily during operation if a diagnostic interrupt burst occurs at all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	red	Component failed or is not reachable • "Not reachable" is displayed for e.g. a module that has been removed or a module that has been configured but does not exist.
	green	Maintenance required (Maintenance Required)
	yellow	Maintenance demanded (Maintenance Demanded)
	red	Error - component faulty or not available due to an incorrect type.
	-	A module in a lower module level does not have the status "Component OK".

Reference

You can find additional information on the "Report system error" in the online help for STEP 7 V12. Keyword: "System diagnostics".

3.8.4 Status overview

Topology - status overview

The "Status overview" provides a clear presentation of all PROFINET IO devices/PROFINET devices (without connection relations) on one page. A quick error diagnostics is possible based on the symbols that show the module statuses.

The overview also provides a link of the modules to the "Module information (Page 26)" website.

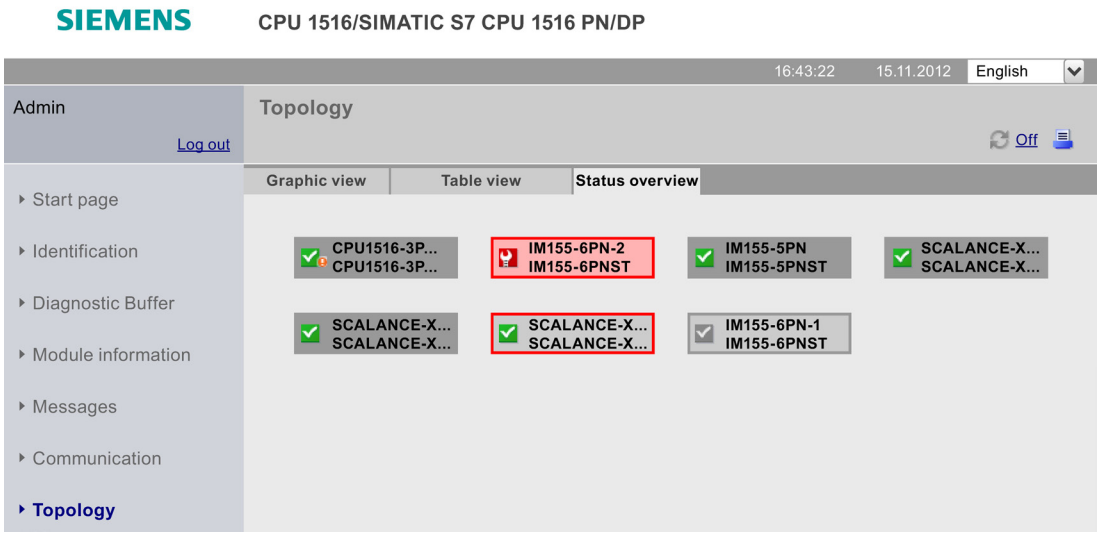


Figure 3-19 Topology - status overview

3.8.5 Examples for graphical topology views

Exemplary information on the different topology views is included in the paragraphs that follow.

"Set topology" is OK

Here you see the connections as they are configured in the topology editor by STEP 7.

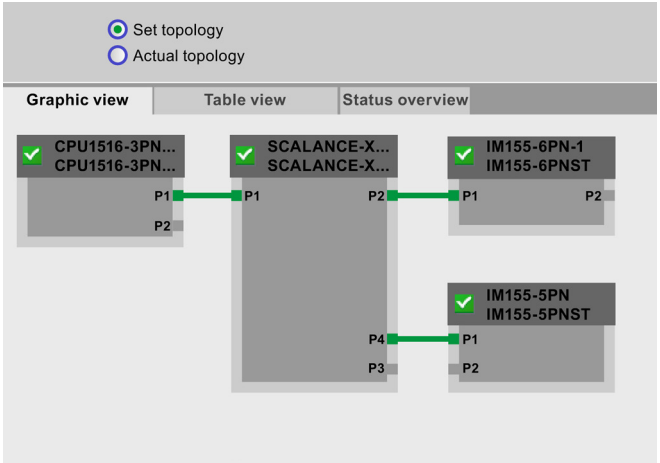


Figure 3-20 "Set topology" is OK

"Actual topology" is OK

Shows the actual layout of all configured devices that can be reached topologically.

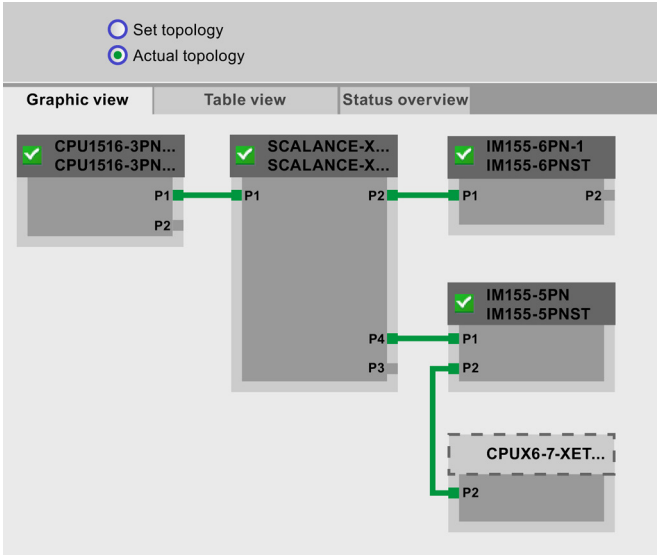


Figure 3-21 "Actual topology" is OK

"Set topology" with failed device

If a device has failed in the meantime, this device remains in the same place in the "Set topology" view. The failed device is displayed with a red border around the device header and the icon.

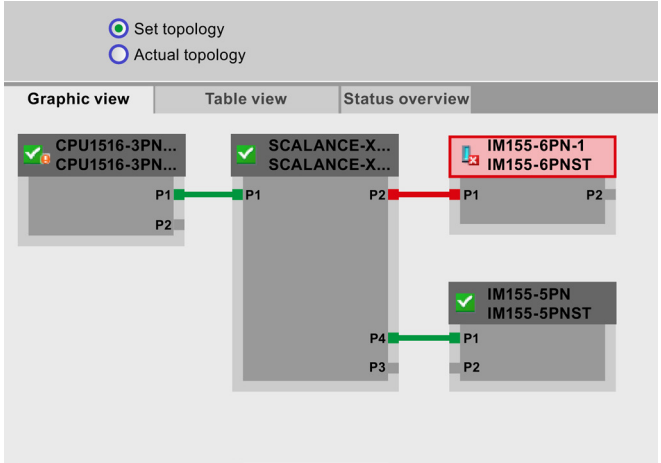


Figure 3-22 "Set topology" with failed device

"Actual topology" with failed device

In the "Actual topology" view, the device that has failed in the meantime is displayed separately in the bottom area of the view. The failed device is displayed with a red border around the device header and the icon.

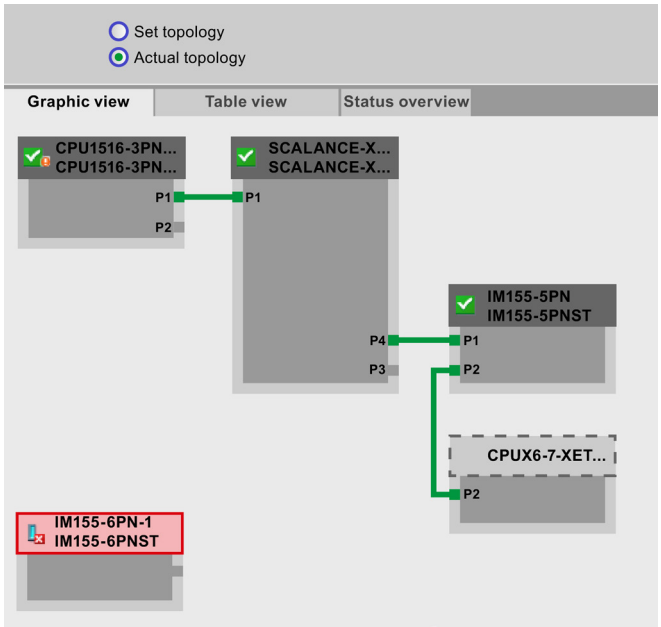


Figure 3-23 "Actual topology" with failed device

"Set topology" with interchanged ports

If a port was interchanged for a configured, directly adjacent PROFINET device, this device remains in the same place in the "Set topology" view. The interchanged connection is indicated by a red line.

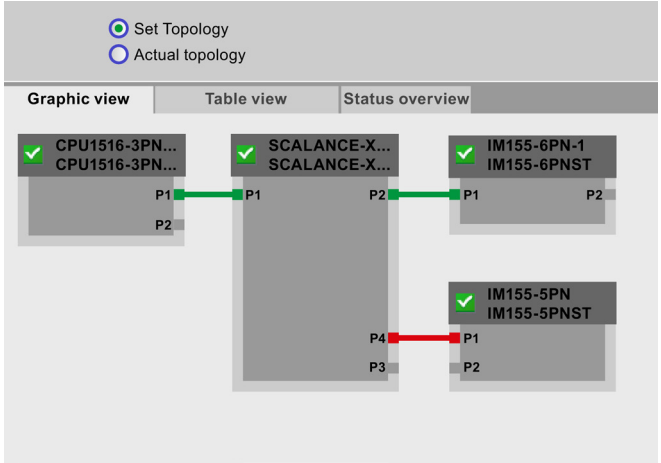


Figure 3-24 "Set topology" with interchanged ports

3.9 User pages

User pages

In the "User pages" area of the Web server you can upload HTML pages you have created yourself for reading out data of the target system.

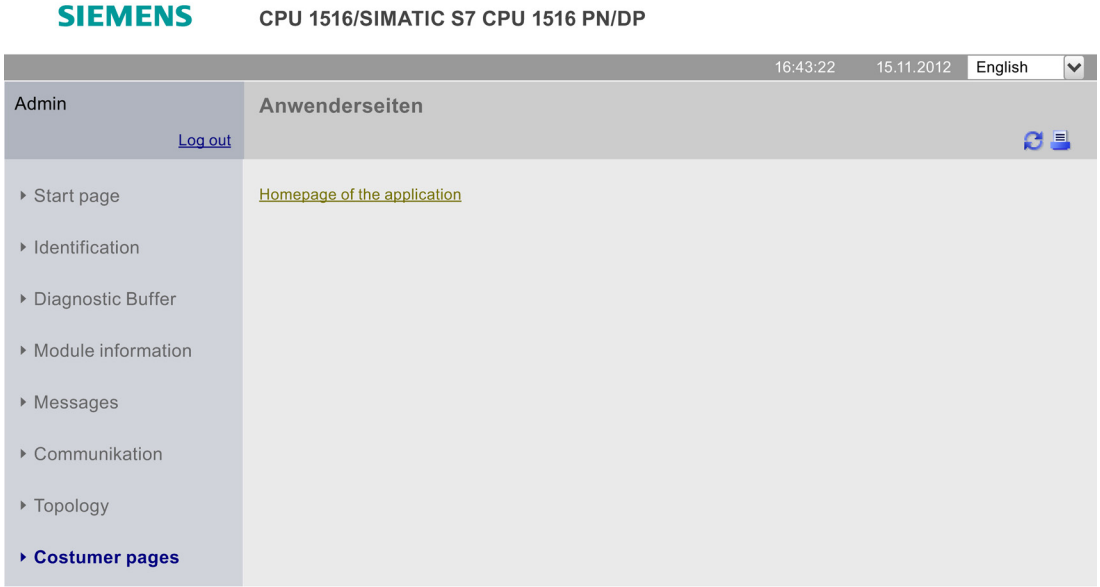


Figure 3-25 User pages

You create the pages with an HTML editor of your choice from which you generate data blocks (Web control DB and Fragment DBs) in STEP 7 and download them to the CPU. The system function SFC 99 "WWW" synchronizes the user program with the Web server on the CPU and initializes the Web server. With the first call of the SFC 99 "WWW", the link to the user page is displayed on the website of the CPU. A click on the link opens the user page in a new window.

Requirements

- You have assigned symbolic names to the tags you want to use on your website in STEP 7 .
- In the Inspector window under "Properties > General > Web server", you have at least
  - activated the Web server.
  - entered a user in the user list.
  - assigned read-only or read and write permissions to this user (and others) for user-defined pages (see chapter Properties of the Web server (Page 9)).
- You completed all necessary communication settings (IP address parameter, subnet mask, etc.).
- You have downloaded the configuration.
- You created your user page in an HTML editor of your choice:
  - Automatic HTML pages, if you want to **disable** control of the page layout by means of the user program (requires at least one call of SFC 99).
    Changes in mode from RUN to STOP do not affect the call of the user pages.
  - Manual HTML pages, if you want to **enable** control of the page layout by means of the user program (cyclic call of SFC 99 required).

Creating user pages

You can use any HTML editor to create your own user page(s). Make sure that your HTML code complies with the standards of the W3C (World Wide Web Consortium), because STEP 7 does not check the HTML syntax in any way.

Proceed as follows:

1. Create the HTML file for your user page with an HTML editor.
   To read out data from the S7-1500 with your HTML code, integrate the AWP commands as HTML comments.
2. Store the HTML file and all associated source files (e.g., *.gif, *.jpg, *.js, etc.) on your PG/PC and write down the storage path.
3. Call the "WWW" instruction in STEP 7 and program it (see chapter Programming the WWW instruction (Page 59)).
4. Configure the user page in STEP 7 (see chapter Configuring user pages (Page 58)). This way you compile the contents of your HTML file, among other things, into data blocks in STEP 7.
5. Download the configuration and the user program to the CPU.
6. Open your user page with your display device by means of a web browser in the Web server of the CPU.

Note

Comprehensive HTML pages, especially those with a lot of images, take up a lot of memory in the load memory. Make sure you select a SIMATIC memory card with sufficient memory to provide ample load memory.

Updating user pages

User pages are not updated automatically in the browser. You can program the HTML code so that the pages are updated automatically.

Pages which read out data from the controller, are always up-to-date due to regular updates.

Note

If the HTML page contains form fields for data input, automatic update can impair the correct data input by the user.

To update the entire page automatically, you can add the following instruction in the <head> area of your HTML page, whereby the number "10" stands for the update interval in seconds:

```
<meta http-equiv="refresh" content="10">
```

Reference

The description of a user page is available in the chapter Example of a user page (Page 61).

Additional help for visualization with user-defined websites is available in the application examples on the Internet:

- S7-1200 and STEP 7 V11 (http://support.automation.siemens.com/WW/view/en/58862931)
- S7-300 / S7-400 and STEP 7 as of V5.5 (http://support.automation.siemens.com/WW/view/en/44212999)

3.9.1 AWP commands

Overview

Automation Web Programming (AWP) commands are a special command syntax for data exchange between CPU and user page (HTML file).

AWP commands are entered as HTML comments and offer the following options for your user pages:

- Reading PLC tags
- Writing PLC tags
- Reading special tags
- Writing special tags
- Define enum types
- Assign enum types to tags
- Define data block fragments
- Import data block fragments

General syntax

All AWP commands, except for the command for reading a PLC tag, have this structure:
`<!-- AWP_< command name and parameter> -->`

Files including AWP commands:

- must be UTF-8 encoded.
  To define UTF-8 as character set of the page, add the following line to your HTML code:
  `<meta http-equiv="content-type" content="text/html; charset utf-8">`

  Note
  Saving the HTML page
  Make sure that you save the file in the editor in UTF 8 character encoding as well.

- may not include the following sequence:]]>
- may not include the following sequence outside "Reading tag areas" (:="<Varname>":): :=
- depending on the use, must identify special characters in tag names or data block names with character escape sequences or quotation marks
- are case-sensitive
- should be additionally enclosed by JavaScript comments ("/*...*/") in JavaScript files

Overview of AWP commands

Table 3- 5 AWP commands

Function	Representation
Reading PLC tags	`:=<Varname>:`
Writing PLC tags	`<!-- AWP_In_Variable Name='<Varname1>' -->`
Reading special tags	`<!-- AWP_Out_Variable Name='<Typ>:<Name>' -->`
Writing special tags	`<!-- AWP_In_Variable Name='<Typ>:<Name>' -->`
Define enum types	`<!-- AWP_Enum_Def Name='<Name Enum-Typ>' Values='0: "<Text_1>",1:"<Text_2>",...,x:"<Text_y>"' -->`
Assigning enum types to tags	`<!-- AWP_Enum_Ref Name='<Varname>' Enum='<Name Enum-Typ>' -->`
Define data block fragments	`<!--AWP_Start_Fragment Name='<Name>'[Type=<Typ>] [ID=<Id>] -->`
Import data block fragments	`<!--AWP_Import_Fragment Name='<Name>' -->`

3.9.1.1 PLC tags

PLC tags

User pages can read PLC tags from the CPU and write data to the CPU.

To do so, PLC tags must:

- be enclosed by double quotation marks ("...").
- also be enclosed by single quotation marks ('" ... "') or with quotation marks masked with a backslash ("\" ... "\").
- be specified by a PLC tag name.
- identify, if the PLC tag name includes the characters \ (backslash) or ', these characters with the escape sequence \\ or \' as normal characters of the PLC tag name.
- be enclosed with single quotation marks ('...'), if an absolute address (input, output, bit memory) is used in the AWP command.

Reading PLC tags

These out tags (output direction as seen from the controller) are inserted at any place in the HTML text with the syntax described below.

Syntax

```
:=<Varname>:
```

<Varname> corresponds to the tag to be read from your STEP 7 project and can be a simple shared tag or a complete tag path to a structure element. Make sure that you use the name of the data block and not its number when you use data blocks.

Examples

```
:="Conveying speed": :="My_datablock".bitmemory1:
:=I0.0:
:=MW100:
```

Writing PLC tags

These in-tags (input direction as seen from the controller) are set on the browser page. This can take place in a form on your HTML page, for example, with text input or list selection boxes that correspond to the tags that can be written.

The tags are either set in the HTTP Header (per cookie or POST method) or in the URL (GET method) by the browser in the HTTP request and are then written by the Web server into the respective PLC tag.

Note

Write access during operation

For data to be written from a user page to the CPU, a user must have the required write permissions and be logged on as this user. This applies to all write accesses of websites to the CPU.

Syntax

```
<!-- AWP_In_Variable Name='"<Varname1>"' Name='"<Varname2>"'
Name='"<Varname3>"' -->
```

If the name of the tag that you are using for the web application is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter.

```
<!-- AWP_In_Variable Name='<Varname_Webapp>' Use='<PLC_Varname>' -->
```

Examples with HTML input boxes

```
<!--AWP_In_Variable Name='"Target_Level"' -->
<form method="post">
<p>Input Target Level: <input name='"Target_Level"'
type="text"><input type="submit" value="Write to PLC"> </p>
</form>

<!--AWP_In_Variable Name='"Data_block_1".Braking' -->
<form method="post">
<p>Braking: <input name='"Data_block_1".Braking' type="text"> <input
type="submit" value="Write to PLC"></p>
</form>
```

Examples with HTML drop-down list

```
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable' -->
<form method="post">
<select name='"Data_block_1".ManualOverrideEnable'>
<option value=1>Yes</option>
<option value=0>No</option>
</select><input type="submit" value="submit setting"> </form>
```

3.9.1.2 Special tags

Special tags

Special tags are mainly the HTTP tags specified in the definitions of the World Wide Web Consortium (W3C). Special tags are also used for cookies and server tags.

Reading special tags

The Web server can read PLC tags and transfer them to special tags in the HTTP response header. You can, for example, read out a path name from a PLC tag to redirect the URL to another storage location with the special tag "HEADER:Storage location".

Syntax

```
<!--AWP_Out_Varible Name='<Type>:<Name>' Use='<Varname>' -->
```

<Type> corresponds to the type of special tag.
Options are:

- HEADER
- COOKIE_VALUE
- COOKIE_EXPIRES

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Status: HTTP status code (if no other value was set, status code 302 is returned).
  - Location: path for redirection to another site. Status code 302 must be set.
  - Retry-After: time for which the service is most likely not available. Status code 503 must be set.
- COOKIE_VALUE:name: value of the named cookie.
- COOKIE_EXPIRES:name: expiration time of the named cookie in seconds.

Examples

The HTTP HEADER tag is written to the PLC tag of the same name:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' -->
```

If the name of the special tag is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' Use='"Status"' -->
```

Writing special tags

The Web server gives you the option to write values of special tags written in the HTTP header in the CPU. You can, for example, save information on the cookie of a user page or on the user that accesses a site in STEP 7.

Syntax

```
<!-- AWP_In_Variable Name='<Type>:<Name>' Use='Varname' -->
```

<Type> corresponds to the type of special tag.
Options are:

- HEADER
- SERVER
- COOKIE_VALUE

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Accept-Language: accepted or preferred language
  - User-Agent: information on the browser
  - Authorization: credentials for a requested resource
- SERVER tags:
  - current_user_id: Indicates whether a user is logged on:
    current_user_id=0: No user is logged on / access by "Everybody" user.
    current_user_id=1: At least one user is logged on.
  - current_user_name: user name of the logged-on user
- COOKIE_VALUE:name: value of the named cookie.

Examples

The HTTP-SERVER tag is written to the PLC tag of the same name:

```
<!--AWP_In_Variable Name='"SERVER:current_user_id"' -->
```

The HTTP-SERVER tag is written to the PLC tag "My_userID":

```
<!--AWP_In_Variable Name='"SERVER:current_user_id"'
Use='"My_userID"'-->
```

3.9.1.3 Enum types

Enumeration types (enum types)

Enum types convert numerical values from the PLC program into texts or vice versa. The numerical values may also be assigned for use with several languages.

Define enum types

You can define enum types in your user pages and assign the values in an AWP command.

Syntax

```
<!-- AWP_Enum_Def_Name='<Name Enum-Typ>' Values='0:"<Text_1>",
1:"<Text_2>",...,x:"<Text_y>"' -->
```

Examples

To store German values as HTML file in the "de" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"on", 1:"off", 2:"Fault"' -
->
```

To store English values as HTML file in the "en" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"on", 1:"off", 2:"error"' -
->
```

Assigning enum types to tags

The assignment of tags from the user program to the individual enum types takes place by means of a separate AWP command. The used tag can be used at a different location of the user pages in a read operation or in a write operation.

For a read operation, the Web server replaces the value read from the CPU with the enum text value defined correspondingly. For a write operation, the Web server replaces the defined enum text value with the corresponding integer value of the enumeration before the value is written to the CPU.

Syntax

```
<!-- AWP_Enum_Ref_Name='<Varname>' Enum="<Enum-Type>" -->
```

<Varname> is the symbolic tag name from the user program; <Enum-Type> the previously specified name of the enum type.

Example for a declaration

```
<!-- AWP_Enum_Ref_Name='"Alarm"' Enum="AlarmEnum" -->
```

Example for use when reading a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No alarms",
1:"Container is full", 2:"Container is empty"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<p> The current value of "Alarm" is :="Alarm": </p>
```

If the value of "Alarm" in the CPU is 2, the HTML page shows 'The current value of "Alarm" is container is empty' because the definition of the enum type assigns the numerical value 2 to the character sequence "Container is empty".

Example for use when writing a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No alarms",
1:"Container is full", 2:"Container is empty"' -->
<!-- AWP_In_Variable_Name='"Alarm"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<form method="post">
<p><input type="hidden" name ='"Alarm"' value='Container is full'
/></p>
<p><input type="submit" value='Set container is full' /></p>
</form>
```

The value 1 is written to the PLC tag "Alarm" because the definition of the enum type assigns the numerical value 1 the text "Container is full".

Keep in mind that the name specified in "AWP_In_Variable" must be exactly the same in "AWP_Enum_Ref".

3.9.1.4 Fragments

Fragments

Fragments are "short paragraphs" of a website that the CPU processes separately.

Fragments are usually entire pages, but they can be individual elements, such as files (e.g. images) or documents.

Note

In each fragment in which enum texts are referenced by a PLC tag, this PLC tag must be assigned to the enum type name with the appropriate AWP command.

Defining fragments

A fragment extends to the beginning of the next fragment or to the end of the file.

Syntax

```
<!-- AWP_Start_Fragment_Name='<Name>' [Type="<Typ>"] [ID="<Id>"] -->
```

This command specifies the start of a fragment.

- <Name> Specifies the name of the fragment. The name must start with a letter [a-zA-Z] or an underscore (_). This first character can be followed by letters, underscores or numbers [0-9].
- <Type> Specifies the type of the fragment.
  - "manual": The user program is notified of the request for a fragment and can react accordingly. The function of the fragment must be controlled with STEP 7 and the tags of the control DB.
  - "automatic": The page is automatically processed (default)

- <Id> You can specify a numerical ID for the fragment. If no ID is assigned, the fragment is automatically assigned an ID. For manual pages (<Type>=manual), the fragment can be addressed with this ID in the user program of the CPU.

  Note

  ID assignment

  Set the ID as low as possible because the highest ID influences the size of the Web control DB.

- <Modus>
  - "visible": The contents of the fragment are displayed on the user page (default).
  - "hidden": The contents of the fragment are **not** displayed on the user page.

Importing fragments

You can specify a fragment in an HTML page and import this fragment into other websites.

Note

Ensure that no AWP command for importing fragments is positioned between an enum assignment and enum usage, because this import can result in the enum assignment being located in a different fragment than the enum usage.

Example

A company logo is to be displayed on all websites of a web application.

The HTML code for the fragment that displays the company logo exists only once. You can import the fragment as often and into as many HTML files as necessary.

Syntax

```
<!-- AWP_Import_Fragment_Name='<Name>' -->
```

<Name> corresponds to the name of the fragment to be imported.

Example

HTML code within a website that creates a fragment for displaying an image:

```
<!-- AWP_Start_Fragment Name='My_company_logo' -->
<p><img src="Company logo.jpg"></p>
```

HTML code that imports the created fragment into another website:

```
<!-- AWP_Import_Fragment Name='My_company_logo' -->
```

3.9.2 Configuring user pages

Configuring user pages

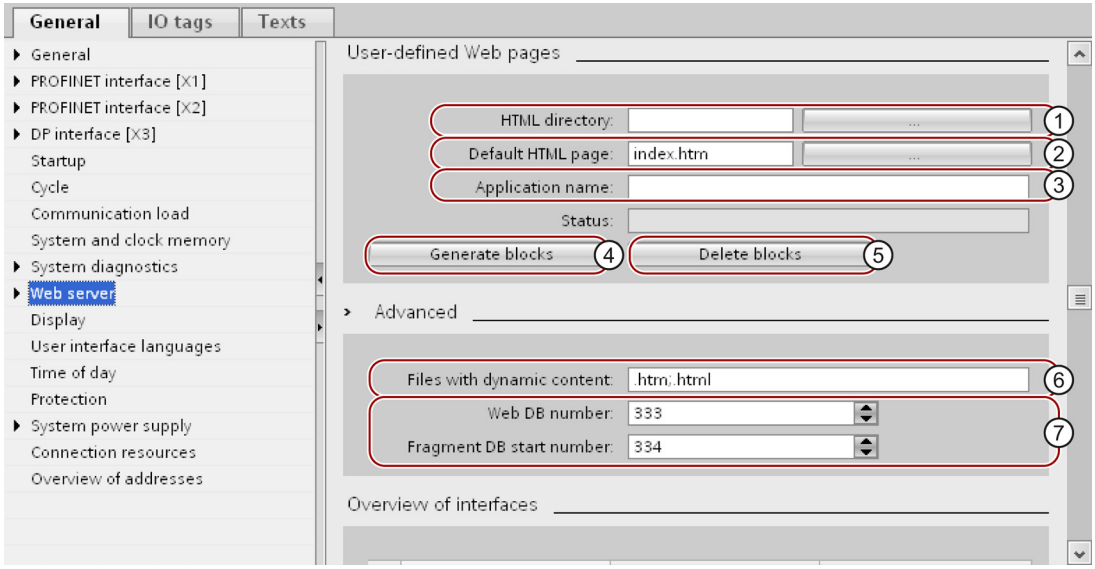


Figure 3-26 Configuring user pages in STEP 7

Proceed as follows to configure the user pages in STEP 7:

- Select the CPU in the device configuration.
- Open the settings in the Inspector window of the CPU under "Properties > General > Web server".
- In the area "User pages" under ① "HTML directory", select the folder on your display device in which you have saved your HTML page.
- Enter the name of the HTML page under ② "Start HTML page" that is to open when you start the application.
- You can also specify a name for your application under ③ "Application name". This name is used to further divide or group the websites. If an application name already exists, the URL is displayed in the following format: http://a.b.c.d/awp/<application name>/<page name>.html
- In the "Extended" area, enter the file extensions that have to be checked for AWP commands in input box ⑥ "Files with dynamic contents". By default, STEP 7 analyses files with the extensions ".js", ".htm" and ".html". Here you can enter other file extensions that you have used when creating your user page.
- You can accept the number for the Web DB ⑦ and the fragment DB start number ⑦ or you can assign a new number of your choice that is not assigned.

- Click the button ④ "Create blocks" to create data blocks from the source files. The created data blocks are stored in the STEP 7 project tree in the folder "System blocks > Web server". These data blocks consist of a control data block (Web control DB) that controls the display of the websites and one or several data block fragments (fragment DBs) with the compiled websites.
- In the network view, select the CPU you want to download and select the command "Download to device" in the "Online" menu to download the blocks. The compilation of the blocks is implicitly triggered before the download. If errors are signaled during this process, they must be remedied before you can download the configuration.

Deleting data blocks

Click the "Delete block" button ⑤ to delete previously generated data blocks. STEP 7 Deletes the Web-Control DB and all fragment DBs from the project containing your user pages.

3.9.3 Programming the WWW instruction

The WWW instruction

The WWW instruction initializes the Web server of the CPU or synchronizes the user pages with the user program in the CPU. The Web control DB is the input parameter for the WWW instruction and specifies the content of the pages as they are displayed in the fragment DBs as well as the status and control information. STEP 7 creates the Web control DB when you click the button "Create blocks".

Programming the WWW instruction

The user program must execute the WWW instruction so that the user pages can be accessed in the Web server.

Table 3- 6 WWW instruction

LAD/FBD	SCL	Description
	`ret_val :=WWW(ctrl_db:=uint_in_) ;`	Access to user pages by means of the Web server

Parameters

The table below shows the parameters of the WWW instruction.

Table 3- 7 Parameters

Parameters	Declaration	Data type	Description
CTRL_DB	Input	DB_WWW	Data block that describes the user pages (Web control DB)
RET_VAL	Output	INT	Error information

RET_VAL parameter

Table 3- 8 RET_VAL

Error code (W#16#...)	Explanation
0000	No error has occurred. There are no pending website requests that must be released by the user program.
00xy	x: indicates if an error occurred during initialization of the Web control DB (CTRL_DB): x=0: no errors. x=1: errors occurred. The error is encoded in the "CTRL_DB.last_error" byte of the Web control DB. y: Number of the pending request. Several requests are possible (e.g., request "0" and "1" are pending: y="3"). y="1": Request "0" y="2": Request "1" y="4": Request "2" y="8": Request "3"
803A	The specified Web Control DB does not exist on the CPU.
8081	Incorrect version or incorrect format of the Web Control DB.
80C1	There are no resources available to initialize the Web application.

3.9.4 Example of a user page

3.9.4.1 Website for monitoring and controlling a wind turbine

Example of a user page

Here you see a user page for monitoring and controlling a wind turbine:

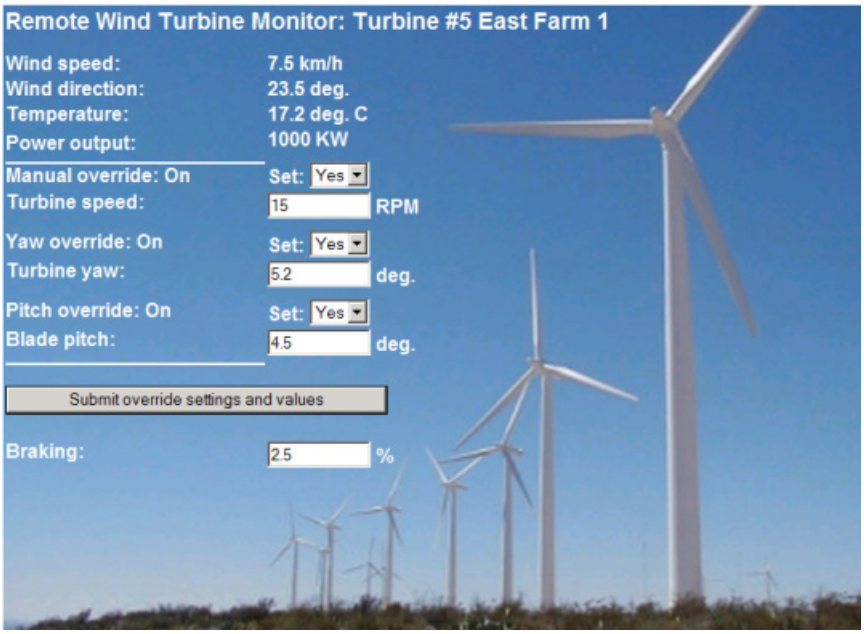


Figure 3-27 Overview of user page wind turbine

The user page was created in English in this example, but you can select any language you wish when you create your own user page.

In this application, each wind turbine of the wind farm has a data block in STEP 7 with specific data for the respective location and the turbine.

The user page gives you the option to access the turbine remotely with a display device. A user can open the standard websites for a CPU of a specific wind turbine and go to the "Remote Wind Turbine Monitor" user page to view the turbine data. A user with the corresponding access permissions can also set the turbine into the manually controlled mode and thus control the tags for speed, orientation and angle of attack of the turbine by means of the website. The user can also specify a brake value regardless of manual or automatic control of the turbine.

STEP 7 checks the Boolean values for override of the automatic control and, if set, uses the values for speed, orientation and angle of attack of the turbine as defined by the user.

Files used

Three files are used in the application example:

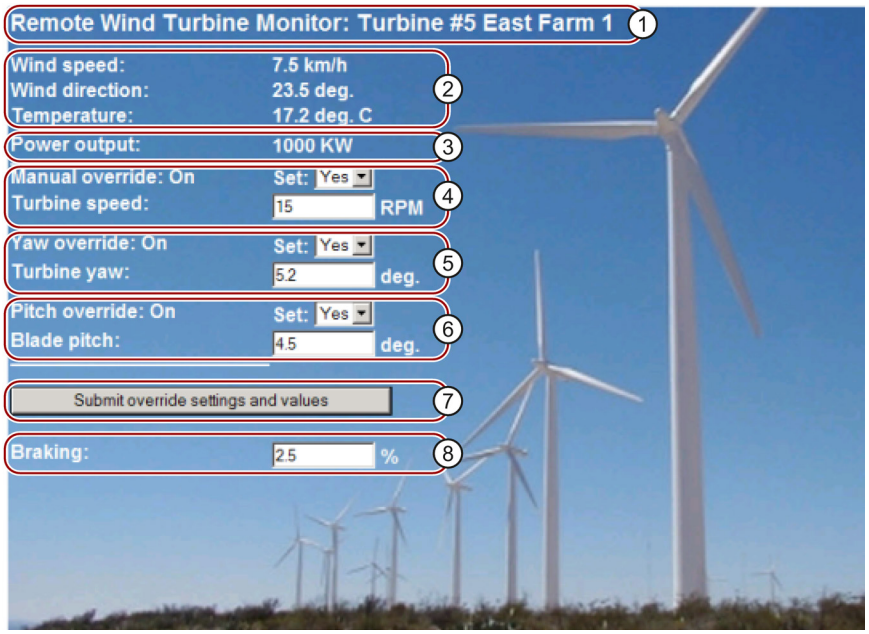
- Wind_turbine.html: The user page in the figure shown above. The control data is accessed by AWP commands.
- Wind_turbine.css: The Cascading Style Sheet which includes the formatting specifications of the user page. The use is optional but can simplify the design of the user page.
- Wind_turbine.jpg: The background image displayed on the user page. The use of images is optional, user pages with lots of images require a lot more memory in the load memory.

These files are not part of your installation but they are described as an example below.

Implementation

The user page uses AWP commands to read out values from the CPU as well as writing values to it. The user page also uses AWP commands for the definition of enum types, such as the assignment of tags to enum types for handling the ON/OFF settings.

The user page is structured as follows:



① Header of the website with number and location of the wind turbine.

② Atmospheric conditions at the turbine, wind speed, wind direction and current temperature are displayed.

③ Read-out power output.

④ Manual override: Activates manual override of the turbine. To make manual settings for speed, orientation and angle of attack, the STEP 7 user program requires that manual override has been activated.

⑤ Override of the orientation: Activates manual override of the turbine orientation.

⑥ Override of the angle of attack: Activates manual override of the angle of attack of the rotor blades.

⑦ By clicking this button, you transfer the override settings to the CPU.

⑧ Manual setting of a percentage value for braking. The setting "Manual override" is not required to enter a brake value.

Figure 3-28 Overview of user page wind turbine

The user page also uses an AWP command which writes the special tag into the tag table; it includes the user ID of the user who currently accesses the page.

3.9.4.2 Reading and displaying data from the CPU

Example HTML code for reading out and displaying data from the CPU

This part of the HTML code is used for displaying the power output on the user side.

The text "Power Output:" is displayed on the left-hand side; on the right-hand side, the value of the tags for the power output including the unit ("KW") is displayed.

The AWP command `:="Data_block_1".PowerOutput` executes the reading operation. The data block is referenced by its symbolic name here and not by its number ("Data_block_1" instead of "DB1").

The code used in the example is:

```
<tr style="height:2%;">
<td>
<p>Power output:</p>
</td>
<td>
<p style="margin-bottom:5px;"> :="Data_block_1".PowerOutput: KW</p>
</td>
</tr>
```

3.9.4.3 Using enum types

Definition of enum types

The described user page uses enum types in three locations. "On" or "Off" is displayed for a Boolean value at these locations.

The enum type for "On" results in a value of 1; the enum type for "Off" results in a value of 0. The following excerpts from the HTML code of the user page show the declaration of an enum type with the name "OverrideStatus" and the values "0" and "1" for "Off" or "On" as well as the specification of an enum type reference of "OverrideStatus" for the tag "ManualOverrideEnable" in the data block "Data_block_1".

Note

Assignment of enum types

If the user page writes into a tag by using an enum type, there has to be a declaration "AWP_In_Variable" for each "AWP_Enum_Ref" declaration.

The code used in the example is:

```
<!-- AWP_In_Variable_Name='"Data_block_1".ManualOverrideEnable' -->
<!-- AWP_Enum_Def_Name="OverrideStatus" Values='0: "Off",1:"On"' -->
<!-- AWP_Enum_Ref_Name='"Data_block_1".ManualOverrideEnable'
Enum="OverrideStatus" -->
```

The following code describes a display box for displaying the current status of "ManualOverrideEnable". A normal read command for tags is used but because of the declared and referenced enum type, the website displays the values "On" and "Off" instead of "1" and "0".

```
<td style="width:24%; border-top-style: Solid; border-top-width:
2px; border-top-color: #ffffff;">
<p>Manual override: :="Data_block_1".ManualOverrideEnable:</p>
</td>
```

The following code describes a drop-down list for changing "ManualOverrideEnable" by the user. The drop-down list consists of the "Yes" and "No" options that are assigned to the "On" or "Off" values by means of the enum type reference. If you make no selection, the status remains the same.

```
<select name='"Data_block_1"ManualOverrideEnable'>
<option value=':"Data_block_1".ManualOverrideEnable:'> </option>
<option value="On">Yes</option>
<option selected value="Off">No</option>
</select>
```

The drop-down list is included in the form on the website. The form is uploaded, when the user clicks on the "Send" button. If the user has selected "Yes", the value "1" is written in the tag "ManualOverrideEnable" in the "Data_block_1" data block; if the user has selected "No", the value "0" is written.

3.9.4.4 Writing user inputs into the controller

Setting options

The user page "Remote Wind Turbine Monitor" includes different AWP commands for writing data into the controller. A user with the corresponding access permissions can control the wind turbine manually, activate the override for the turbine speed and the turbine orientation as well as the angle of attack of the rotor blades with the declaration of different "AWP_In_Variable" write commands. The user can also specify floating-point numbers for turbine speed, orientation angle of attack and percentage of braking. The user page uses an HTTP command in the format "POST" to write the tags into the controller.

The code used in the example for setting the brake value is:

```
<!-- AWP_In_Variable Name='"Data_block_1"' -->
...
<tr sytle="vertical-align: top; height: 2%;">
<td style="width: 22%;"><p>Braking:</p></td>
<td>
<form method="POST">
<p><input name='"Data_block_1".Braking' size="10" type ="text">
%</p>
</form>
</td>
</tr>
```

This excerpt from the HTML code first defines a "AWP_In_Variable" for the "Data_block_1" data block which enables the user page to write any number of tags into the data block. The text "Breaking:" is displayed on the left-hand side; a box is available on the right-hand side in which the user can make inputs for the tag "Braking" in the data block.

The user page reads out the actual braking value from the controller and displays it in the text box. A user with the corresponding access permissions can then write a brake value that controls the braking process into the data block of the CPU.

Note

Declaration of data blocks

If you declare an entire data block by means of a "AWP_In_Variable", each tag in the data block can be written by means of the user page. If you want only specific tags in the data block to be writable, you have to declare it specifically using `<!-- AWP_In_Variable Name='"Data_block_1".Breaking'>`, for example.

3.9.4.5 Writing special tags

Using special tags

The user page "Remote Wind Turbine Monitor" writes the special tag "Server:current_user_id" into a tag of the CPU. The tag value contains the value "1" if a user is logged on and "0" if a user is not logged on. In this example, a user is logged on, so the tag value is set to "1". The special tag is written into the CPU by the user page and does not need a user interface.

The code used in the example is:

```
<!-- AWP_in_variable Name="SERVER:current_user_id" Use="User_ID" -->
```

3.9.4.6 HTML code of the user page "Remote Wind Turbine Monitor"

The complete HTML code of the example user page "Remote Wind Turbine Monitor" as well as the used Cascading Style Sheet (CSS) is listed below.

Wind_turbine.html

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd"><!--
This test program simulates a website for monitoring and operating a
wind turbine.
Required PLC tags and data block tags in STEP 7:
PLC tag:
User_ID: Int
Data blocks:
Data_block_1
Tags in Data_Block_1:
Location: StringTurbineNumber: IntWindSpeed: RealWindDirection:
RealTemperature: RealPowerOutput: RealManualOverrideEnable:
BoolTurbineSpeed: RealYawOverride: BoolYaw: RealPitchOverride:
BoolPitch: RealBraking: Real
```

```
The user-defined website shows the current values for the PLC data
and offers a drop-down list to specify the three Boolean values with
the assigned enumeration type. The selected Boolean values as well
as the data text boxes for speed, orientation and angle of attack of
the turbine are uploaded with the "Send" button. The brake value can
be specified without the "Send" button.

No actual STEP 7 program is required for using this page. The STEP 7
program would theoretically only respond to the values for speed,
orientation and angle of attack of the turbine, if the assigned
Boolean values were specified. The only requirement for STEP 7 is
that the WWW instruction is called with the DB number of the
generated data blocks for this page.
-->
<!-- AWP_In_Variable Name='"Data_block_1"' -->
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable' -->
<!-- AWP_In_Variable Name='"Data_block_1".PitchOverride' -->
<!-- AWP_In_Variable Name='"Data_block_1".YawOverride' -->
<!-- AWP_In_Variable Name="SERVER:current_user_id" Use="User_ID"-->
<!-- AWP_Enum_Def Name="OverrideStatus" Values='0:"Off",1:"On"' -->
<!-- AWP_Enum_Ref Name='"Data_block_1".ManualOverrideEnable'
Enum="OverrideStatus" --><!-- AWP_Enum_Ref
Name='"Data_block_1".PitchOverride' Enum="OverrideStatus" --><!--
AWP_Enum_Ref Name='"Data_block_1".YawOverride' Enum="OverrideStatus"
-->

<html>
  <head>
    <meta http-equiv="content-type" content="text/html; charset=utf-
8">
    <link rel="stylesheet" href="Wind_turbine.css" type="text/css">
    <title>Remote monitoring of wind turbines
    </title>
  </head>
  <body>
    <form method="post" action="">
      <table style=
      "background-image: url('./Wind_turbine.jpg'); width: 904px;
height: 534px;"
      cellpadding="0" cellspacing="2">
        <tr style="height: 2%;">
          <td colspan="2">
            <h2>
              Remote Wind Turbine Monitor: Turbine
              #:="Data_block_1".TurbineNumber:
              :="Data_block_1".Location:
            </h2>
          </td>
        </tr>

<tr style="height: 2%;">
          <td style="width: 24%;">
              Wind speed:
          </td>
```

```
                <td>
                    :="Data_block_1".WindSpeed: km/h
                </td>
            </tr>
            <tr style="height: 2%;">
                <td style="width: 24%;">
                    Wind direction:
                </td>
                <td>
                    :="Data_block_1".WindDirection: deg.
                </td>
            </tr>
            <tr style="height: 2%;">
                <td style="width: 24%;">
                    Temperature:
                </td>
                <td>
                    :="Data_block_1".Temperature: deg. C
                </td>
            </tr>
            <tr style="height: 2%;">
                <td style="width: 24%;">
                    Power output:
                </td>
                <td>
                  <p style="margin-bottom:5px;">
                    :="Data_block_1".PowerOutput: KW
                </td>
            </tr>
            <tr style="height: 2%;">
                <td style=
                "width=24%; border-top-style: Solid; border-top-width:
2px; border-top-color: #ffffff;">
                <p>
                    Manual override:
                    :="Data_block_1".ManualOverrideEnable:
                </td>
                <td class="Text">
                  Set: <select name=
                  '"Data_block_1".ManualOverrideEnable'>
                    <option value="On">Yes</option>
                    <option value="Off">No</option>
                  </select>
                </td>
            </tr>
            <tr style="vertical-align: top; height: 2%;">
                <td style="width: 24%;">
                    Turbine speed:
                </td>
                <td>
                  <p style="margin-bottom:5px;">
                    <input name='"Data_block_1".TurbineSpeed' size="10"
                    value=':="Data_block_1".TurbineSpeed:' type="text">
                    RPM
```

```
            </td>
          </tr>
          <tr style="vertical-align: top; height: 2%;">
            <td style="width: 24%;">
                Yaw override: :="Data_block_1".YawOverride:
            </td>
            <td class="Text">
              Set: <select name='"Data_block_1".YawOverride'>
                <option value="On">Yes</option>
                <option value="Off">No</option>
              </select>
            </td>
          </tr>
          <tr style="vertical-align: top; height: 2%;">
            <td style="width: 24%;">
                Turbine yaw:
            </td>
            <td>
              <p style="margin-bottom:5px;">
                <input name='"Data_block_1".Yaw' size="10" value=
                ':="Data_block_1".Yaw:' type="text"> deg.
            </td>
          </tr>
          <tr style="vertical-align: top; height: 2%;">
            <td style="width: 24%;">
                Pitch override: :="Data_block_1".PitchOverride:
            </td>
            <td class="Text">
              Set: <select name='"Data_block_1".PitchOverride'>
                <option value="On">Yes</option>
                <option value="Off">No</option>
              </select>
            </td>
          </tr>
          <tr style="vertical-align: top; height: 2%;">
            <td style="width=24%; border-bottom-style: Solid; border-
bottomwidth: 2px; border-bottom-color: #ffffff;">
            <p>
                Blade pitch:
            </td>
            <td>
              <p style="margin-bottom:5px;">
                <input name='"Data_block_1".Pitch' size="10" value=
                ':="Data_block_1".Pitch:' type="text"> deg.
            </td>
          </tr>
          <tr style="height: 2%;">
            <td colspan="2">
              <br>
              <input type="submit" value=
              "Submit override settings and values">
            </td>
          </tr>
          <tr style="vertical-align: top; height: 2%;">
            <td style="width: 24%;">
```

```
                Braking:
            </td>
            <td>
                <input name='"Data_block_1".Braking' size="10" value=
                ':="Data_block_1".Braking:' type="text"> %
            </td>
          </tr>
        </table>
      </form>
    </body>
  </html>
```

Wind_turbine.css

```
H2 {
    font-family: Arial;
    font-weight: bold;
    font-size: 14.0pt;
    color: #FFFFFF;
    margin-top:0px;
    margin-bottom:10px;
}
P {
    font-family: Arial;
    font-weight: bold;
    color: #FFFFFF;
    font-size: 12.0pt;
    margin-top:0px;
    margin-bottom:0px;
}
TD.Text {
    font-family: Arial;
    font-weight: bold;
    color: #FFFFFF;
    font-size: 12.0pt;
    margin-top:0px;
    margin-bottom:0px;
}
```

3.10 File browser

Requirements

Execute permissions must be assigned for the user in the user administration.

File browser

The browser displays the content of the SIMATIC memory card on the "File browser" website. This means, for example, that you can read and edit the log files generated by the CPU without having to run STEP 7.

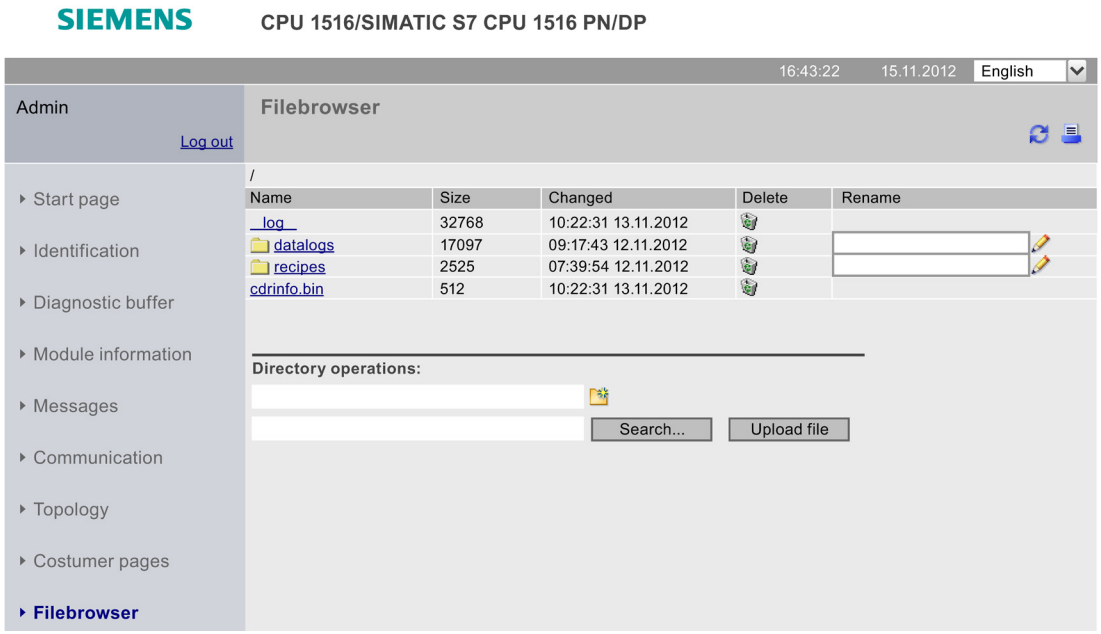


Figure 3-29 File browser view

The file browser lists all existing files and directories on the SIMATIC memory card. Depending on the file type, the files can be downloaded, deleted, renamed or uploaded. The directories can only be created, deleted or renamed.

Deleting data logs on the memory card

If you delete data logs (csv files that were generated with data log applications) on the memory card via the Web server, this could result in undefined behavior of the data log during further operation. The data logs might not be removed completely by the deletion procedure given above.

Remedy: To delete data logs reliably, use the "DataLogDelete" instruction in the user program or format the memory card.

Exception system files

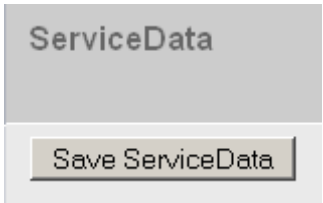
The system files include the job file and all special directories including their contents to which the job file refers. System files are not displayed, which means they cannot be changed or deleted.

3.11 Reading out service data

The Web server gives you the option to save service data. In addition to the content of the diagnostic buffer, they include additional information on the internal status of the CPU. If you should encounter a problem with the CPU that cannot be resolved otherwise, you therefore have the option to submit the service data to the Service&Support team.

Procedure

1. Enter the following address in the address bar of your web browser:
   "http://<CPU IP address>/save_service_data.html", e.g.,
   "http://192.168.3.141/save_service_data.html"
2. Your screen displays the service data page with a button for saving the service data.



3. Save the service data locally on your display device by clicking "Save ServiceData".

Result

The data is saved into a .dmp file with the following naming convention: "<MLFB><serial number><time stamp>.dmp". The user can change the file name at a later time.

Glossary

Automation system

An automation system is a programmable logic controller that consists of at least one CPU, various input and output modules, as well as operating and monitoring devices.

AWP

Automation Web Programming

AWP commands

Special command syntax for data exchange between CPU and HTML file.

Configuration

Systematic arrangement of individual modules (design).

CSS

A CSS (Cascading Style Sheet) specifies how an area or content marked up in HTML is displayed.

Diagnostics

The detection, localization, classification, visualization and further evaluation of errors, malfunction and alarms.

Diagnostics provides monitoring functions that run automatically during plant operation. This increases the availability of plants by reducing commissioning times and downtimes.

Firewall

A firewall is used to restrict the network access based on sender or target address of the used services. The firewall decides based on specified rules which of the network packets it handles are forwarded and which are not. This way the firewall tries to prevent unauthorized network access.

It is not the function of a firewall to detect attacks. It only implements rules for network communication.

HTTP

Hypertext Transfer Protocol (HTTP). Protocol for data transmission across a network.

HTTPS

Hypertext Transfer Protocol Secure (HTTPS). Protocol for tap-proof transmission of sensitive data across a network.

Identification data

Identification data is stored on a module, and contains information which supports the user in

- Checking the system configuration
- Locating hardware changes in a system
- Correcting errors in a system

Modules can be clearly identified online using the identification data.

Master

The master in possession of the token is an active device. This master has the option to receive data from other devices and to send data to other devices.

PROFIBUS

PROcess **F**ield **BUS**, process and field bus standard specified in standard IEC 61784-1:2002 Ed1 CP 3/1. It specifies functional, electrical, and mechanical properties for a bit-serial field bus system.

PROFIBUS is available with the protocols DP (= Distributed I/O), FMS (= Fieldbus Message Specification), PA (= Process Automation), or TF (= Technological Functions).

PROFINET

Within the framework of Totally Integrated Automation (TIA), PROFINET represents the consistent continuation of:

- PROFIBUS DP, the established field bus
- Industrial Ethernet, the communication bus for the cell level

Experience gained from both systems was and is being integrated into PROFINET.

PROFINET as an Ethernet-based automation standard from PROFIBUS International (previously PROFIBUS User Organization) defines a vendor-independent communication, automation, and engineering model.

PROFINET component

A PROFINET component includes the entire data of the hardware configuration, the parameters of the modules, and the corresponding user program. The PROFINET component is made up as follows:

- Technological Function

  The (optional) technological (software) function includes the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical programmable controller or field device including the I/O, sensors and actuators, mechanical parts, and the device firmware.

PROFINET IO

As part of PROFINET, PROFINET IO is a communication concept that is used to implement modular, distributed applications.

PROFINET IO allows you to create automation solutions which are familiar to you from PROFIBUS.

PROFINET IO is implemented by the PROFINET standard for automation devices on the one hand, and on the other hand by the engineering tool STEP 7.

That is, you have the same application view in STEP 7, regardless of whether you configure PROFINET or PROFIBUS devices. Programming your user program is essentially the same for PROFINET IO and PROFIBUS DP if you use the extended blocks and system status lists for PROFINET IO.

PROFINET IO controller

Device used to address connected I/O devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

PROFINET IO device

A distributed field device that is assigned to one of the IO controllers (e.g., remote IO, valve terminals, frequency converters, switches).

UTF-8

Abbreviation for 8-bit UCS (Universal Character Set) transformation format. Most popular coding of unicode characters.

Each unicode character is assigned a specially coded byte string of variable length in this format. UTF-8 supports up to four bytes on which all unicode characters can be mapped.

Web browser

Web browsers are visualization programs for websites and can communicate with Web servers.

Typical web browsers are, for example:

- Microsoft Internet Explorer
- Mozilla Firefox

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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP
Analog value processing

Function Manual

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01/2013

A5E03461439-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Ⓟ 01/2013 Technical data subject to change

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Preface

Purpose of the documentation

This documentation covers general topics applicable to all products.

In addition to introductory information about analog value processing, this manual covers the following topics:

- Wiring transducers to analog inputs
- Wiring actuators/loads to analog outputs
- Compensating for reference junction temperatures
- Calibrating analog modules

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of analog value processing (analog technology)
- Knowledge of the industrial automation system SIMATIC
- Experience of working with STEP 7 (TIA Portal)

Scope of validity of the documentation

This manual is considered the basic documentation for all analog input and analog output modules of the S7-1500, ET 200MP and ET 200SP product families.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for "STEP 7 V12 (TIA Portal)" and subsequent versions of the configuration and programming software.
This documentation includes images of the products its describes. The products supplied may differ slightly from these images.

Please note the information marked as follows:

Note

Notes contain important information on a point in the documentation of particular importance.

Additional support

Additional information on SIMATIC products is available on the Internet.
The associated documentation is also available on the Internet.

- The portfolio of technical documentation for SIMATIC products and systems can be accessed at Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and ordering system are available at Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC product range has a modular structure and covers a range of topics related to your automation system.

The complete documentation for the S7-1500, ET 200MP and ET 200SP systems consists of the respective system manual, function manuals and product manuals.

Overview of additional documents related to analog value processing

The following table lists further references that supplement this description of analog value processing.

Table 1- 1 References for analog value processing

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Configuring interference-free controllers	Function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog module	Product manual of the respective analog module	• Connecting • Parameters • Technical specifications • Parameter data record • Tables of analog values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

What you should know about analog technology 2

2.1 Overview

Introduction

This chapter is intended to familiarize you with the essential parameters of analog input modules and analog output modules based on the fundamentals of analog technology. The descriptions and examples provided on the following pages serve as a reference to the manuals for the respective analog module and are intended to facilitate the handling of these manuals.

Analog and binary signals

Binary signals know only two states: "voltage applied" (signal state 1) and "no voltage applied" (signal state 0). In control engineering, it is frequently necessary to read, process and output analog signals in addition to binary signals. In contrast to binary signals, analog signals take on any number of values within a specific range. Possible analog variables include:

- temperature
- pressure
- speed
- fill level
- pH value

Transducers

Controllers are only capable of processing analog values in the form of bit patterns. For this purpose, transducers which can be connected to the analog module measure physical variables such as pressure or temperature. The analog input module reads this analog value in the form of current or voltage. To enable the CPU to process the current or voltage measured, an integrated analog-to-digital converter in the analog input module converts the value into a 16-bit integer value. Depending on the type of measurement, you can use the following transducers:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Further information on connecting various types of transducers to analog inputs can be found in Wiring transducers (Page 49).

Example

Speed is acquired using a transducer which converts the speed range of 0 to 1500 rpm to a voltage range of 1 to 5 V. At a measured speed of 865 rpm, the transducer outputs a value of 3.3 V.

The resulting voltage value is calculated as follows:

$$U = \frac{4\ V}{1500\ \frac{r}{pm}} * 865\ \frac{r}{pm} + 1\ V = 3.3\ V$$

The graph below illustrates voltage acquisition:

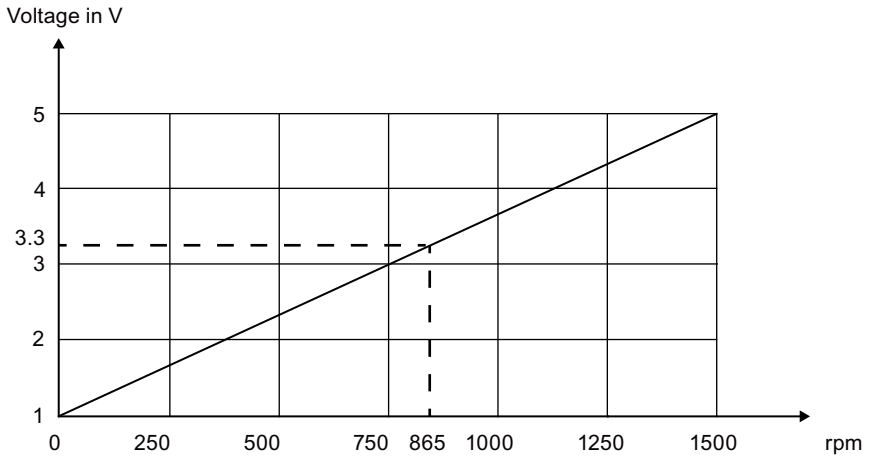
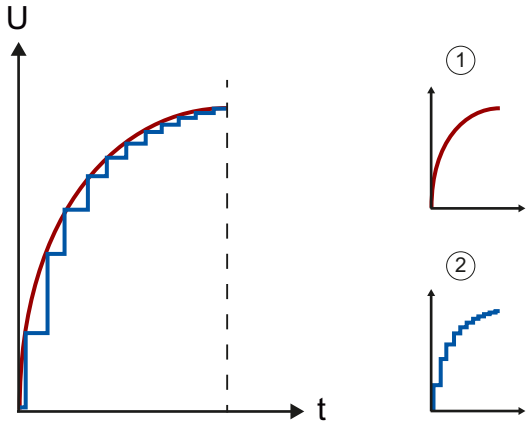


Figure 2-1 Speed measurement

Analog-to-digital conversion

A CPU processes information exclusively in digital format. The analog value is therefore converted into a bit pattern. Conversion is done using an integrated ADC (analog-to-digital converter) in the analog input module. This conversion always returns a 16-bit word for SIMATIC products. The ADC used digitalizes the analog signal and approximates its value with a stepped curve. Resolution and conversion speed are the most important ADC parameters.



① Analog value
② Digital value

Figure 2-2 Approximation of an analog value with a stepped curve

Digital-to-analog conversion

Once the CPU has processed the digital signal, an integrated DAC (digital-to-analog converter) in the analog output module reconverts the output signal to an analog current or voltage value. The resulting value is the output value used to control the analog actuators. Such actuators include, for example, small servo drives or proportional valves. You will find more information on connecting actuators in Connecting loads/actuators (Page 81).

Important parameters of analog modules

Alongside the type and range of measurement, the precision, resolution and conversion time are the main points to consider when selecting an analog module. For some applications such as systems which cover a large area, common mode or channel isolation are also important. The parameters listed here are examined in more detail in the following pages.

Processing analog signals

The following figure demonstrates analog signal processing in a PLC.

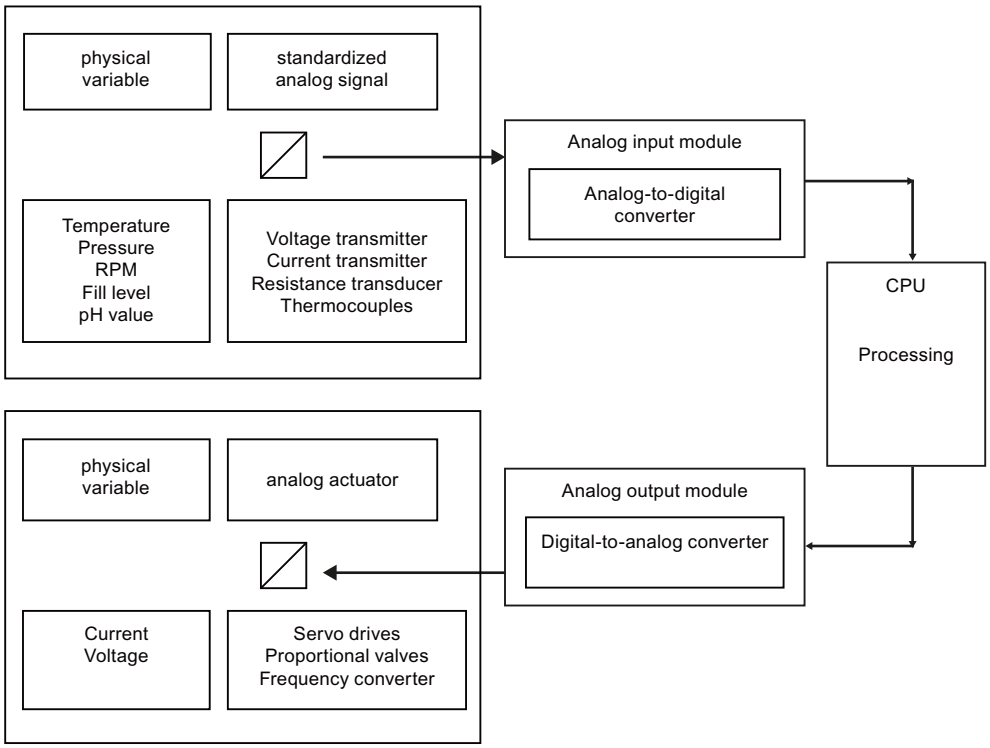


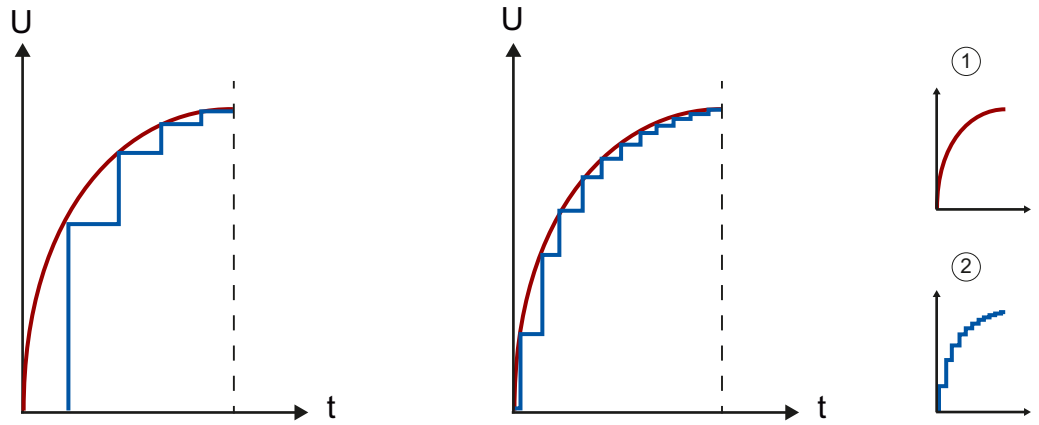
Figure 2-3 Analog value processing

2.2 Precision/resolution

The resolution of an analog module depends on the converter and its external circuitry. An approximation of the analog signal to be acquired/output is returned by a stepped curve. The resolution determines the number of increments of the analog value along this stepped curve. A higher module resolution reduces the length of increments and adds precision to the digitization of the analog signal.

Approximation of an analog value

The figures below show the approximation of an analog value by means of a stepped curve. A low resolution only returns a rough approximation of the actual curve (left figure), while the approximation is more precise at higher resolutions (right figure).



① Analog value
② Digital value

Figure 2-4 Approximation of an analog value with a stepped curve

Visualization of the measuring range at a resolution of 13 bits and 16 bits

The unipolar measured value from a module having a resolution of 13 bits (= 12 bits + S) is segmented into a total of 2^{12} = 4096 increments. The smallest increment is 10 V/4096 at a measuring range of 0 to10 V, equal to 2.4 mV.

A module with16-bit (15 bits + S) resolution has a voltage of 0.3 mV. If the resolution increases by one bit, the number of increments doubles and the width of an increment halves.

If the resolution increases from 13 bits to 16 bits, the number of increments increases eightfold from 4096 to 32768. With a resolution of 13 bits, the smallest value that can be displayed is therefore 2.4 mV. By contrast, this value is approximately 0.3 mV at a resolution of 16 bits.

Over and under range

For the display of the measuring range, the SIMATIC S7 distinguishes between the rated range, the over range or under range, and the overflow or underflow. This distinction allows you to recognize whether 10 V is actually in place or whether the measuring range is exceeded. The overflow and underflow ranges are necessary for error detection.

However, at a resolution of 16 bits the theoretically possible 32768 increments are distributed across a voltage range of 11.852 mV, which means that only 27648 increments are actually available for a resolution of 10 V. The minimum value which can be represented is therefore 0.3617 mV (see table).

Table 2- 1 Example of resolution for the 0 to 10 V measuring range of a SIMATIC S7 module

Value (increments)	Voltage measuring range	
Decimal	0 to 10 V	Range
32767	11.852 V	Overflow
32512		
32511	11.759 V	Over range
27649		
27648	10.0 V	Rated range
20736	7.5 V	
1	361.7 µV	
0	0 V	
not relevant for this example		Under range
as negative values are not possible		Underflow

The digitized visualization of the input ranges, separated into bipolar and unipolar input ranges, is shown in the section Visualization of the input ranges (Page 47). The digitized visualization of the output ranges, separated into bipolar and unipolar output ranges, is shown in the section Visualization of the output ranges (Page 48). You will find a summary of all measuring ranges which you can use with your analog module in the corresponding device manual.

Analog module precision

The precision of an analog module is specified as a percentage value or absolute value, for example, in K or °C. This characterizes the total error of measured value acquisition. The basic error limit at 25 °C, as well as the operational limit, are specified in accordance with international standard IEC 61131, which also forms the basis for European Standard EN 61131. For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 19) section.

Relation between resolution and precision

A certain resolution must be given to reach a specific precision (operational error).

Example

Measuring error as a result of digitization at a resolution of 8 bits and 14 bits

An analog module has a measuring range of 0 V to 10 V. A resolution of 8 bits represents a total of 256 values. This is equivalent to a minimum possible voltage step of 39 mV or 0.4% of the measuring range end value. A resolution of 14 bits represents a total of 16384 values. This is equivalent to a minimum possible voltage step of 0.61 mV or 0.006% of the measuring range end value.

The percentages derived in this way also represent the theoretical best-case values for the operational limit. With a resolution of 8 bits and a measuring range of 0 to 10 V, it is therefore impossible to achieve a precision of more than 0.4 %. In practical life, this value would be clearly worse, depending on the implemented circuitry.

Calculating the maximum measuring error

The maximum measuring error of a 0 to 10 V analog module with an operational limit of ±0.5 % across the entire temperature range is calculated as follows:

10 V x 0.5/100 = 50 mV

This means the maximum measuring error is approximately ±50 mV. This also means that each analog voltage input is subject to a distortion of ±50 mV across the entire input range. A voltage of 3.5 V that is to be measured is therefore visualized by any value between 3.45 V and 3.55 V.

For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 19) section.

2.3 Linearity errors

Definition

Linearity denotes the deviation of the actual A/D or D/A conversion from the ideal lines within a specified measuring range. The linearity error therefore represents the deviation of the real transmission function from the ideal straight line. The error is given in the technical data as a percentage of the rated range of the analog module.

The following figure shows the linearity error of an ADC in percent.

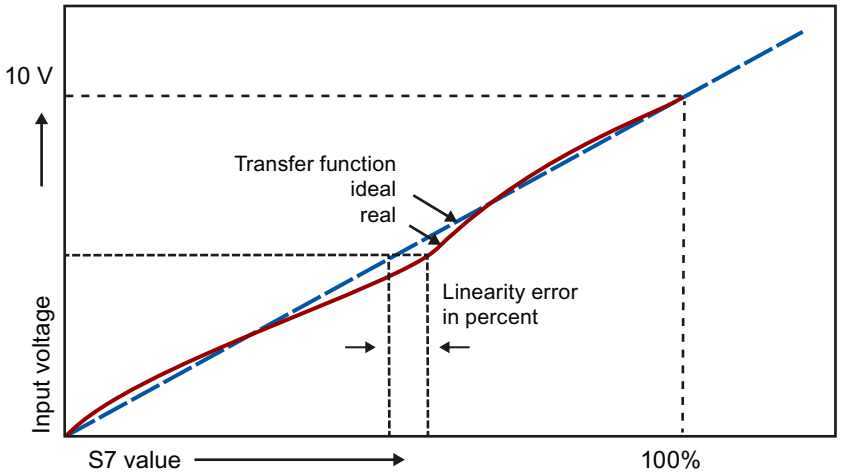


Figure 2-5 Linearity errors

Example

An error of ±1 mV is returned at an input range of ±10 V and a linearity error of ±0.01%. The error is calculated as follows: 10 V · 0.01 % = 1 mV

The linearity error information given in the technical specifications is taken into account in the operational limit. You will find a detailed description of the operational limit in Operational and basic error limits (Page 19).

2.4 Repeat accuracy

Definition

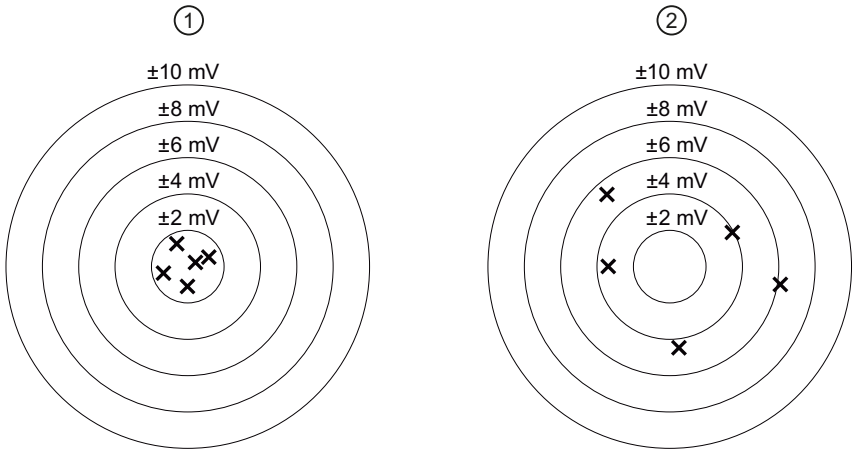
The repeat accuracy is the maximum deviation in measured/output value for the same input signal or output value after another value has been created or output. The repeat accuracy refers to the rated range of the module and applies in a steady temperature state.

Measured value variance

The repeat accuracy provides information on the variance of individual measurements. The smaller the variance, the greater the repeat accuracy. The repeat accuracy is therefore one of the most important properties of measuring devices. In the technical data, the repeat accuracy is given as a percentage of the input or output range at 25°C in the steady state.

Example

The specified repeat accuracy for an analog module is ±0.02 %. If the measured value defined is 10 V, this means the repeat accuracy is 2 mV. If you change the defined measured value from 10 V to -10 V and then measure with 10 V again, the measured value deviation may not exceed ±2 mV.



① good repeat accuracy
② poor repeat accuracy

Figure 2-6 Repeat accuracy of measured values output

2.5 Operational and basic error limits

Introduction

The following sections explain how, using the technical data, you can specify the operational limit and basic error limit to set the measuring and output error for the current or voltage measured. The worst-case configuration ensures that the module will not exceed the specified value within the valid operational range.

Operational limit

The operational limit covers the entire measurement or output error rate of the module within the approved temperature range, referenced to the rated range of the module.

Basic error limit

The basic error limit represents the entire measurement and output error rate at 25 °C, referenced to the rated range of the module.

The basic error limit is more or less a theoretical value, as a constant temperature of 25 °C is rarely maintained in plants. For this reason, the operational limit always takes priority in terms of the practical selection and assessment of a module.

Note

The operational and basic error limit percentages listed in the technical specifications always relate to the **maximum possible** I/O value in the rated range of the module.

Example of output error calculation

An analog output module is used for voltage output in a range of 0 to 10 V. The module is operating at an ambient temperature of 30 °C, which means that the operational limit applies. Technical specifications of the module:

- Operational limit for the voltage output: ±0.1%

The result is an output error of approximately ±10 mV (±0.1 % of 10 V) across the rated range of the module.

For example, the output value may range from 2.49 V to 2.51 V at an actual voltage of 2.50 V.

Note

Bipolar measuring ranges

The calculation also applies to bipolar measuring ranges.

An error of ±10 mV is also returned at an input range of ±10 V and a linearity error of ±0.1%.

2.6 Temperature error

Introduction

Analog modules are exposed to operational conditions that have an impact on their precision and on the measurement results they return. Temperature errors develop, for example, if the operating temperature of the module deviates from a room temperature of 25 °C. These temperature errors within the approved temperature range are taken into account in the operational limit.

Definition

The temperature error is the drift in the measured or output values caused by a change in the ambient temperature of the analog module. It is specified in percent per Kelvin, e.g. ±0.005 %/K, of the rated range of the analog module.

Temperature error of compensation

The temperature error of the reference junction temperature compensation function only occurs with thermocouple measurements. The temperature error of compensation is added to the actual temperature error if "Internal reference junction" operating mode is selected. The temperature error of compensation is defined in the technical specifications as a percentage of the physical rated range of the analog module or as an absolute value in °C.

Example

In this example, the total error of the temperature measurement is to be determined with the help of a type K thermocouple. The type K thermocouple takes measurements at a temperature range from -270 °C to +1372 °C.

The technical specifications state an operational limit of >-200 °C ±2.4 K for the type K thermocouple. The temperature error of compensation amounts to ±6 °C.
The total temperature error is measured as follows at a temperature of >-200 °C:

Operational error (±2.4 K) + temperature error of compensation (±6 °C) = ±8.4 °C.

Note

Calculating the error in thermocouple measurements

Add the error of a thermocouple measurement to the error of the compensation measurement to determine the total error of a thermocouple measurement.
These errors are defined in the respective manual.

2.7 Interference frequency suppression

Definition

The interference frequency suppression function is applied to analog input modules to suppress the noise caused by the frequency of the AC voltage supply used.

The frequency of the AC voltage supply is likely to have a negative effect particularly on the values returned by measurements in the low voltage range and on thermocouples.

Parameter assignment

The line frequency at which the system is operated can be set by means of module parameters, for example, in STEP 7.

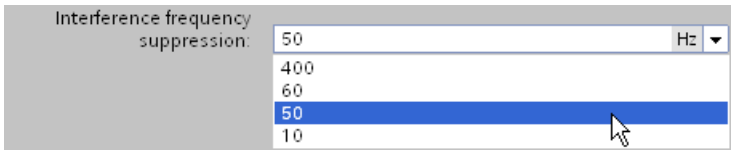


Figure 2-7 Interference frequency suppression

The conversion time changes in line with the set interference frequency suppression. The data sheets of the respective module define this dependency.

Please note the following when selecting interference frequency suppression:

The higher the frequency setting, the shorter the conversion time.

Note

Line frequency

Always select the interference frequency based on the line frequency used. Mismatch errors must be expected if a frequency that deviates from this line frequency is set, for example, to reduce the conversion time. In this case, the specified technical data and, in particular, precision are possibly outside the specified range.

Line frequencies used

The line frequency is the frequency used in an electricity network for AC supply. It is measured in hertz and indicates the number of oscillations per second in a periodic signal. A line frequency of 50 Hz, for example, means 50 oscillations per second.

Europe, Australia and most countries in Asia and Africa use a line frequency of 50 Hz. North and Central America and most countries in South America have electricity networks with a line frequency of 60 Hz.

Frequencies of 400 Hz are most commonly used in on-board networks for airplanes, in the aerospace sector and for military applications. One reason for this is that engines with a line frequency of 400 Hz can usually be made smaller and lighter. As, however, it is not economic to transport such high frequencies over large distances, 400 Hz applications are usually subject to significant spatial limits.

A frequency of 16.6 Hz is used for the traction power supply in Germany, Austria and Switzerland. Certain modules of the SIMATIC S7 product range support this line frequency. The configurable interference frequency suppression in these cases is 16.6 Hz.

2.8 Common mode interference (UCM)

Definition

Common mode interference denotes interference voltages and currents in the lines connecting electrical devices and system components. They affect both the positive and negative line with the same phase angle and amplitude. The interference signal needs an additional current path to affect the utility signal. This current path is usually provided by common reference potential, e.g. earth or ground connection, of the utility signal and interference source.

Common mode interference in analog modules

Common mode interference occurs in analog input and output modules if their reference potential is different from the reference potential of the connected sensor or actuator.

Common mode interference is most likely to occur when analog modules are operated with grounded sensors. The size of the overall system means that voltage differences may develop between machine components with grounded sensors and the analog module reference. These voltage differences affect both the positive and negative signal path equally, which is why they are termed common mode interference.

In operation with non-grounded sensors, the occurrence of common mode interference is not as obvious as in grounded operation. Nevertheless, capacitive or inductive coupling can also create voltage differences in such cases which have the effect of common mode interference. Depending on the conditions in grounded and non-grounded operation, common mode voltage can occur as direct or as alternating voltage.

Example

The following figure of an analog module with two inputs (Ch_1/Ch_2) shows the coupled interference voltages at the inputs (U_{CM1}/U_{CM2}) as well as an interference voltage coupled between these inputs (U_{CM3}). Common mode rejection indicates the extent to which these interference signals can be suppressed. It is calculated using the following equation:
CMR [dB] = 20 · log (U_{CM} / U_a)

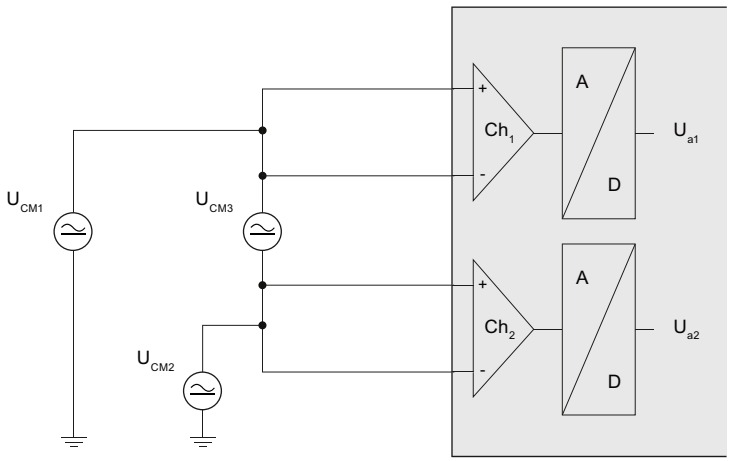


Figure 2-8 Common mode voltage coupled between two inputs

If there is common-mode voltage (U_{CM}), the equation is solved for U_a to calculate the measuring error (U_a):

$$U_a = U_{CM} * 10^{-\frac{CMR}{20}}$$

Note

The common mode rejection (CMR) is detailed in "Common mode interference" in the technical data of the device manual for your analog module.

2.9 Series mode interference (USM)

Definition

Series mode interference is interference voltages and currents affecting the connection lines in opposite directions. They have opposite polarity in the positive and negative directions. Series mode interference currents cause a voltage drop at the input impedance that has the effect of an interference voltage.

Causes

Series mode interference is caused by capacitive or inductive coupling. Inductive coupling generates a magnetic flow that is radiated between adjacent current-carrying conductors. This induces an interference voltage in the conductor. Galvanic coupling is given where different circuits influence each other due to common conductor sections, e.g. common ground connection.

The diagram below shows series mode interference as a voltage source (U_{SM}) connected in series to the actual measuring signal (U_M). The index "SM" stands for "Series Mode". Series Mode rejection indicates the extent to which these interference signals are suppressed. It is calculated using the following equation: SMR [dB] = 20 · log (U_{SM} / U_a)

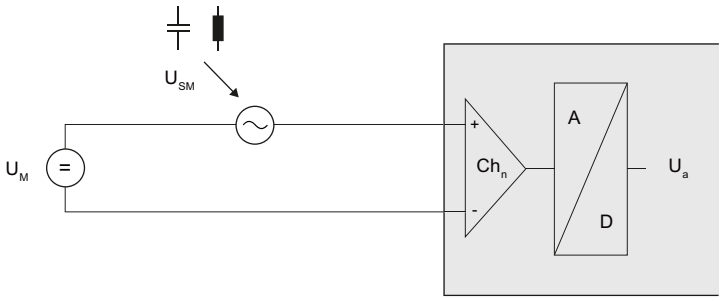


Figure 2-9 Capacitive or inductive interference coupling to the signal cable

The voltage (U_a) measurement error is calculated by solving the equation for U_a.

$$U_a = U_{SM} * 10^{-\frac{SMR}{20}}$$

The following equation shows the calculation of current (I_a) measuring errors using a current input.

$$I_a = \frac{U_{SM}}{R_{ein}} * 10^{-\frac{SMR}{20}}$$

Note

The series mode rejection (SMR) is detailed in "Series mode interference" in the technical data of the device manual for your analog module. The level of input resistance (R_{ein}) is also specified in the technical data.

2.10 Interference voltage suppression

Definition

Interference voltage suppression gives the factor by which the interference signal is suppressed in measurement value acquisition. Higher values reduce the effect of interference on the measurement signal. The technical data differentiates between "Common mode interference" and "Series mode interference". Interference voltage suppression is specified in decibels.

Example

The diagram below shows the measuring error for interference voltages in volts and interference voltage suppression of 0 to 120 dB.

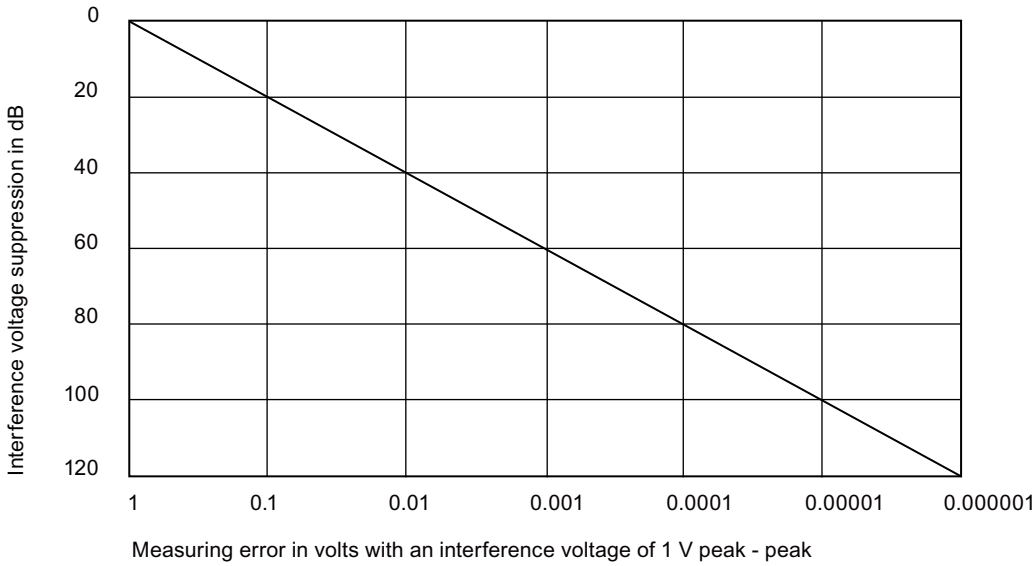


Figure 2-10 Interference voltage suppression

With an interference voltage suppression of 40 dB and an interference voltage of 1 V, the measured value is only distorted by 0.01 V.

Note

Disturbance variables can be substantially reduced by means of appropriate grounding and shielding to increase interference immunity of the configuration. You will find a detailed description of how to avoid interference in the Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Common mode rejection

The table below sets out the possible common mode rejection specifications in the technical data of an analog input module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Common mode interference	> 100 dB
Common mode voltage, max.	10 V

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for common mode interference will only apply for the frequencies 50 Hz, 100 Hz, 150 Hz, ... Immunity is lower for all other frequencies. Interferences caused by the line voltage distort the measured utility signal in the ratio of 100,000 : 1. An interference voltage amplitude of 1 V, for example, will affect the utility signal by 10 µV.

The Common Mode voltage (U_{CM}) defines the maximum permitted deviation of the potential between two channels and between one channel and analog ground. If the specified voltage, for example 10 V, is exceeded, an error will occur and the ADC will stop converting correctly. Depending on the module used, this error may be diagnosed and an error message output. The maximum common mode voltage may be exceeded as a result of varying input or overly long lines.

Series mode rejection

The table below sets out the possible series mode rejection specifications in the technical data of an analog module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Series mode interference	> 60 dB

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression will only apply for the frequencies 50 Hz, 100 Hz, 150 Hz, ... Immunity will be lower for all other frequencies. Overall, interference caused by the line voltage distorts the utility signal measured by 1000 : 1. For example, an interference voltage amplitude of 1 V will affect the utility signal by 1 mV.

2.11 Crosstalk between channels

Origin of the term

The term crosstalk/XT was originally used in the field of telecommunication to denote unwanted coupling of voice signals between two cable conductors of different subscribers.

Definition

Crosstalk between signal channels denotes the interactive influence between two independent channels as a result of leakage currents and capacitive or inductive coupling. Crosstalk between the channels changes the signal by the value of the amplitude of the crosstalk signal.

Causes

Technically, it is not feasible to totally isolate the module channels from environmental conditions. This means that it is always possible for leakage currents or disturbance coupling having an interactive effect.

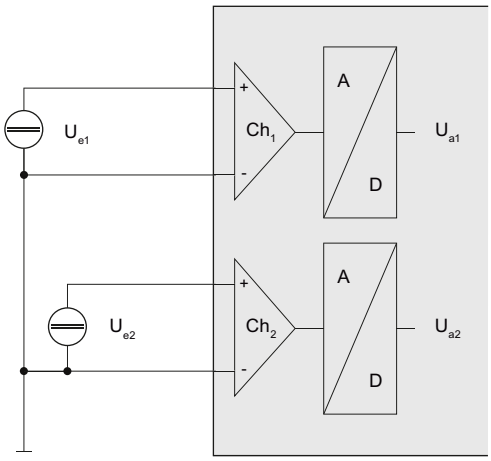


Figure 2-11 Crosstalk between two channels

The diagram shows the effects of crosstalk for the user with two channels (Ch_1/Ch_2) of an analog module. The crosstalk value is the factor by which the utility signal at a second channel U_{a2} is affected by the signal at the first channel U_{e1}. The measuring error (U_{a1}) can be calculated using the following equation:

$$U_{a1} = U_{e2} * 10^{-\frac{XT\,[dB]}{20}}$$

Example of crosstalk attenuation

The "crosstalk between inputs" value in the technical specifications is defined as a value of >-100 dB at a measuring range of -10 V to +10 V on channel 1 of an eight-channel analog input module. The voltage at the input has an amplitude of 10 V. What is the error caused by crosstalk at channel 0 (measuring range ±10 V) and channel 2 (measuring range ±80 mV)?

100 dB are equal to a factor of 100,000. The measured values at channels 0 and 2 to 7 are therefore affected by 10 V / 100,000 = 100 µV. This distortion is added to or subtracted from the pending measuring signal and its effect depends on the selected measuring range.

- Channel 0: 100 µV / 10 V = 0.001 %
- Channel 2: 100 µV / 80 mV = 0.125 %

A voltage of 10 V set at channel 1 distorts the measured value at channel 0 by 0.001% and the measured value at channel 2 by 0.125%. The measuring error resulting from crosstalk in this example is therefore 0.001 % or 0.125 %. The basic error limit already includes the error generated as a result of crosstalk between the channels.

Calculating measuring error

You calculate the measurement error at channel 1 in this example based on a change in the measurement voltage of 10 V at channel 2. The crosstalk (XT [dB]) value is defined in the technical specifications in the manual of the analog module that you are using.

$$\text{Measured value error channel 1 [in V]} = \text{measured value change at channel 2 [in V]} * 10^{\frac{\text{XT [dB]}}{20}}$$

$$\text{Measured value error channel 1 [in V]} = 10\ \text{V} * 10^{\frac{-80\ \text{dB}}{20}} = 0.001\ \text{V}$$

A change in the measurement voltage of 10 V at channel 2 causes a measurement deviation of 0.001 V at channel 1.

2.12 Diagnostics

Diagnostics for analog modules

SIMATIC analog modules can diagnose errors. A number of different types of diagnostics are available for analog modules in STEP 7. Please note that the parameter assignment options vary depending on the analog module and product type used. The tables below give examples of S7-1500 diagnostics. Further information on the types of diagnostics can be found in the device manual for your analog input or analog output module.

Proceed as follows to select the diagnostics types of the analog module used:

1. Open STEP 7.
2. Select the analog module in the Device view.
3. Select "General" in the "Properties" tab.
4. Select the inputs or the required channel of the analog module in the Inspector window.

Table 2- 2 Overview of diagnosable errors

Type of diagnostics	Analog input module	Analog output module
Wire break	✓	✓
Missing supply voltage L+	✓	✓
Overflow	✓	✓
Underflow	✓	✓
Common mode error	✓	
Short-circuit to ground		✓
Reference channel error	✓	

Diagnostics are carried out while the system is in operation, on the basis of the current output variable such as current or voltage. If there is no longer sufficient output current or output voltage, the module will not be able to run reliable diagnostics. The limits within which diagnostics are possible are specified in the technical data for each module.

The module sends the diagnosed state to the CPU using a diagnostic error interrupt. Diagnostics are output on LED displays on the affected module, on the CPU display, on the Web server or on an HMI device.

The configurable diagnostics types depend on the respective selected measuring or output type. The following table shows the relationship between the diagnostics and measuring or output types of an analog input or analog output module.

Table 2- 3 Diagnostics available for each type of measurement selected for an analog input module

	Missing supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference channel error
Voltage	✓	✓ (1 to 5 V)	✓	✓	✓	
Current (4-wire transducer)	✓	✓ (4 to 20 mA)	✓	✓	✓	
Current (2-wire transducer)	✓	✓ (4 to 20 mA)	✓	✓	✓	
Resistor (4-wire connection)	✓	✓	✓	✓		
Resistor (3-wire connection)	✓	✓	✓	✓		
Resistor (2-wire connection)	✓	✓	✓	✓		
Thermal resistor (4-wire connection)	✓	✓	✓	✓		
Thermal resistor (3-wire connection)	✓	✓	✓	✓		
Thermocouple	✓	✓	✓	✓	✓	✓

Table 2- 4 Configurable diagnostic types dependent on the selected output mode of an analog output module

	Missing supply voltage L+	Wire break	Overflow	Underflow	Short-circuit to ground
Voltage	✓		✓	✓	✓
Current	✓	✓	✓	✓	

Note

Measuring ranges

Note that the diagnostic types that can be parameterized depend on the selected measurement/output type as well as on the respective measuring range.

Note

Minimum output values

Certain errors such as wire break and short circuit cannot be diagnosed below a given current or voltage value. Diagnostics are only possible again once the output returns to above this minimum value.

Missing supply voltage L+

You can diagnose a missing or low supply voltage L+ at the analog module by activating the "Missing supply voltage L+" check box. If the supply voltage is missing or too low, the status and error display on the analog module will provide the relevant information. The entry in the diagnostic buffer also makes this information available to the CPU.

If there is no supply voltage, no other types of diagnostics available are possible either.

Wire break

The term wire break denotes a failure state that is triggered by the interruption of a usually closed electrical circuit.

Wire break in analog input modules

The "Wire break" diagnostics function facilitates the detection of errors during system operation. STEP 7 lets you define the module properties by setting different parameters. Depending on the module used, you may, for example, be able to set a current limit parameter at which a wire break is to be reported.

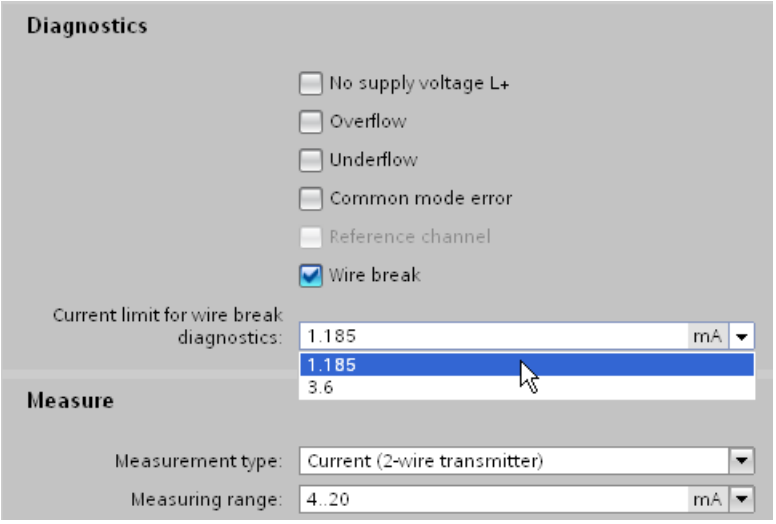


Figure 2-12 Configuring the wire break current limit for an analog input module in STEP 7

Usually, the live zero technique is deployed to detect wire breaks. The start of the measuring range for the standard live zero signal of 4 to 20 mA is assigned the 4 mA signal value.
A wire break between the input and sensor can therefore be detected based on the missing current flow. Instead of a current signal, you may also use a voltage signal from 1 to 5 V to detect a wire break. The "Wire break" diagnostics function can therefore only be configured for a range of 4 to 20 mA or 1 to 5 V.

For "Resistor", "Thermal resistor" and "Thermocouple" measurements, a current is impressed into the line. If a wire break occurs, the flow of current is interrupted and the analog module therefore detects the wire break.

Wire break in analog output modules

A wire break at an analog output can only be diagnosed in current output mode. The analog signal output is used for wire break detection. Reliable wire break diagnostics is not possible if the voltage is too low. In this case, the diagnostic function is deactivated without triggering a change of the diagnostic status.

The current limit up to which the module will diagnose wire break can be found in the technical data for the module.

Overflow/underflow

The resolution of the measuring range of an analog input module distinguishes between the rated range, the over range or under range, and the overflow or underflow. The following table assign the number of increments into which the measured signal is divided to the various voltage measuring ranges.

Table 2- 5 Voltage measuring range ±10 V of an analog input module

Value (increments)	Voltage measuring range	Range
Decimal	±10 V	
32767	> 11.759 V	Overflow
32511	11.759 V	Over range
27649		
27648	10.0 V	Rated range
0	0 V	
-27648	-10 V	
-27649		Under range
-32512	-11.759 V	
-32768	< -11.759 V	Underflow

As of a decimal value of 32512, the value acquired is beyond the over range and is no longer valid. If this is the case, the error status "Overflow" is diagnosed. The over range is a tolerance range before overflow is reached.

As of a decimal value of -32513, the value acquired is below the configured measuring range and is no longer valid. If this is the case, the error status "Underflow" is diagnosed. The under range is the equivalent of the over range, but for negative values.

An "overflow" diagnostics may be caused, for example, by a wire break or by an incorrect measuring range.

Note

Accuracy

The accuracy specified in the technical data of the relevant module is only guaranteed within the rated range.

Common mode error

Activating the "Common mode" checkbox diagnoses a violation of the maximum potential difference U_{CM}. The maximum potential difference U_{CM} may, for example, be exceeded between the reference point of the measuring inputs and the analog ground M_{ANA} .

Possible causes:

- Wiring error
- Environments with EMC disturbance
- Incorrectly grounded transducers
- Long line lengths
- Sensor not connected
- 2-wire transducer connected to M_{ANA}

Note

With 4-wire transducers, a current meter connected in series will result in too great a drop in voltage.

Potential differences U_{CM} beyond the valid limits may lead to measurement errors and malfunctions. If you want to ensure that the maximum value is not exceeded, interconnect the measuring inputs and analog ground M_{ANA} with an equipotential bonding cable. Further information can be found in Wiring transducers (Page 49).

Short-circuit to ground

Selecting the "Short circuit to ground" checkbox activates short-circuit diagnostics for an analog output channel. The diagnostics function is triggered by channel overload.

Possible causes:

- Wiring error (e.g. short circuit between conductors at the connections or in the cable)
- Use of faulty or incorrect actuators (e.g. internal short circuit or low input resistance as a result of actuator failure)

A "Short circuit to ground" diagnostics is only available for the voltage output mode. The analog signal output is used for short circuit detection. If the voltage is too low, reliable short-circuit diagnostics are not possible. In this case, the diagnostic function is deactivated without triggering a change of the diagnostic status. The voltage limit up to which the module will diagnose a short circuit can be found in the technical data for the module.

SIMATIC modules have a special protective circuit to prevent short circuit. The short circuit current is limited internally in the module. The level of short circuit current is specified in the technical data of your analog module.

Note

Please note that overload exposes the modules are exposed to a greater thermal load. This can affect the precision of the output channels. You should therefore avoid continuously running analog output modules in overload.

Reference channel error

This type of diagnostics can only be selected for analog input modules for "Thermocouple" measuring. Selecting the "Reference channel" checkbox diagnoses an error on the reference channel for compensating the reference junction temperature.

The temperature at the reference junction of a thermocouple is measured at the reference channel of the module using an external resistance temperature detector (RTD). If an error occurs, for example as a result of a wire break, the temperature measured at the reference junction of the thermocouple will no longer be compensated. The reference temperature may then be outside the valid range.

Further information on connecting thermocouples and resistance temperature detectors and on how they operate can be found in Thermocouples (Page 61) and Wiring transducers (Page 49).

2.13 Conversion time of an analog module

Basic conversion time and conversion time of an analog input channel

The basic conversion time is the minimum time required by one single channel to convert analog values. The actual conversion time comprises both the basic conversion time and, depending on the analog input module used:

- Processing time for measuring resistance
- Processing time for wire break monitoring
- Processing time for overflow/underflow monitoring
- Processing time for checking common mode errors

Example

This example shows channel 6 of an analog input module for resistance measurement in the range of 6000 Ω, a configured integration time of 20 ms, and activated wire break monitoring.

The conversion time of the channel is derived from the total of the following measurement variables:

Measurement variable	Time in ms
Basic conversion time	27
Processing time for RTD/resistance (6000 Ω)	4
Processing time for wire break monitoring in the RTD/resistance and thermocouple areas	9
Conversion time of the channel	**40**

Conversion time of the analog output channels

The conversion time of an output channel starts with the transfer of the digital value from internal memory of the module and ends with the digital-to-analog conversion.

The conversion time does not include the settling time for the analog signal at the module terminal. Detailed information on the settling time can be found in Settling and response times of analog output modules (Page 37).

2.14 Cycle time of an analog module

Definition

The cycle time of an analog module represents the time that the module needs to process all channels used. The cycle time depends on the form of measured value acquisition used, e.g. multiplex or parallel measured value acquisition.

Sequential measured value processing

This procedure processes the analog channels in the module one after another (sequentially). For analog inputs, the values are connected to a converter, for example using a multiplexer, and sequentially converted.

The cycle time of the analog module is derived from the total conversion time of all activated analog channels of the module. provides the option of deactivating unused analog channels. to reduce the cycle time.

The figure below gives an overview of the factors that determine the cycle time of an n-channel analog module.

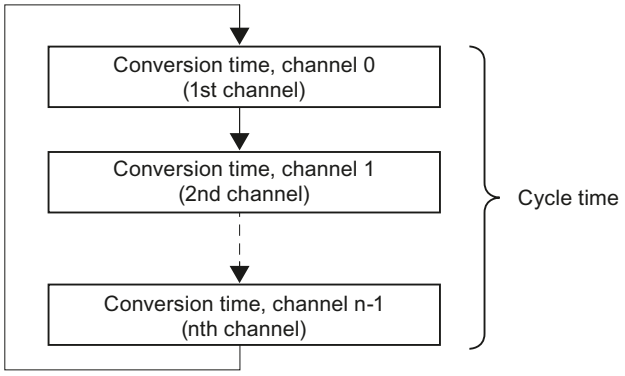


Figure 2-13 Cycle time of an analog module with multiplex conversion

Parallel measured value acquisition

This procedure processes the analog channels of a module at the same time (in parallel) rather than one after another. In parallel measured value processing, the cycle time of the module is usually constant and does not depend on the number of channels used.

2.15 Settling and response times of analog output modules

Settling and response times provide information on the delay of the output of a specified analog output variable and its availability to the process.

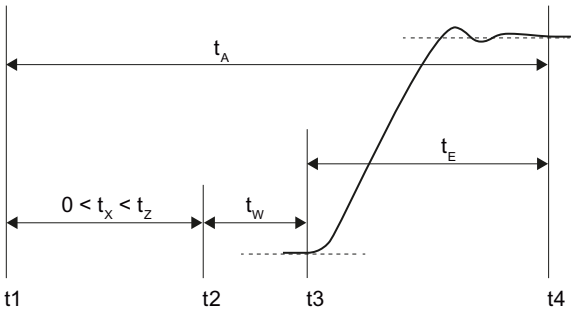
Response time

The response time for a new output value is defined as the time between the input of a digital output value to the internal memory of the module and the value to be output at the analog output being reached (with a residual error of 1 %).

The response time (t_A) is the sum of application time (t_X), conversion time (t_W) and settling time (t_E):

$t_A = t_X + t_W + t_E$

Settling and response times of analog output modules



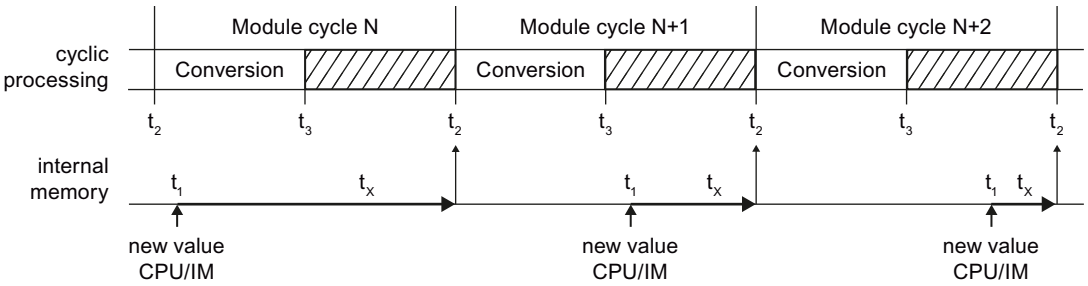
t_A	Response time
t_X	Application time
t_Z	Module cycle time
t_W	Conversion time
t_E	Settling time
t1	New digital output value is available in the internal memory of the module
t2	Module activates the digital output value and starts conversion
t3	Module ends conversion at the terminal of the analog output channel and outputs the analog signal
t4	Signal has settled and the specified analog output value has been reached (residual error 1%)

Figure 2-14 Settling and response time of an output channel

Application time

The CPU/IM (Interface Module) writes new output values to the internal memory of the analog output module. These output values are converted asynchronously to their entry in buffer memory. The worst-case application time (t_X) may be equal to the cycle time (t_Z). This situation develops if the CPU writes a new value to internal memory of the module immediately after the transfer of the value for conversion. This new value will not be processed until the next conversion.

The following figure shows acyclic access of the analog output module to output values from the internal memory.



t_X Application time

t1 New digital output value is available in the internal memory of the module

t2 Module activates the digital output value and starts conversion

t3 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

Figure 2-15 Application of the output values

Conversion time

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module (t_2) and ends with the digital-to-analog conversion (t_3).

Settling time

The settling time starts when the analog signal is output to the module (t_3) terminals and ends when the output value (t_4) is reached. The output value is reached as soon as the output signal has settled at its final value, taking into account a residual error of 1%.

The settling time depends on the type of output for the module, and on the connected load. The load for the analog output consists of connecting line and connected actuator. When the output is current, the settling time increases with ohmic resistance. Inductive loads cause subsequent fluctuation in the output value. When the output is voltage, the capacitive load causes subsequent fluctuation.

2.16 Smoothing

Using the smoothing functions

Most analog input modules allow you to configure smoothing for the measuring signal in STEP 7 . Smoothing analog values reduces the effect of interference signals. Smoothing is useful with slow changes in measured values, for example in temperature measurements.

Smoothing principle

The measured values are smoothed by means of filtering. The module forms mean values from a specified number of converted (digitalized) analog values. Smoothing should not be confused with the integration of measured values over a defined period of time. It is therefore not possible to smooth measured signals to filter out a specific interference frequency. However, this smoothing returns more "stable" data values because it suppresses peaks which overlay the measured signal.

4 (none, weak, medium, strong) or more levels of smoothing can be configured by the user depending on the module used. The level determines the number of analog values from which the mean value is generated. The greater the smoothing factor, the better the filtering.

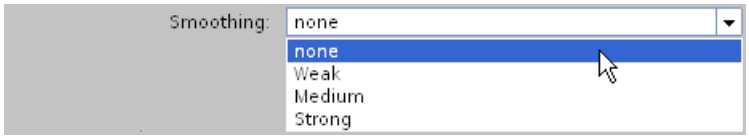


Figure 2-16 Selecting smoothing level in STEP 7

Smoothing method

A smoothing algorithm is applied to a configurable number of measured values (e.g. 4, 8, 32) in line with the moving average. Each new measured value is factored in, and the oldest measured value then ignored. This mechanism suppresses interference peaks which overlay the measured signal. Utility signal jumps only become evident in the date after some time (see examples below).

The modules of the various product ranges use different smoothing algorithms. Smoothing is either linear or exponential. The differences are apparent particularly with strong smoothing and lead to a faster or slower rate of rise depending on the product used.

For information on whether or not a specific module supports customization of the smoothing function, please refer to the manual of the analog input module.

Example 1: Linear smoothing

The diagram below shows the number of module cycles (k) it takes for each smoothing level setting for the smoothed analog value to reach approximately 100 % after a step response. This specification is valid for all signal changes at the analog input.

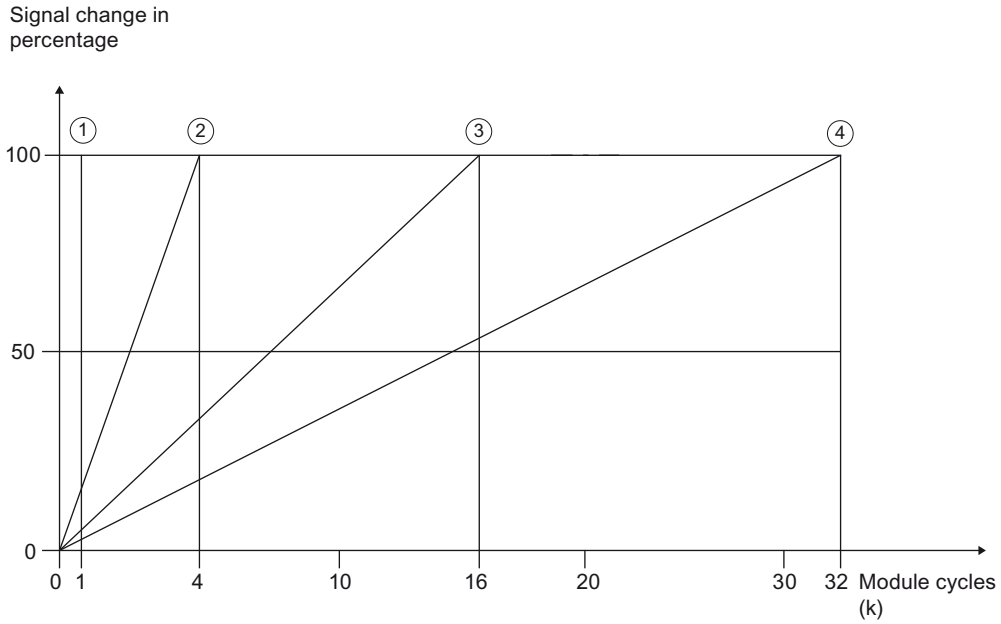


Figure 2-17 Linear smoothing with four smoothing levels

①	No smoothing (k = 1)
②	Weak smoothing (k = 4)
③	Medium smoothing (k = 16)
④	Strong smoothing (k = 32)

Example 2: Exponential smoothing

The diagram below shows the step response of the smoothing factor for different numbers of module cycles.

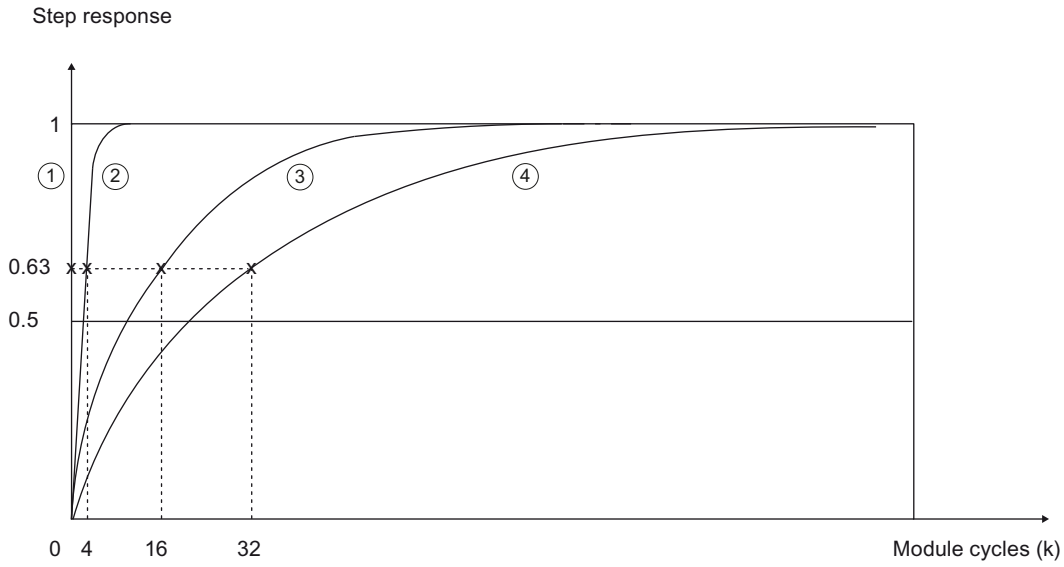


Figure 2-18 Exponential smoothing with four smoothing levels

①	No smoothing (k = 1)
②	Weak smoothing (k = 4)
③	Medium smoothing (k = 16)
④	Strong smoothing (k = 32)

2.17 Burden with 2-wire transducers

2-wire transducers

2-wire transducers are current transducers which convert the process variable into a current signal of between 4 and 20 mA. Two connection lines supply the transducer with an output current of at least 4 mA. Detailed information on connecting 2-wire transducers to analog input modules can be found in Wiring current transducers (Page 55).

Burden

The burden indicates how great the external resistance in a current loop may be. If the external resistance is greater than the specified burden, the 2-wire transducer supply voltage is too low. The burden consists of the resistance of the transducer and all other resistances connected to the current loop.

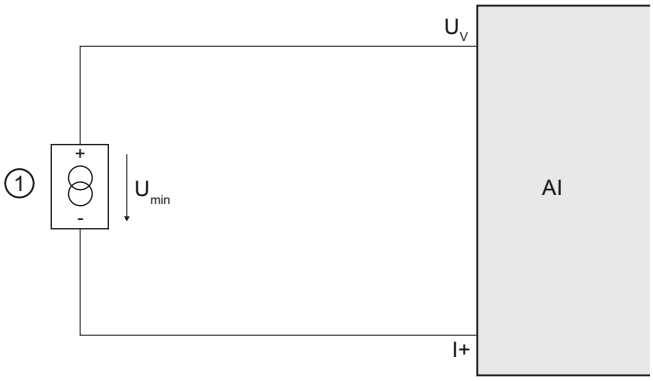
The maximum admissible burden of the transducer, e.g. 820 Ω, is specified in the technical data of the analog module.

Example 1: Connecting a transducer to the electrical circuit

In accordance with the technical data of the 2-wire transducer used, it requires a supply voltage (U_{min}) of at least 8.5 V. Using Ohm's Law, you can calculate the resistance of the transducer used (R_{2DMU}) for a current of 20 mA.

$$R_{2DMU} = \frac{U_{min}}{I} = \frac{8.5\ V}{0.020\ A} = 425\ \Omega$$

With a supply voltage of at least 8.5 V, the transducer has a resistance of 425 Ω. The resistance is less than 820 Ω. You can therefore connect the transducer to the analog input module (AI) without exceeding the maximum burden.



① 2-wire transducers

U_V Terminal for feed voltage at the channel

I+ Terminal for current input

U_{min} Voltage drop at 2-wire transducer

Figure 2-19 Connecting a transducer to the electrical circuit

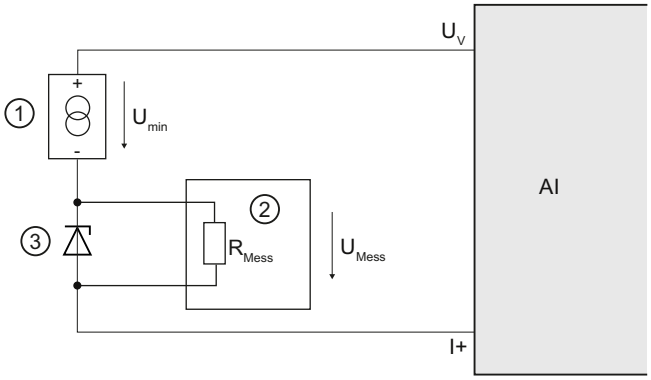
Example 2: Connecting a transducer and other devices

If multiple measuring devices are connected in series, the sum of all connected resistances may not exceed the value of the maximum burden.

If you have connected a 2-wire transducer to a supply voltage of 8.5 V, you will need to allow for the resistance of the measuring device connected ②.

Maximum transducer burden:	820 Ω
Transducer resistance upon a voltage drop of 8.5 V:	425 Ω
Maximum resistance of additional devices connected:	395 Ω

The resistance of the measuring instrument may therefore not exceed 395 Ω.



① 2-wire transducers
② Digital multimeter
③ Zener diode
U_V Terminal for feed voltage at the channel
I+ Terminal for current input
U_{min} Voltage drop at 2-wire transducer
R_{Mess} Resistance at measuring instrument
U_{Mess} Voltage drop at the measuring instrument

Figure 2-20 Connecting a transducer and other devices to the circuit

Calculating admissible voltage drop

The maximum additional resistance in the current loop may not exceed 395 Ω at a maximum current of 20 mA. You can calculate the voltage drop at the connected measuring instrument (U_{Mess}) as follows using Ohm's Law:

$U_{Mess} = R_{Mess} * I = 395\ \Omega * 0.020\ A = 7.9\ V$

The voltage drop at the measuring instrument should therefore not exceed 7.9 V.

Representation of analog values 3

3.1 Overview

Conversion of analog values

The CPU only processes analog values in digitalized format.

Analog input modules convert the analog signal into a digital value for further processing by the CPU.

Analog output modules convert the digital output value from the CPU into an analog signal.

Analog value representation at 16-bit resolution

The digitized analog value is the same for all I/O values at the same rated range.
The analog values are represented as fixed point numbers in twos complement.
This leads to the following conditions:

Table 3- 1 Representation of analog values

Resolution	Analog value															
Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Significance of the bits	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Sign

The sign of the analog is always set in bit 15:

- "0" → +
- "1" → -

Resolution less than 16 bits

The analog value is left-aligned in the memory of analog modules with a resolution of less than 16 bits. The unused least significant digits are padded with "0" values.

This reduces the number of measured values that can be represented. Modules occupy a range of values of between+32767 and -32768 regardless of the resolution. The scaling between two successive values depends on the resolution of the module.

Example

The following example shows how the least significant digits are padded with "0" values:

- The module with 16-bit resolution is capable of incrementing the values in steps of one unit ($2^0 = 1$).
- The module with 13-bit resolution is capable of incrementing the values in steps of 8 units ($2^3 = 8$).

Table 3- 2 Example: Bit pattern of a 16-bit and 13-bit analog value

Resolution	Analog value															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
13-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	0	0	0

S = sign

Note

For information on the resolution supported by each analog module, please refer to the technical data for the relevant module.

3.2 Representation of input ranges

The tables below set out the digitalized representation of the input ranges by bipolar and unipolar range. The resolution is 16 bits.

Please see the device manuals for each analog input module for assignment of the values to the specific measured values in each measuring range.

Table 3- 3 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 3- 4 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Under range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

3.3 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Please see the device manuals for each analog output module for assignment of the values to the specific output values in each measuring range.

Table 3- 5 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < -32512 are specified, the output value is limited to -117.593%.

Table 3- 6 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < 0 are specified, the output value is limited to 0%.

Connecting transducers 4

4.1 Overview

Introduction

This chapter describes the basic procedure for wiring transducers to analog inputs. Information on specific wiring options is available in the manual of each module.

For more information, e.g. on cable routing and shielding or potential equalization, please refer to the function manual for Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Transducers that can be wired to analog inputs

You can wire the following transducers to the analog input modules, depending on the type of measurement:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Isolated transducers and non-isolated transducers

Transducers are available in various models:

- Isolated transducers are **not** connected locally to the ground potential. Floating operating is possible.
- Non-isolated transducers are **connected** locally to the ground potential.

  Non-isolated transducer connections are connected to the conductive enclosure.

  Note: All non-isolated transducers must have a galvanic connection to each other and be locally connected to the ground potential.

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AI	Analog input module
M	Ground connection
L+	Supply voltage connection
M_n+/M_n-	Measuring input, channel n
I_{Cn}+/I_{Cn}-	Current output to thermal resistor (RTD) channel n
U_n+/U_n-	Voltage input channel n
I_n+/I_n-	Current input channel n
COMP+/COMP-	Compensation input
I_{Comp}+/I_{Comp}-	Current output for compensation
U_V	Supply voltage at the channel for 2-wire transducers (2WT)
U_{CM}	Potential difference between the reference points of the measuring inputs / the analog ground M_{ANA}
U_{ISO}	Potential difference between the reference points of the measuring inputs and the central ground
M_{ANA}	Reference point of the analog ground

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

4.2 Wiring analog inputs with MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated in analog input modules with M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value U_{ISO} is not exceeded, interconnect terminal M_{ANA} and the central ground with an equipotential bonding cable.

Limited potential difference U_{CM} (common mode)

Always verify that the admissible potential difference U_{CM} between the reference point of the measuring inputs and the analog groundM_{ANA} is not exceeded.

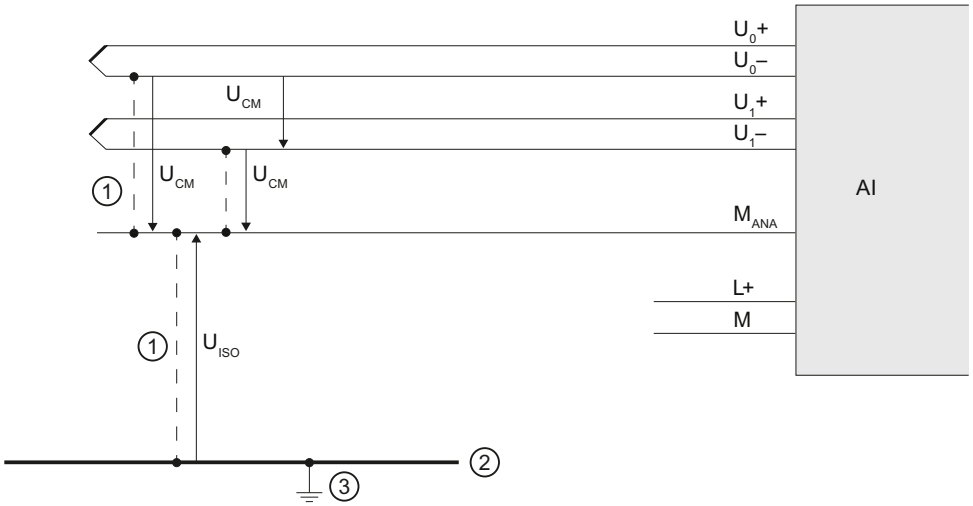
Potential differences U_{CM} may be caused by:

- Environments with EMC disturbance
- The use of grounded transducers,
- The use of long lines.

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the maximum value U_{CM} is not exceeded, interconnect the reference points of the measuring inputs and the analog ground M_{ANA} with an equipotential bonding cable.



① Equipotential bonding cable
② Grounding bus cable
③ Central ground

Figure 4-1 Example: Reference potential for analog input modules with M_{ANA} connection

4.3 Wiring analog inputs without MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated from each other in analog input modules without an M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the maximum potential difference U_{ISO} between the reference points of the measuring inputs and central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum valueU_{ISO} is not exceeded, interconnect the reference points of the measuring inputs and the central ground with an equipotential bonding cable.

Limited potential difference U_{CM} (common mode)

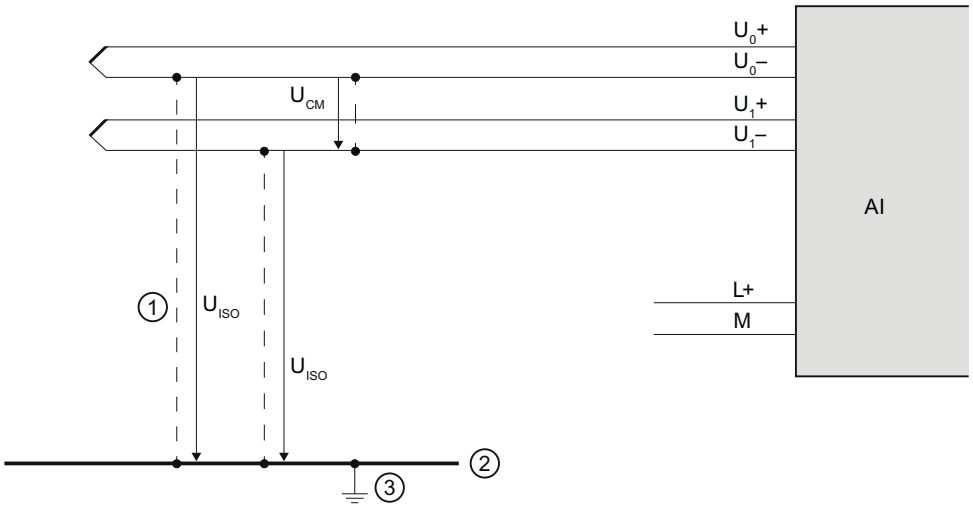
Always ensure that the permitted potential difference U_{CM} between the reference points of the measuring inputs is not exceeded.

Potential differences U_{CM} may be caused by: Environments with EMC disturbance, use of grounded sensors, use of long cables.

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure the admissible value U_{CM} is not exceeded, interconnect the reference measuring inputs with an equipotential bonding cable.

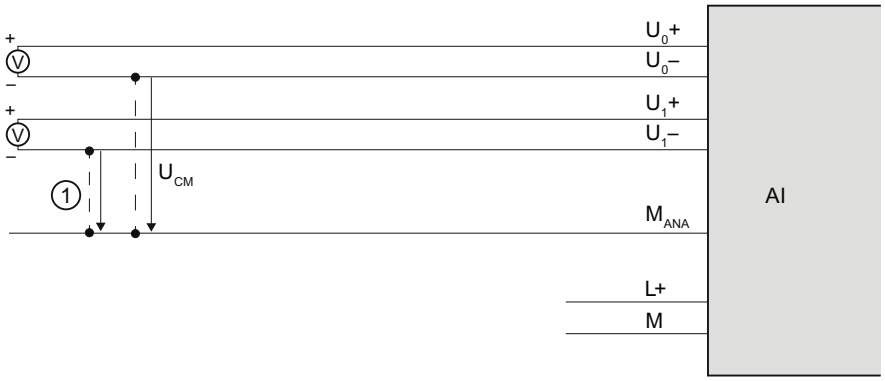


① Equipotential bonding cable (not for 2-wire and resistance transducers)
② Grounding bus cable
③ Central ground

Figure 4-2 Example: Reference potential for analog input modules without M_{ANA} connection

4.4 Wiring voltage transducers

The figure below shows how to connect voltage transducers. If you want to ensure that the maximum value U_{CM} is not exceeded, interconnect the reference points of the measuring inputs and the analog ground M_{ANA} with an equipotential bonding cable.



① Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-3 Example: Wiring voltage transducers to an analog input module

4.5 Wiring and connecting current transducers

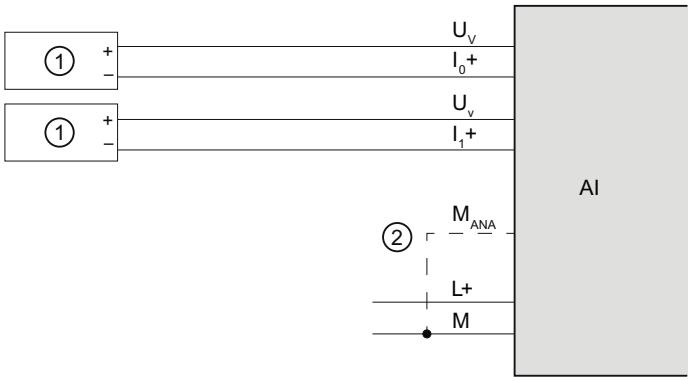
Current transducers are available as 2-wire transducers and 4-wire transducers.
Below are a number of ways to supply current transducers with voltage.

Wiring 2-wire transducers with power supply from the module

The 2-wire transducer converts the process variable into a current. The 2-wire transducer is wired to the short circuit-proof supply voltage at the terminals of the analog input module. The transducer is therefore frequently also called a "passive transducer". Its simple wiring means that the 2-wire transducer is frequently used in industrial environments. If you use this type of connection, you will need to set current measurement in STEP 7 (**2-wire transducer**).

Note

2-wire transducers must be electrically isolated.



① 2-wire transducers (2WT)

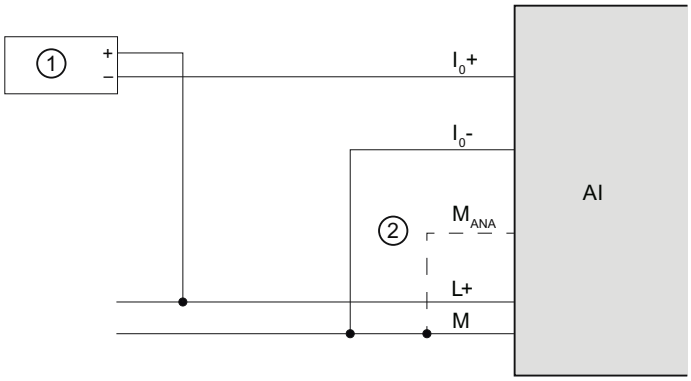
② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-4 Example: Wiring 2-wire transducers to an analog input module

Wiring 2-wire transducers to an analog input for 4-wire transducers

The figure below shows an alternative to the above connection: supplying the 2-wire transducer from supply line L+ of the module. If you use this type of connection, you will need to set current measurement in STEP 7 (**4-wire transducer**).

In this type of connection, galvanic isolation between supply voltage L+ and the analog circuit will be removed.



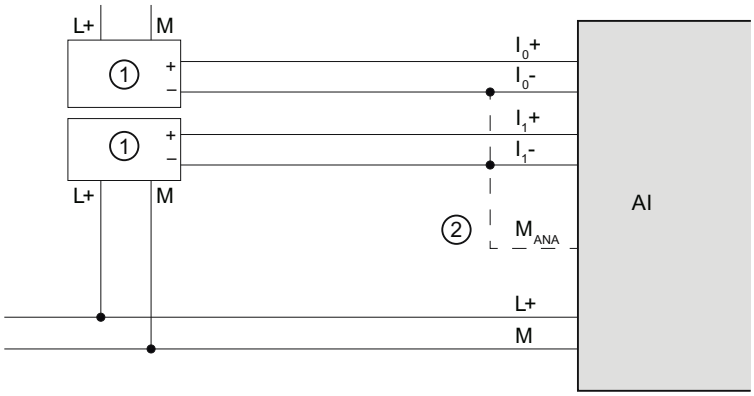
① 2-wire transducers (2WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-5 Example: Wiring 2-wire transducers to an analog input for 4-wire transducers

Wiring and connecting 4-wire transducers

4-wire transducers provide terminals for connecting a separate supply voltage. They are powered with an external supply and are frequently called "active transducers". If you use this type of connection, you will need to set current measurement in STEP 7 (**4-wire transducer**).



① 4-wire transducers (4WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-6 Example: Wiring 4-wire transducers to an analog input module

4.6 Wiring thermal resistors and resistors

The module provides a constant current at terminals I_C+ and I_C- for resistance measurements. The constant current is fed to the resistance to be measured where it is measured as voltage drop. It is important to wire the constant current cables directly to the resistance thermometer/resistor.

Measurements with 4-wire or 3-wire connection compensate for line resistance and therefore return a higher precision compared to measurements with 2-wire connection.

Measurements with 2-wire transducers always acquire the resistance value plus line resistance; you must therefore allow for a loss of precision in the measuring results.

The figures below give some connection examples.

4-wire connection of a resistance thermometer

The voltage at the resistance temperature detector is acquired using high-impedance measurement via the M_0+ and M_0- terminals. Make sure the wiring is correctly poled (I_{C0}+ and M_0+, and I_{C0}- and M_0- to the resistance temperature detector).

Always wire the **I_{C0}+ and M_0+** lines, and the **I_{C0}- and M_0-** lines directly to the resistance temperature detector.

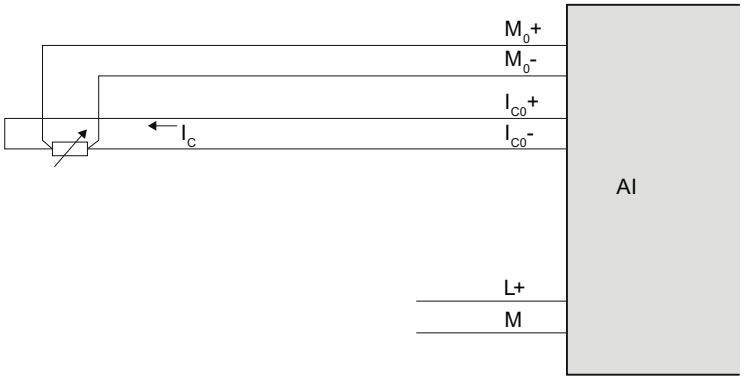


Figure 4-7 Example: 4-wire connection of a resistance thermometer to an analog input module

3-wire connection of a resistance thermometer

Depending on the module, for a 3-wire connection to modules with 4 terminals (per channel), you may need to insert a bridge between **M_0- and I_{C0}-** (see figure below) or between **M_0+ and I_{C0}+** . Always wire the **I_{C0}+** and **M_0+** lines directly to the resistance temperature detector.

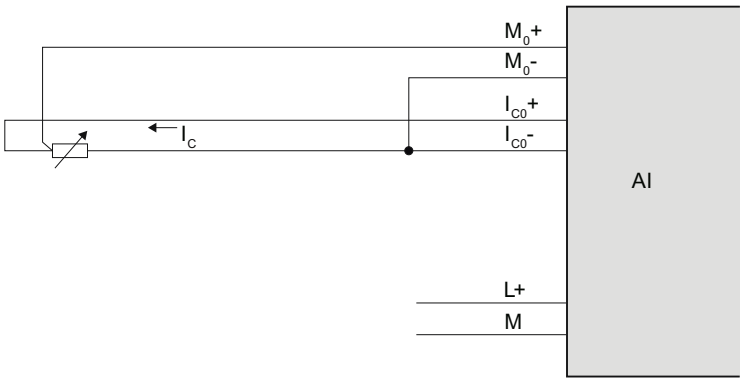


Figure 4-8 Example: 3-wire connection of resistance thermometers to an analog input module

2-wire connection of a resistance thermometer

When installing a 2-wire device on modules with 4 terminals (per channel), you will need to insert bridges at the module between **M_0+ und I_{C0}+** and between **M_0- und I_{C0}-** as shown in the figure below. The line resistance is measured, but not compensated. This type of measurement is based on physical conditions and lacks the precision of 3-wire or 4-wire measurements. The wiring for this type of measurement is, however, simple as the bridges required can be wired in the plug, saving line.

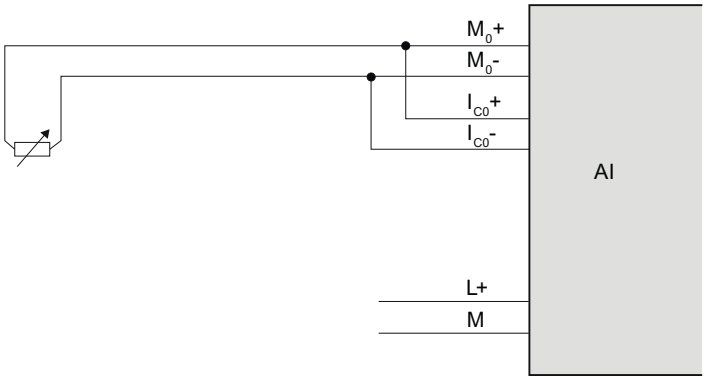


Figure 4-9 Example: 2-wire connection of resistance thermometers to an analog input module

4.7 Wiring thermocouples

Introduction

Thermocouples are generally supplied ready-to-use. Protective casing prevents the thermocouples from being destroyed by mechanical force, for example.

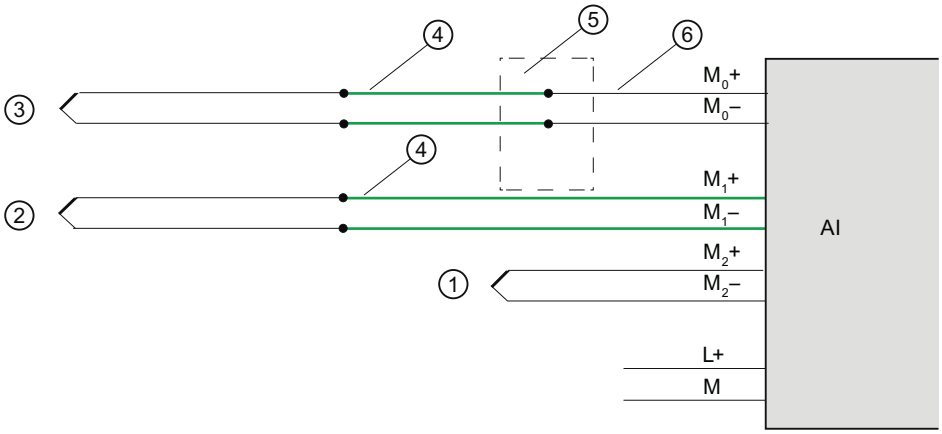
Compensating lines

The compensating lines belonging to the respective thermocouples are identified by a special color code, because only the compensating line that is made of the material matching the thermocouple may be used. The standardized compensating lines are specified in DIN EN 60584. Observe the maximum temperatures in the manufacturer's specifications.

Thermocouple connection options

There are various different ways to connect thermocouples to an analog input module:

- Directly ①.
- Using compensating lines ②.
- With a compensating line to the reference junction, connected with a supply line, e.g. copper ③.



① Thermocouple without compensating line
② Thermocouple with compensating line
③ Thermocouple with compensating line and supply line
④ Compensating line (same material as thermocouple)
⑤ Reference junction
⑥ Copper supply cable, for example

Figure 4-10 Example: Wiring thermocouples to an analog input module

Further information

Further information, for example on the choice of thermocouples and how they operate, can be found in Thermocouples (Page 61).

Thermocouples 5

5.1 Thermocouple selection

Introduction

Thermocouples are electrical devices for precise temperature measurement. They consist of two different metals connected at one point. Temperature affecting this point generates a voltage difference from which the temperature can be calculated.

Thermocouples can measure a wide range of temperatures and come in extremely robust models. They are therefore frequently used in industrial applications. Below are some of the criteria to consider when choosing a thermocouple:

- Temperature range
- Atmospheric conditions
- Price

Grounded thermocouples

In grounded thermocouples, a conductive thermocouple wire is attached to the inside of the sensor housing. This results in good heat transfer from the sensor housing to the thermocouple measuring tip.

Non-grounded thermocouples

In non-grounded thermocouples, the thermocouple is not connected to the sensor housing. The response time following temperature changes is longer than with grounded thermocouples. The measuring point is galvanically isolated.

Type and temperature range

The different thermocouple types are derived from different material compositions.

Due to physical conditions, thermocouples are extremely inaccurate outside the specified temperature range. Only use thermocouple in the temperature range specified by the manufacturer.

The following table lists the types and material compositions, as well as the temperature measuring range of different thermocouples:

Type	Material composition	Temperature range
B	PtRh-PtRh	250 to 1820 °C
C	W-Re	0 to 2315 °C
E	NiCr-CuNi	-270 to 1000 °C
J	Fe-CuNi	-210 to 1200 °C
K	NiCr-Ni	-270 to 1372 °C
L	Fe-CuNi	-200 to 900 °C
N	NiCrSi-NiSi	-270 to 1300 °C
R	PtRh-Pt (Pt 13%)	- 50 to 1769 °C
S	PtRh-Pt (Pt 10%)	-50 to 1769 °C
T	Cu-CuNi	-270 to 400 °C
U	Cu-CuNi	-200 to 600 °C
TXK/XKL	NiCr-CuCr	-200 to 800 °C

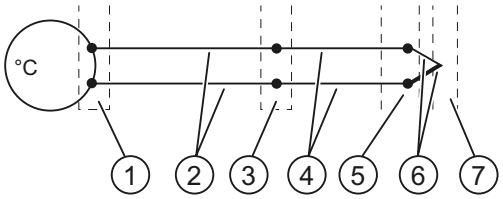
5.2 Structure and operating principle of thermocouples

Thermocouple structure

A thermocouple consists of a pair of thermal sensors and the respective installation and wiring elements. Two wires made of different metals/alloys are welded together at their ends (hot end). The welding point forms the so-called measuring point, while the free ends of the thermocouple form the reference junction.

The free ends are interconnected with the evaluation device (e.g. analog input module) via insulated wires or cables.

The different thermocouple types, e.g. K/J/N, are derived from different material composition; the same measuring principle is applied to all thermocouples, independent on their type.



① Thermal voltage acquisition point
② Copper supply cable, for example
③ Reference junction
④ Compensating line (same material as thermocouple)
⑤ Connection point
⑥ Thermocouple with positive and negative thermal elements
⑦ Measurement point

Figure 5-1 Thermocouple

Operating principle of thermocouples

Temperature differences between the measuring point and the free ends of the pair of thermal sensors (connection point) generate a thermal voltage at the reference junction. The value of the thermal voltage is determined by the temperature difference between the measuring point and the free ends, as well as by the material composition of the pair of thermal sensors.

Thermocouples always acquire a differential temperature, which means that the temperature at their free ends (reference junction) must be known to determine the temperature at the measuring point.

The thermocouple can be extended with compensating lines from the connection point. This allows the reference junction to be located at a specific point, for example where the temperature can be kept constant or the temperature sensor is easy to install. The compensating lines and thermocouple wires are made of the same material. Copper cables are used to connect the reference junction to the module.

Note

Always observe the polarity, as incorrect wiring will result in unacceptable measuring errors.

5.3 Compensation for the reference junction temperature

5.3.1 Overview

Introduction

You have several options for measuring the reference junction temperature in order to obtain a correct temperature value as a function of the temperature difference between the reference junction and the measuring point.

You have various compensation options to suit requirements at the location of the reference junction.

The compensation options supported by the analog module used are specified in the manual of the respective module.

Options of compensating for the reference junction temperature

Table 5- 1 Compensation options: Explanation and use case

Compensation options	Explanation	Use case / special feature
Internal reference junction	**Function principle** With this type of compensation, the temperature of the reference junction is measured using an integrated sensor in the analog module. **Procedure** Connect the thermocouple to the I/O module directly, or with compensating lines; see chapter Compensation by means of internal reference junction (Page 67).	• For the connection, use compensating lines that match the thermocouple material. • If the reference junction temperature and the module temperature are identical in your system, you may also use lines made from a different material. • Advantages: – Inexpensive – No external reference junction required – No additional wiring required
Reference channel of the module	**Properties** With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the reference channel of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation via reference channel of the module (Page 69).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction. • Advantages: – More precise compared to compensation with internal reference junction; however, you need to install and wire an additional thermal resistor.
Reference channel of group 0	**Properties** With the "TC" (thermocouple...) setting, the channel acts as receiver for the reference junction temperature of group 0. The associated transmitter of group 0 is set up to for the RTD channel. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the configured reference channel for group 0 of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation, reference channel of Group 0 (Page 71).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction (transmitter).

Compensation options	Explanation	Use case / special feature
Fixed reference temperature	**Properties** With this type of compensation, the reference junction temperature is stored in the module as fixed value. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Depending on the module, you can enter a fixed reference junction temperature in the configuration data (e.g. 20 °C), or use the fixed reference junction temperature of the module (0 °C); see chapter Compensation by means of fixed reference temperature (Page 74).	• You keep the reference junction temperature constant and know the temperature value. • To ensure high precision, you must ensure that the temperature remains constant (this can be complicated, depending on the application).
Dynamic reference temperature	**Properties** With this type of compensation, the reference junction temperature is determined using a module. Transfer this temperature value to other modules in the user program by means of a data record. **Procedure** Wire the thermal resistor (RTD) for the reference junction to any channel. The reference junction temperature is transferred from the CPU or IM to the module in data records by means of a function block call; see Compensation by means of dynamic reference temperature (Page 77).	• You are using multiple modules at the reference junction and can therefore compensate for all channels using a common temperature value. • You only need a thermal resistor (RTD) or a thermocouple to measure the temperature value.

5.3.2 Compensation by means of internal reference junction

Function principle

The reference junction for compensation via internal reference junction is at the terminals of the analog input module. Wire the thermocouples or compensating lines directly to the module inputs. The internal temperature sensor acquires the module temperature and returns a compensating voltage.

Note that compensation via internal reference junction will not always reach the precision of external compensation!

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measurement" area.
5. Select the "Thermocouple" value as "Type of measurement".
6. Select the "Internal reference function" value as "Reference junction for TC".

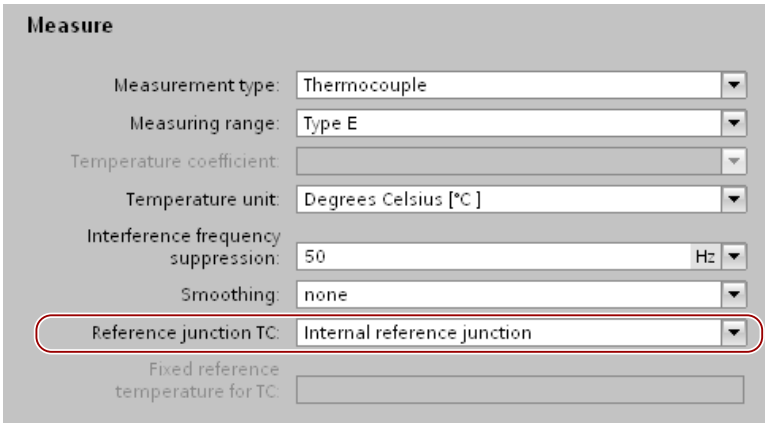
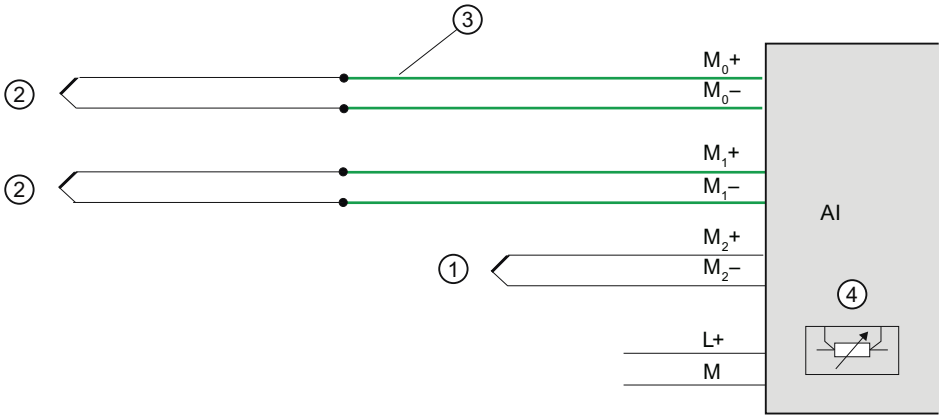


Figure 5-2 Internal reference junction

Wiring thermocouples

Wire the thermocouples directly or indirectly via compensating lines to the module inputs.



① Thermocouple without compensating line
② Thermocouple with compensating line
③ Compensating line (same material as thermocouple)
④ Internal reference junction

Figure 5-3 Example: Wiring thermocouples for compensation via internal reference junction

5.3.3 Compensation via reference channel of the module

Function principle

With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). Certain modules provide an internal reference channel.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measurement" area.
5. Select the "Thermocouple" value as "Type of measurement".
6. Select the "Reference channel of the module" value as "Reference junction for TC".

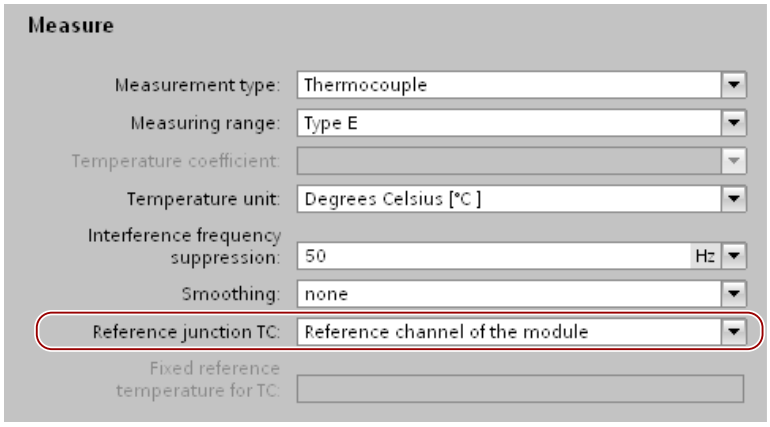
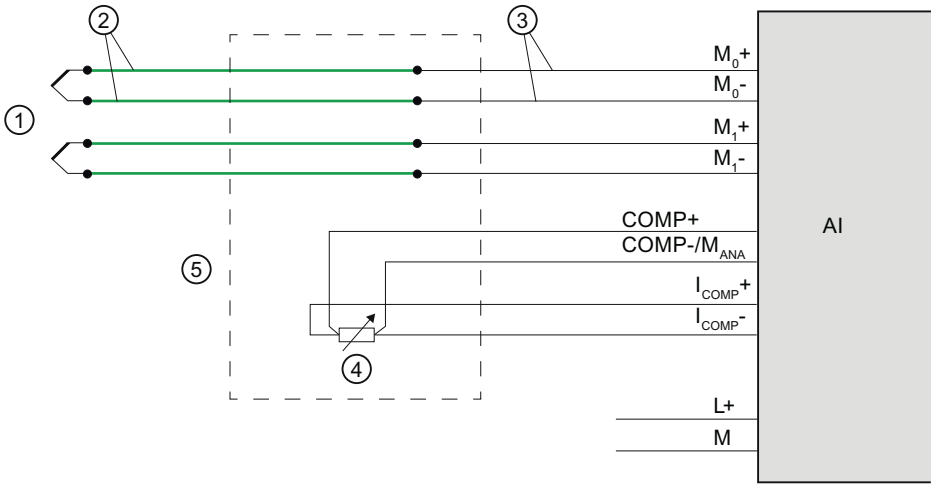


Figure 5-4 Reference channel of the module

Wiring thermocouples and thermal resistors

Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-5 Example: Wiring thermocouples/thermal resistors for compensation by means of reference channel of the module

5.3.4 Compensation, reference channel of Group 0

Function principle

For this compensation, a module channel with a connected thermal resistor (RTD) acts as "Reference temperature transmitter". Other channels (reference temperature receivers) with connected thermocouples can be compensated using this reference temperature. The measured temperatures of all channels (receivers) that you have configured for this compensation type will be compensated automatically by the temperature value of the reference junction (transmitter).

The reference junction temperature is determined by means of an external thermal resistor (RTD).

Procedure

Configuration steps:

1. Open the project in STEP 7
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the inspector window of the selected module
4. Select the area "Inputs/measurement".
5. For the channel of the relevant module, specify as transmitter:

   As "Type of measurement" select, for example, "Thermal resistor (4-wire connection)".

   As "Reference junction", select the value "Reference channel of group 0".

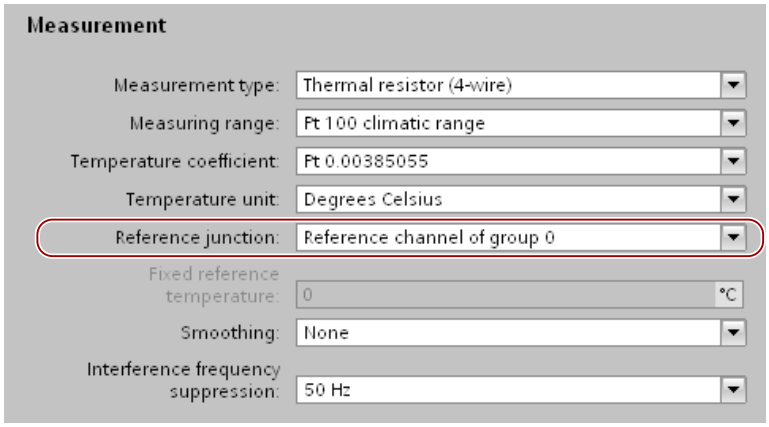


Figure 5-6 Transmitter: Reference channel of group 0

6. For the channels you specify as receivers:

   Select the "Thermocouple" value as "Type of measurement".

   As "Reference junction", select the value "Reference channel of group 0".

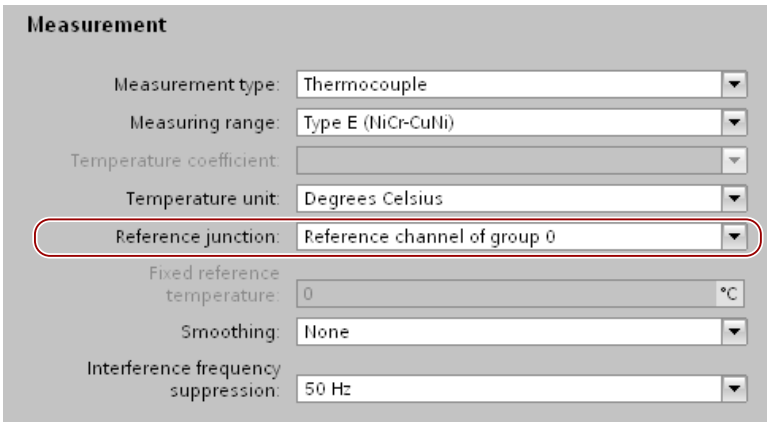


Figure 5-7 Receivers: Reference channel of group 0

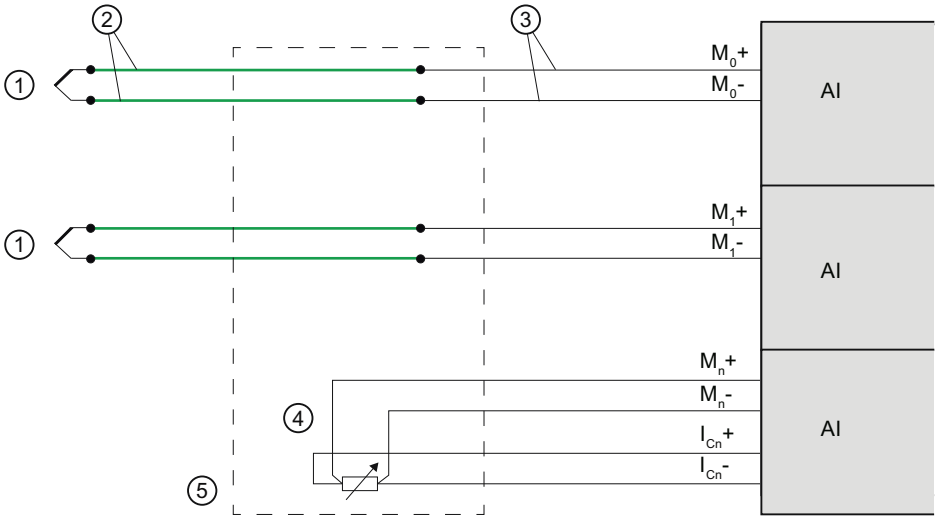
Wiring thermocouples and thermal resistors

The example below shows:

- An analog module with thermal resistor as reference temperature transmitter and
- Two analog modules with thermocouple as reference temperature receivers.

Connect the thermocouples to the supply lines at the reference junction, either directly or with compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-8 Example: Wiring thermocouples/thermal resistors for group 0 compensation

5.3.5 Compensation by means of fixed reference temperature

Function principle

With this type of compensation, the reference junction temperature is stored in the module as fixed value.

Procedure

Configuration steps:

- Open the project in STEP 7.
- Select the analog module in the Device view .
- Select the "General" tab in the Inspector window of the selected module.
- Go to the area "Inputs/Measurement".
- Select the "Thermocouple" value as "Type of measurement".
- Select the "Fixed reference temperature" value as "Reference junction for TC".
- Specify the temperature of the reference junction in the "Fixed reference temperature" area, for example, 20 °C.

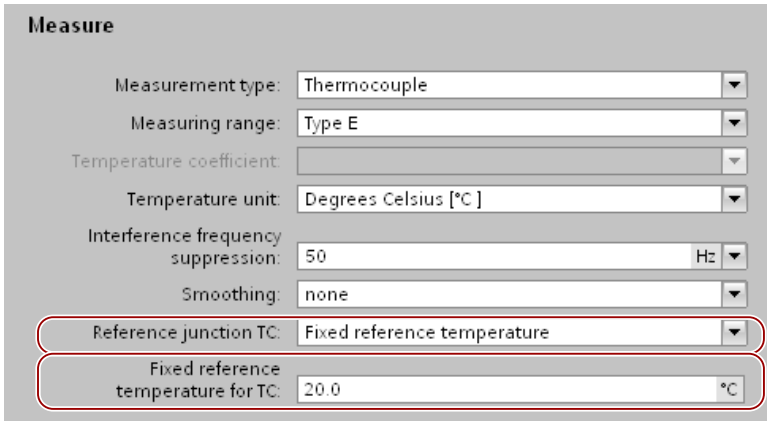
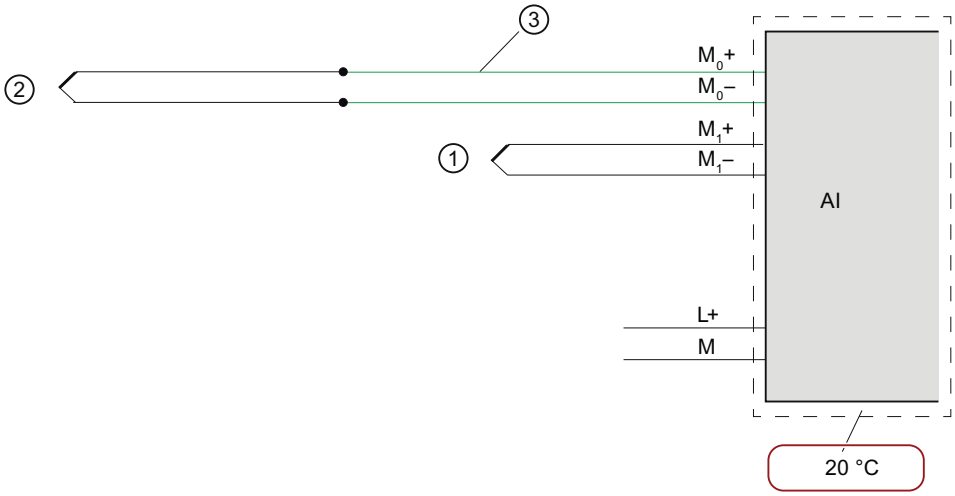


Figure 5-9 Fixed reference temperature

Temperature condition with "Fixed reference temperature" setting

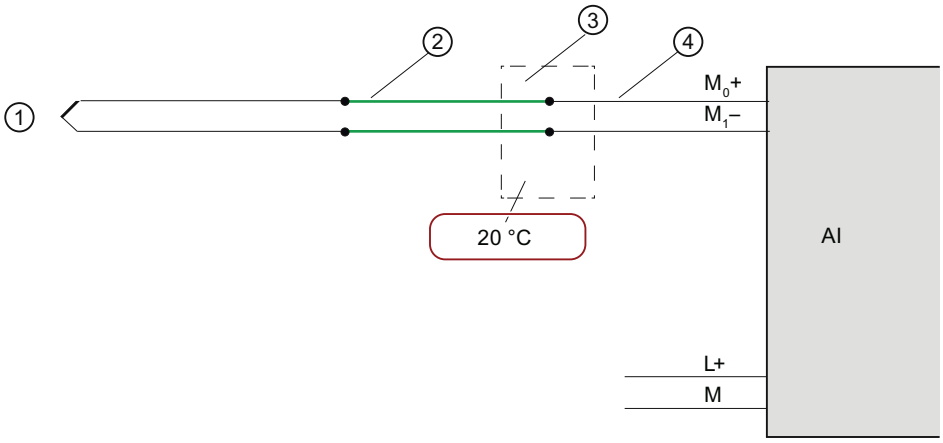
The figure below shows the connection options for thermocouples provided the temperature of the module is kept at a fixed reference temperature (20 °C), for example by installing it in an air-conditioned switch cabinet. The reference junction is in the module.



① Thermocouple without compensating line
② Thermocouple via compensating line
③ Compensating line (same material as thermocouple)

Figure 5-10 Example 1: Wiring a thermocouple to an analog module for compensation with fixed reference temperature

The figure below shows the connection options for thermocouples provided the temperature of the reference junction (outside the module) is kept at a fixed reference temperature (20 °C).



① Thermocouple with compensating line and supply line
② Compensating line (same material as thermocouple)
③ Reference junction
④ Copper supply cable, for example

Figure 5-11 Example 2: Wiring a thermocouple to an analog module for compensation with fixed reference temperature

5.3.6 Compensation by means of dynamic reference temperature

Function principle

This compensation type allows you to handle the reference junction temperature for temperature compensation in the user program. You can derive the temperature value from any other module of the station. The reference junction temperature is transferred via data records using the instruction **WRREC** (SFB 53).

The structure of the data records is detailed in the device manual for each module.

Requirement

STEP 7 project with the following contents:

- User program with WRREC (SFB 53) instruction for transferring the data records with reference temperature
- Analog module with thermocouple at which the measured temperature value is to be compensated
- Analog module with thermal resistor (RTD) for measuring the reference junction temperature

Procedure for analog modules with thermocouple (TC)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measurement" area.
5. Select the "Thermocouple" value as "Type of measurement".
6. As "Reference junction", select the value "Dynamic reference temperature".

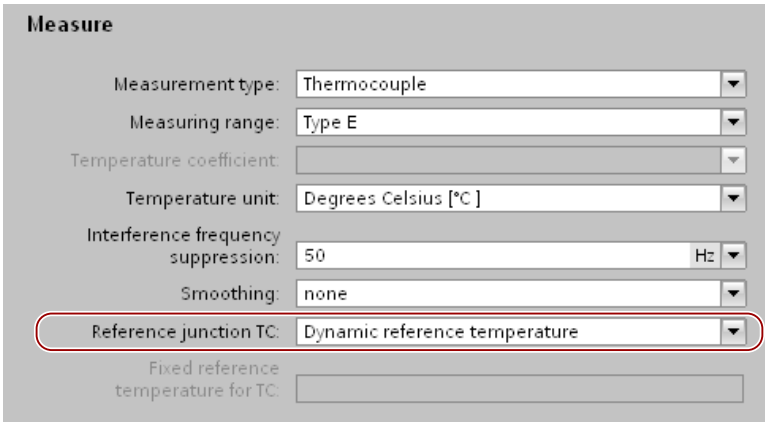


Figure 5-12 Dynamic reference temperature

Procedure for analog modules with thermal resistor (RTD)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measurement" area.
5. Select the "Thermocouple (4-wire connection)" value as "Type of measurement".

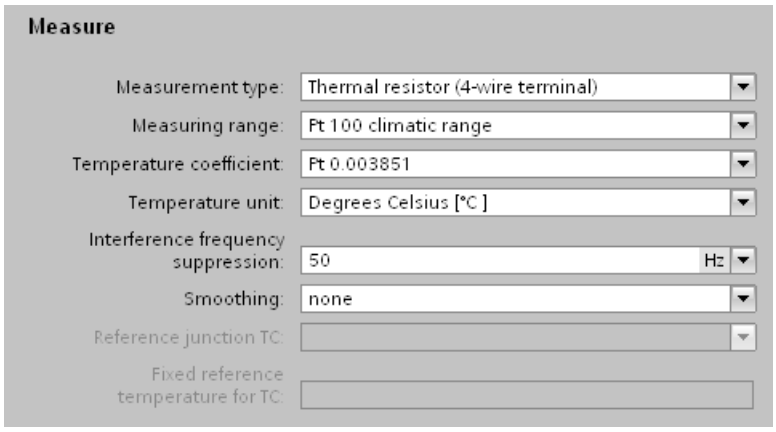
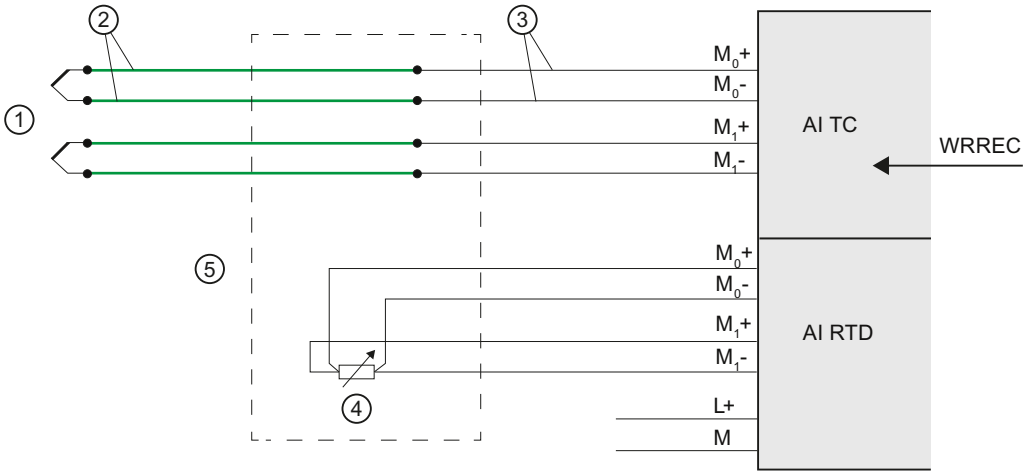


Figure 5-13 Settings for thermal resistor (RTD) type of measurement

Wiring thermocouples and thermal resistors

Connect the thermocouples, for example, to the module inputs using supply lines for temperature compensation with dynamic reference temperature. In this case, the temperature is acquired at the reference junction by means of a thermal resistor (RTD). This reference junction temperature is transferred to the analog module with thermocouple in corresponding data records by executing the WRREC instruction.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-14 Example: Wiring thermocouples/thermal resistors for compensation by means of dynamic reference temperature

Connecting loads/actuators 6

6.1 Overview

Introduction

This chapter describes the basic procedure for wiring loads/actuators to analog outputs. Information on specific wiring options is available in the manual of each module.

For detailed information on cable routing and shielding, potential equalization, etc. please refer to the function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AQ	Analog output module
M	Ground connection
L+	Supply voltage connection
S_n+/S_n-	Sense line channel n
QV_n+/QV_n-	Voltage output channel n
QI_n+/QI_n-	Current output channel n
M_{ANA}	Reference point of the analog ground
U_{ISO}	Insulation voltage

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

6.2 Connecting loads/actuators

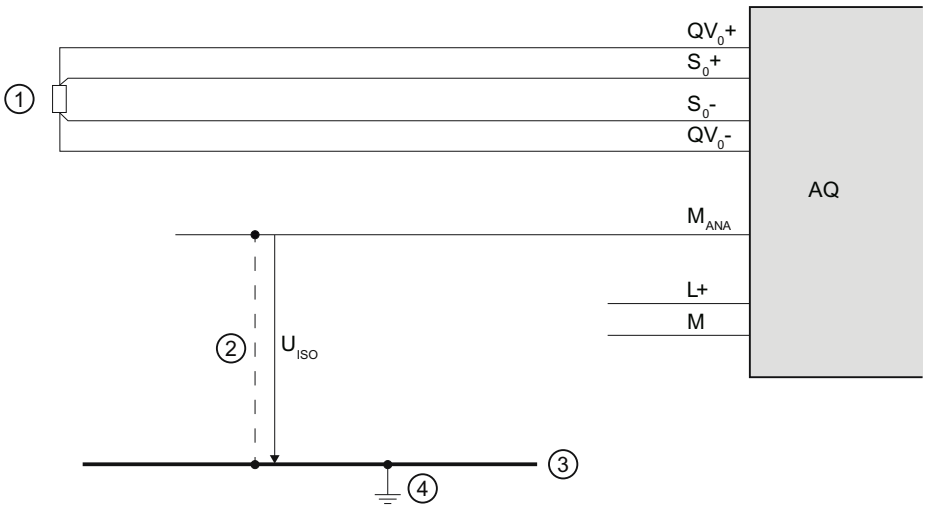
Reference potential for analog output modules with M_{ANA} connection

Analog output modules have no galvanic connection between the reference point of the analog ground M_{ANA} and the central ground.

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value U_{ISO} is not exceeded, interconnect terminal M_{ANA} and the central ground with an equipotential bonding cable.



① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 6-1 Example: Reference potential for an analog output module with M_{ANA} connection

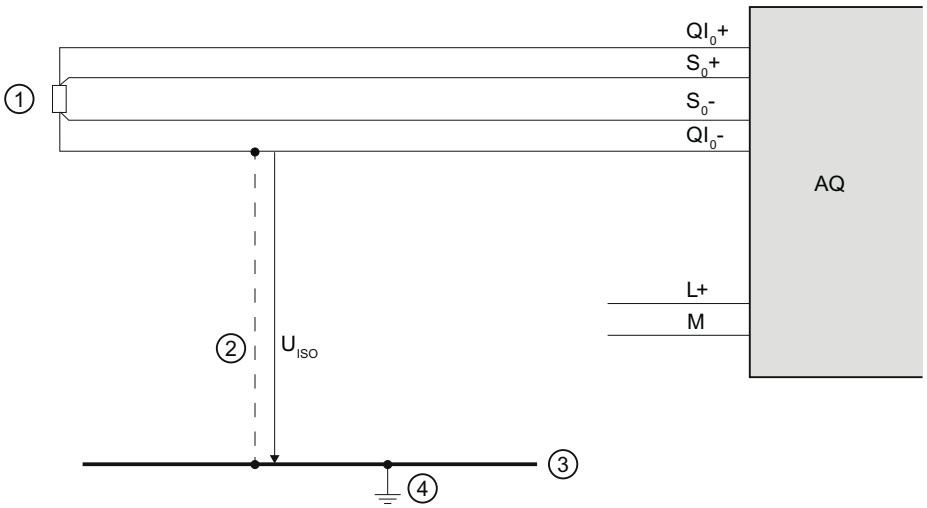
Reference potential for analog output modules without M_{ANA} connection

Analog output modules have no galvanic connection between the reference potential of the analog output circuits and central ground.

Always verify that the maximum potential difference U_{ISO} between the reference points of the analog output circuits and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

f you want to ensure the maximum value U_{ISO} is not exceeded, interconnect each analog output circuit with the central ground using an equipotential bonding cable.



① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 6-2 Example: Reference potential for an analog output module without M_{ANA} connection

Supported functions 7

7.1 Calibrating analog modules

7.1.1 Overview

Introduction

This section describes how to calibrate analog modules.

You can find additional information in the STEP 7 online help.

Calibrating analog modules

SIMATIC analog modules have excellent long-term stability; calibration is therefore not required during runtime.

Certain regulations and directives, for example from the Food and Drug Administration (FDA), require regular calibration for all components in a measuring circuit. These components include analog input and output modules. Some SIMATIC analog modules support "Calibration" functionality.

The device manual for each module will tell you whether it supports "Calibration" functionality.

Scope of functions

The "Calibration" group offers the following functions:

- Specifying the current calibration of all channels
- Calibrating a channel
- Canceling a running calibration
- Resetting the calibration of a channel to the factory settings

7.1.2 Calibrating analog modules

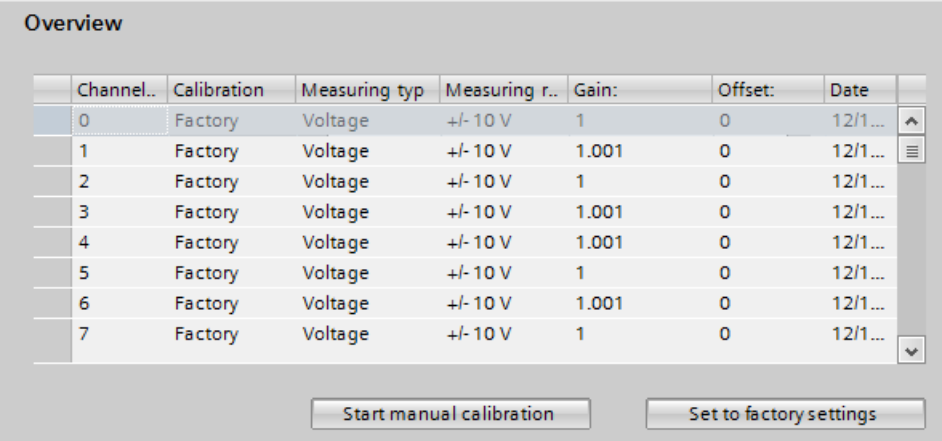
Requirement

- The associated CPU is online.
- You have opened the "Online & Diagnostics""view of the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- Configuration reflects the actual structure of the station.
- No calibration process is busy on the module (if you want to launch calibration).
- The last step was successfully completed
  (if you want to continue or conclude calibration).

Procedure

To start the calibration, follow these steps:

1. Select the line associated with the channel to be calibrated in the overview table.
2. Click the "Start manual calibration" button.



Channel..	Calibration	Measuring typ	Measuring r..	Gain:	Offset:	Date
0	Factory	Voltage	+/- 10 V	1	0	12/1...
1	Factory	Voltage	+/- 10 V	1.001	0	12/1...
2	Factory	Voltage	+/- 10 V	1	0	12/1...
3	Factory	Voltage	+/- 10 V	1.001	0	12/1...
4	Factory	Voltage	+/- 10 V	1.001	0	12/1...
5	Factory	Voltage	+/- 10 V	1	0	12/1...
6	Factory	Voltage	+/- 10 V	1.001	0	12/1...
7	Factory	Voltage	+/- 10 V	1	0	12/1...

Figure 7-1 Calibration table

3. Now go through the steps in the "Manual calibration" section.
   – Follow the instructions in the "Command" field.
   – Click ""Next".

   The figure below shows an example of channel calibration with "Voltage" measurement, measuring range "+/- 10 V".

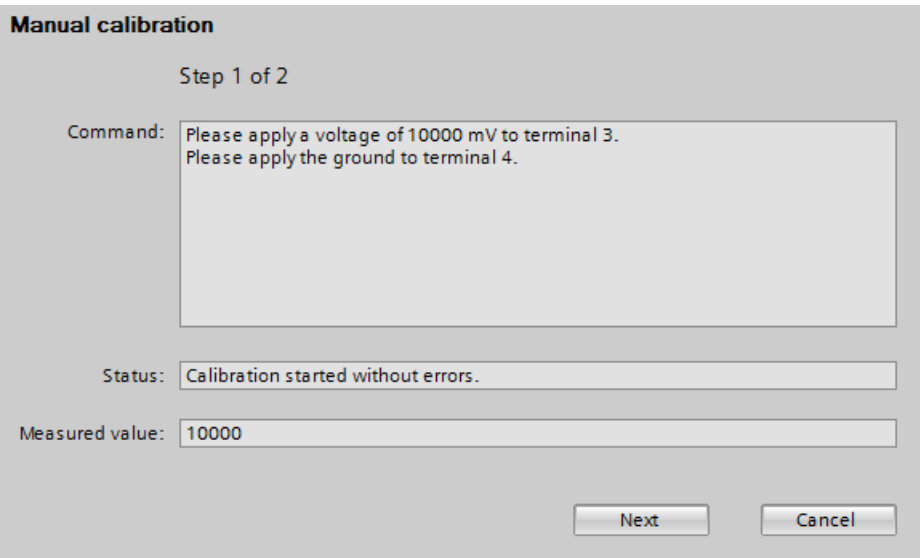


Figure 7-2 Manual calibration

Result

Calibration sets new settings for the channel.

Error occurrence

If an error occurs during the calibration, the module cancels the calibration. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.3 Canceling a calibration

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.
- A calibration is currently running on the analog module.

Procedure

To cancel a running calibration, follow these steps:

1. Click the "Cancel" button.

Result

The active calibration is canceled. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.4 Resetting analog modules to factory settings

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.

Procedure

Proceed as follows to reset the channel of an analog module to factory settings:

1. In the overview table, select the line of the channel to be calibrated.
2. Click the "Restore factory settings" button.

Result

The factory settings of the channel are restored.

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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection

Function Manual

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Service & Support A

06/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of the documentation

This documentation supports you in configuring and programming technology modules for counting and measurement tasks of the S7-1500, ET 200MP and ET 200SP, as well as in position feedback and position detection.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Validity of the documentation

This documentation is intended for use with the S7-1500 technology module
TM Count 2x24V and TM PosInput 2 and the corresponding ET 200SP technology modules.

Conventions

Please observe notes marked as follows:

Note

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Additional assistance

- You will find information about the technical support in the appendix Service & Support (Page 137).
- The range of technical documentation for the individual SIMATIC products and automation systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP and ET 200SP systems consists of the system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you configure and program your automation system.

Overview of the documentation on the topic of counting, measurement and position detection

The following table lists additional documentation that supplements this description of counting, measurement and position detection.

Table 1- 1 Documentation on the topic of counting, measurement and position detection

Subject	Documentation	Important contents
STEP 7 (TIA Portal)	STEP 7 online help	Configuring and programming with the engineering software
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	
TM	Device manual TM Count 2x24V Technology Module (http://support.automation.siemens.com/WW/view/en/59193105)	• Connecting • Interrupts and diagnostic alarms • Parameter data records • Technical specifications • Dimensional drawing
	Device manual TM PosInput 2 Technology Module (http://support.automation.siemens.com/WW/view/en/61777657)	

Subject	Documentation	Important contents
Motion Control	Function manual S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279)	• Configuring • Programming • Commissioning • Diagnostics

SIMATIC Manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) and can be downloaded free of charge.

The basics of counting, measurement and position detection 2

2.1 Overview of technology modules and properties

Technology modules

The table below summarizes the performance features of the technology modules for counting, measurement and position input:

Table 2- 1 Technology modules for counting, measurement and position input

Property	S7-1500		ET 200SP	
	TM Count 2x24V	TM PosInput 2	TM Count 1x24V	TM PosInput 1
Number of channels	2	2	1	1
Maximum signal frequency	200 kHz	1 MHz	200 kHz	1 MHz
Maximum count frequency for incremental encoders with quadruple evaluation	800 kHz	4 MHz	800 kHz	4 MHz
Maximum counter / position value range	32 Bit	32 Bit/31 Bit	32 Bit	32 Bit/31 Bit
RS422/TTL connection to incremental and pulse encoder	—	X	—	X
24 V connection to incremental and pulse encoder	X	—	X	—
SSI absolute encoder connection	—	X	—	X
5 V encoder supply	—	X	—	X
24 V encoder supply	X	X	X	X
Number of digital inputs per channel	3	2	3	2
Number of digital outputs per channel	2	2	2	2
Gate control	X	X	X	X
Capture function	X	X	X	X
Synchronization	X	X	X	X
Comparison functions	X	X	X	X
Frequency, velocity and period measurement	X	X	X	X
Isochronous mode support	X	X	X	X
Diagnostic interrupt support	X	X	X	X
Hardware interrupt support	X	X	X	X
Configurable filter for count signals and digital inputs	X	X	X	X

2.2 Overview of applications

Introduction

The technology module is configured and assigned parameters using the configuration software.

The technology module functions are controlled and monitored via the user program.

System environment

The technology modules can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central and distributed operation in an S7-1500 system with a corresponding ET 200 system	• S7-1500 automation system • ET 200 distributed I/O system • Technology module	STEP 7 (TIA Portal): • Device configuration with hardware configuration (HWCN) • Parameter settings with High_Speed_Counter technology object	Counting and measuring functions: High_Speed_Counter instruction for the technology object Position input: Direct access to technology module control and feedback interface in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200 distributed I/O system • Technology module	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with GSD file	Direct access to technology module control and feedback interface in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • Technology module	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to technology module control and feedback interface in the I/O data

Parameter assignment options

In an S7-1500 system, you have two options for parameter assignment and control of technology module functions:

- Configuration using the High_Speed_Counter technology object and control with the corresponding High_Speed_Counter instruction
  The technology module control and feedback interface is accessed with the technology object.
- Parameter settings with HWCN
  The control and feedback interface of the technology module is accessed using direct access to the I/O data.

Configuration via technology object

For central and distributed use in an S7-1500 system, we recommend simple configuration with graphic support using a High_Speed_Counter technology object. A detailed description of this configuration can be found in section High_Speed_Counter technology object (Page 67) and below.

You can define "Operation with technology object" for the technology module in the device configuration: see section Operating mode (Page 105).

You can assign the technology module and counting channel in the basic parameters of the technology object: see section Basic parameters (Page 72).

Parameter setting via HWCN

Additional support for parameter settings via HWCN is available in the context-sensitive help for the parameters in STEP 7 (TIA Portal). A description of the control and feedback interface is available in the following sections:

Assignment of the control interface (Page 130)

Assignment of the feedback interface (Page 133)

2.3 Counting functions

2.3.1 Overview of counting functions

Counting refers to the recording and adding up of events. The counters of the technology modules capture and evaluate pulse and incremental signals. The count direction can be specified using encoder or pulse signals or through the user program.

You can control counting processes using the digital inputs of the technology module. You can switch the digital outputs exactly at defined counter values, regardless of the user program.

You can configure the response of the counters using the functionalities described below.

Counting limits for incremental and pulse encoders

The counter limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The highest counter limit that can be set is 2147483647 (2^{31}–1). The lowest counter limit that can be set is –2147483648 (–2^{31}).

You can configure the response of the counter at the counter limits:

- Continue or stop counting upon violation of a counter limit (automatic gate stop)
- Set counter value to start value or to opposite counter limit upon violation of a counter limit

Start value for incremental and pulse encoders

You can configure a start value within the counter limits. The start value can be modified during runtime by the user program.

The technology module can, as configured, set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counter limit or when the gate is opened.

Gate control for incremental and pulse encoders

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The hardware gate is controlled externally via a digital input of the technology module. The software gate is controlled via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current count value or position value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input (for incremental and pulse encoders) ###

For incremental and pulse encoders, you can configure whether counting continues from the current counter value or from the start value after the Capture function.

Synchronization for incremental and pulse encoders

You can configure an external reference signal edge to load the counter with the specified start value. The following external signals can load the counter with the start value:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Comparison values

You can specify two comparison values to control the channel's two digital outputs. If the counter value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process. The comparison values are configurable and can be modified during runtime using the user program.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the count value or position value fluctuate around this position. If a comparison value or a limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Hardware interrupt

The technology module can trigger a hardware interrupt in the CPU if, for example, a comparison event occurs; in the event of overflow or underflow; in the event of a zero crossing of the counter and/or of a change in count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts in the event of errors. You enable the diagnostic interrupts for certain errors in the device configuration. Refer to the device manual for the technology module to learn about the events that can trigger a diagnostic interrupt during operation.

2.3.2 Behavior at the counting limits

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another upward count pulse is received. The low counting limit is violated when the current counter value is equal to the low counting limit and another downward count pulse is received.

The appropriate status bit is set in the feedback interface in the event of limit violation:

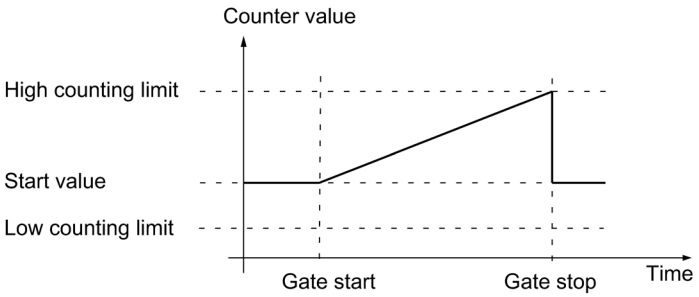
Counting limit violated	Status bit
High counting limit	EVENT_OFLW is set
Low counting limit	EVENT_UFLW is set

You can reset the status bits with RES_EVENT .

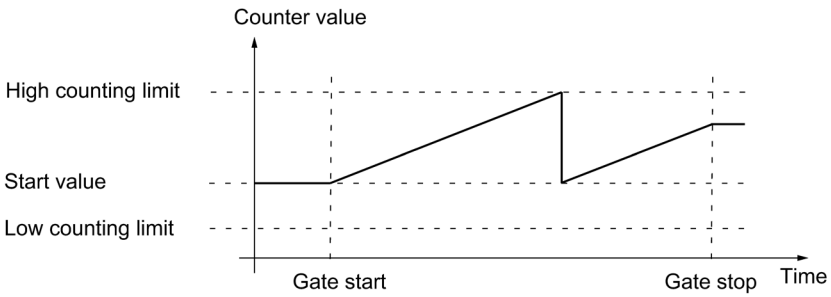
You can configure whether or not and from which counter value counting is to continue following counting limit violation.

Examples

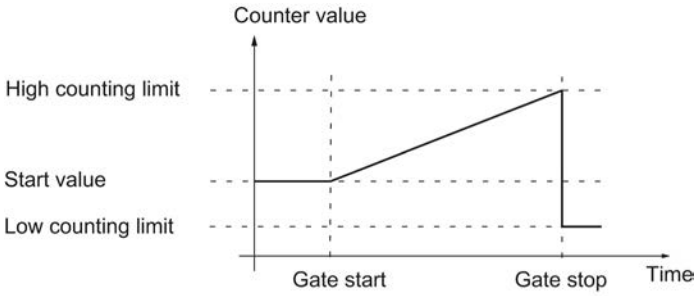
The figure below shows an example for terminating the counting process (automatic gate stop) after an overflow and setting the counter to the start value:



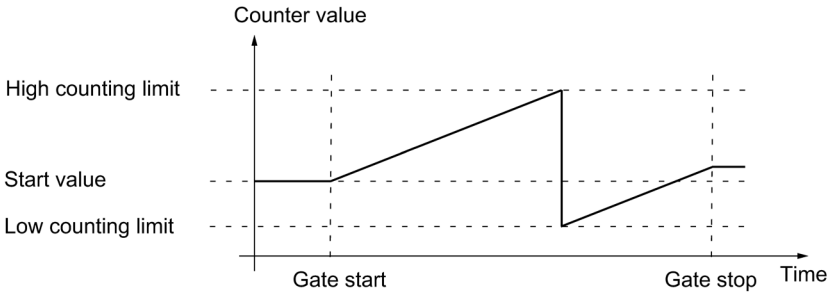
The figure below shows an example for continuing the counting process after an overflow and setting the counter to the start value:



The figure below shows an example for terminating counting after setting the counter to the opposite counting limit:



The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:



2.3.3 Gate control

Many applications require counting processes to be started or stopped in accordance with other events. In such cases, counting is started and stopped using the gate function.

The technology modules have two gates for each channel. These define the resulting internal gate:

- Software gate
- Hardware gate

2.3.3.1 Software gate

The software gate of the channel is opened and closed with the control bit (Page 130) SW_GATE. The status of the software gate is indicated by the feedback bit (Page 133) STS_SW_GATE .

2.3.3.2 Hardware gate

The hardware gate is optional. You open and close the hardware gate by means of signals at the configured digital inputs of the channel.

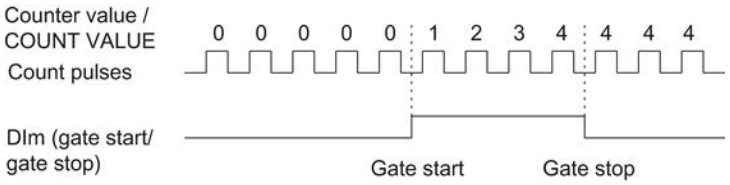
Note

The configured input filters delay the control signal of the digital input.

The status of a DIm digital input is indicated by the respective feedback bit (Page 133) STS_DIm .

Level-triggered opening and closing of the hardware gate with a digital input

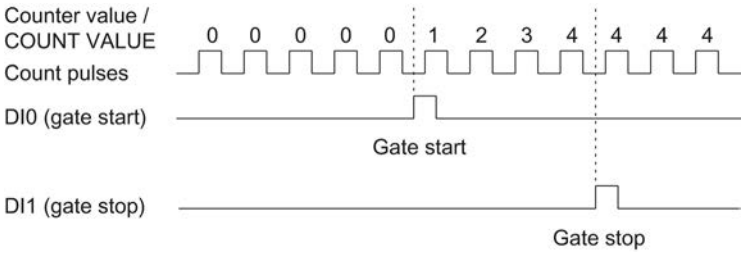
The figure below shows an example of level-triggered opening and closing with a digital input. The digital input is configured to be active with high level:



As long as the digital input is active, the hardware gate is open and the count pulses are counted. The hardware gate is closed when the digital input becomes inactive. The counter value stays constant and ignores any further count pulses.

Edge-triggered opening and closing of the hardware gate with two digital inputs

The figure below shows an example of opening and closing with two digital inputs. The two digital inputs are configured so that the rising edge of the hardware gate opens:



The hardware gate is opened with the configured edge at the digital input that is configured for opening. The hardware gate is closed with the configured edge at the digital input that is configured for closing.

2.3.3.3 Internal gate

Internal gate

The internal gate is open if the software gate is open and the hardware gate is open or has not been configured. The status of the internal gate is indicated by the feedback bit (Page 133) STS_GATE.

If the internal gate is open, counting is started. If the internal gate is closed, all other count pulses are ignored and counting is stopped.

If you want to control a counting process with the hardware gate only, the software gate must be open. If you do not configure a hardware gate, the hardware gate is considered to be always open. In this case, you open and close the internal gate with the software gate only.

Hardware gate	Software gate	Internal gate
Open/not configured	open	open
Open/not configured	closed	closed
closed	open	closed
closed	closed	closed

When you configure the counter behavior, you can specify whether the counting process is to start from the start value or from the current counter value when the internal gate is opened.

The internal gate can also be automatically closed upon violation of a counting limit. The software or hardware gate must then be closed and reopened to continue counting.

2.3.3.4 Counter behavior at gate start

You have the following configuration options for counter behavior upon gate start:

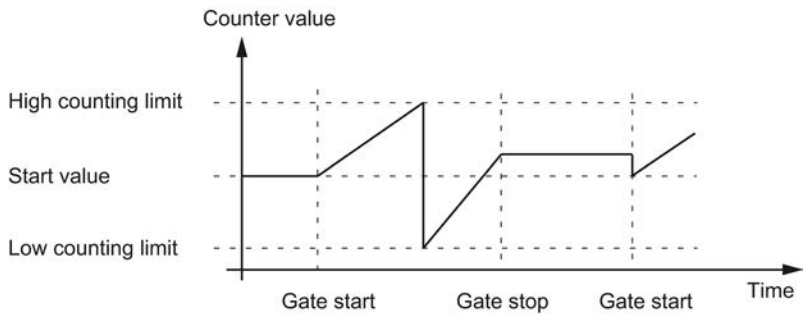
- Setting counter to start value
- Continuing with the current counter value

Setting counter to start value

Counter behavior is as follows for this configuration:

Each counting process starts with the start value when the internal gate is opened.

The figure below shows an example for continuing the counting process after counter is set to the start value:

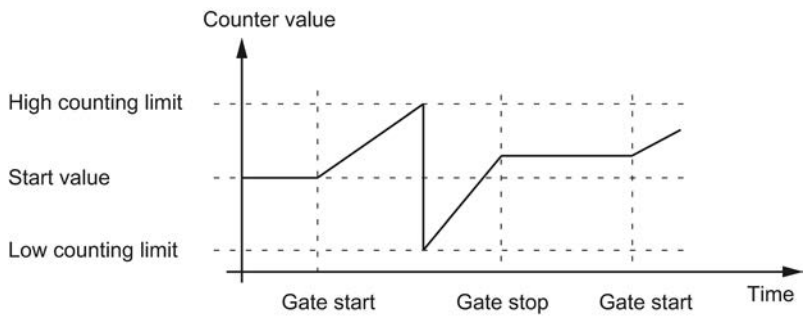


Continuing with the current counter value

Counter behavior is as follows for this configuration:

Each counting process starts from the current counter value after the internal gate is reopened.

The figure below shows an example for continuing the counting process with the current counter value:



2.3.4 Capture

Description

The "Capture" function is used to save the current counter value with an external reference signal. You can configure the Capture function for the following reference signals:

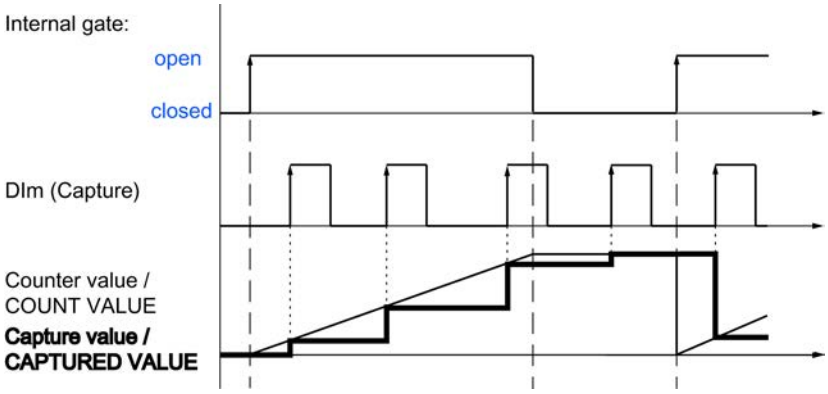
- Rising or falling edge at a digital input
- Rising and falling edge at a digital input
- Rising edge of signal N at the encoder input

Function principle

The Capture value is always the exact counter value at the time of the edge in question (delayed by the configured input filter time). The Capture function is effective regardless of the status of the internal gate. The unchanged counter value is saved when the gate is closed.

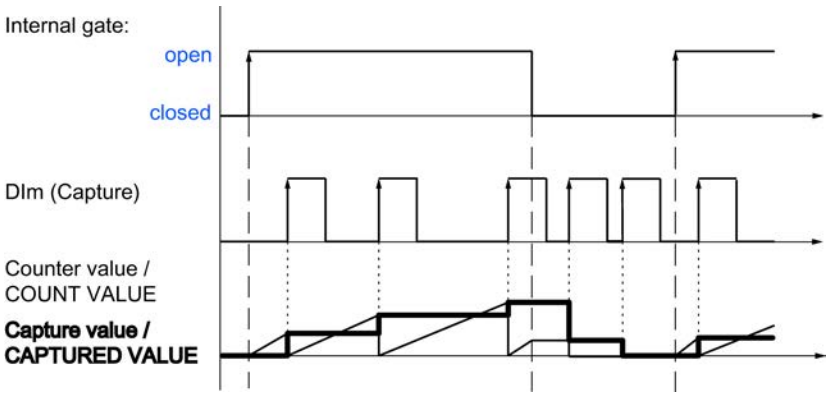
The figure below shows an example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Continue counting after Capture event



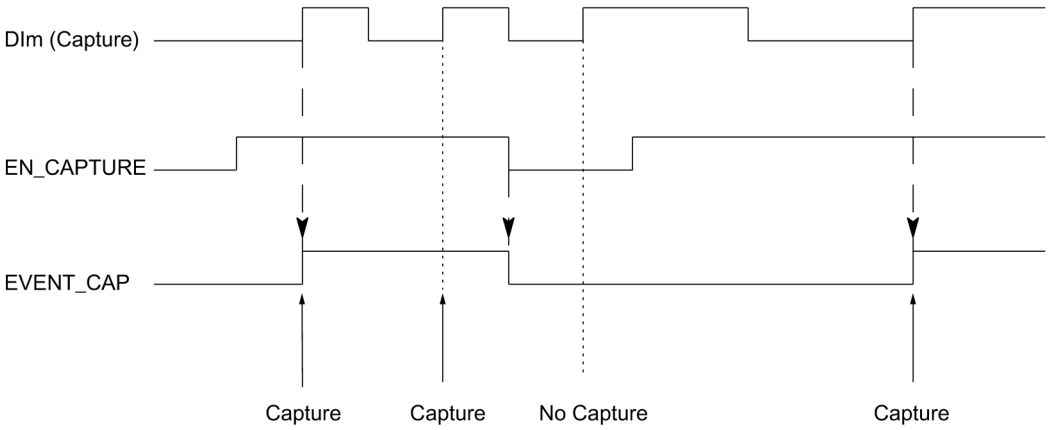
The figure below shows another example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Reset counter value to start value after Capture event and continue counting.



The control bit (Page 130) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 133) EVENT_CAP indicates that a counter value has been saved as a Capture in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 133) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the Capture function by the rising edge at a digital input:



Note

The configured input filters delay the control signal of the corresponding digital input.

The Capture function has no effect on the feedback bit STS_CNT and the LEDs UP and DN.

Hardware interrupt

You can configure a hardware interrupt for the Capture function. Individual hardware interrupts may be lost if the hardware interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.3.5 Synchronization

Description

You use the "Synchronization" function to set the counter to the pre-defined start value with an external reference signal. You can configure synchronization for the following reference signals:

- Rising or falling edges at a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input defined by the level of a digital input

Function principle

Synchronization always takes place exactly at the time of the reference signal. Synchronization is effective regardless of the status of the internal gate.

You use the control bit (Page 130) EN_SYNC_UP to enable synchronization for counting in an upwards direction. Use the control bit (Page 130) EN_SYNC_DN to enable synchronization for counting down. The feedback bit (Page 133) EVENT_SYNC indicates that synchronization has been performed. Resetting EN_SYNC_UP or EN_SYNC_DN also resets EVENT_SYNC.

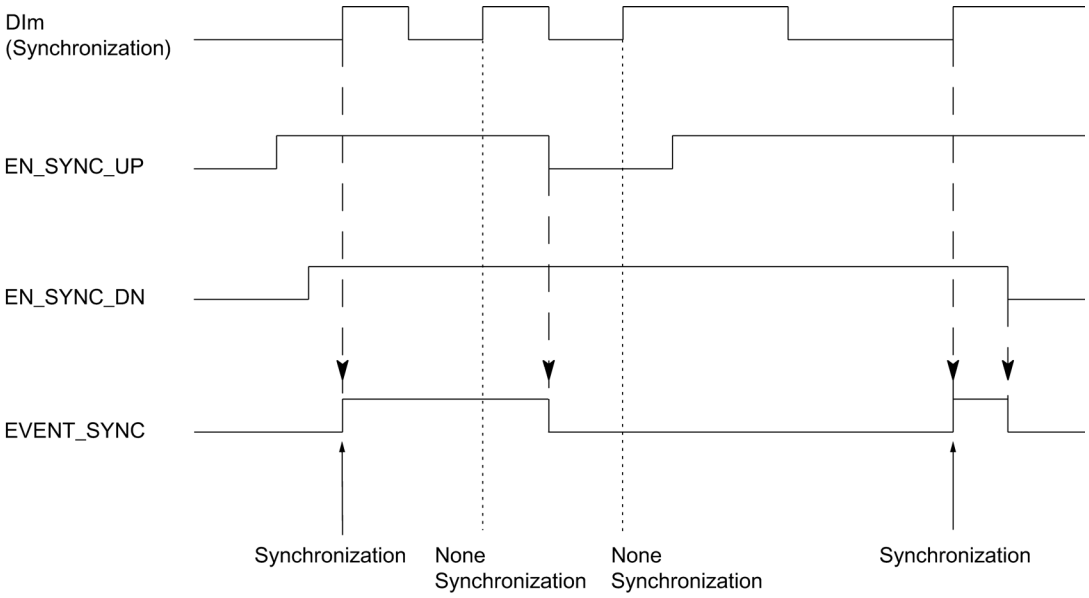
Note

The configured input filters delay the control signal of the corresponding digital input.

Synchronization has no effect on the feedback bit (Page 133) STS_CNT and the LEDs UP and DN.

Single synchronization

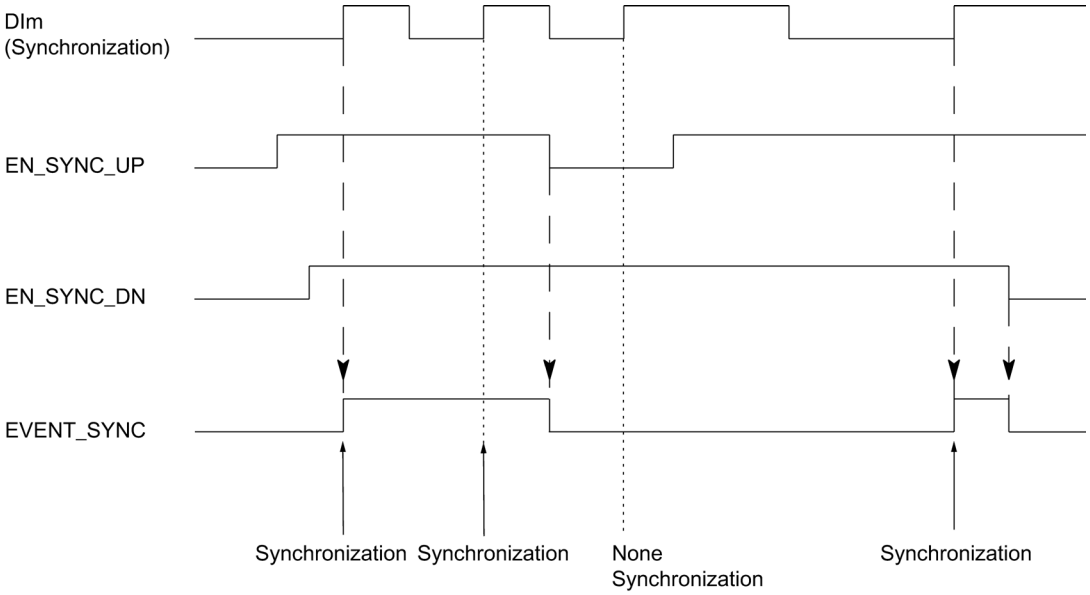
The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DNand EVENT_SYNC bits with single synchronization by an edge at a digital input for count pulses in an upwards direction:



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first rising edge at the configured digital input. The counter can only be synchronized again once the control bit (Page 130) EN_SYNC_UP has been reset and set again.

Periodic synchronization

The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DN and EVENT_SYNC bits with periodic synchronization by an edge at a digital input for count pulses in an upwards direction:



As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

Hardware interrupt

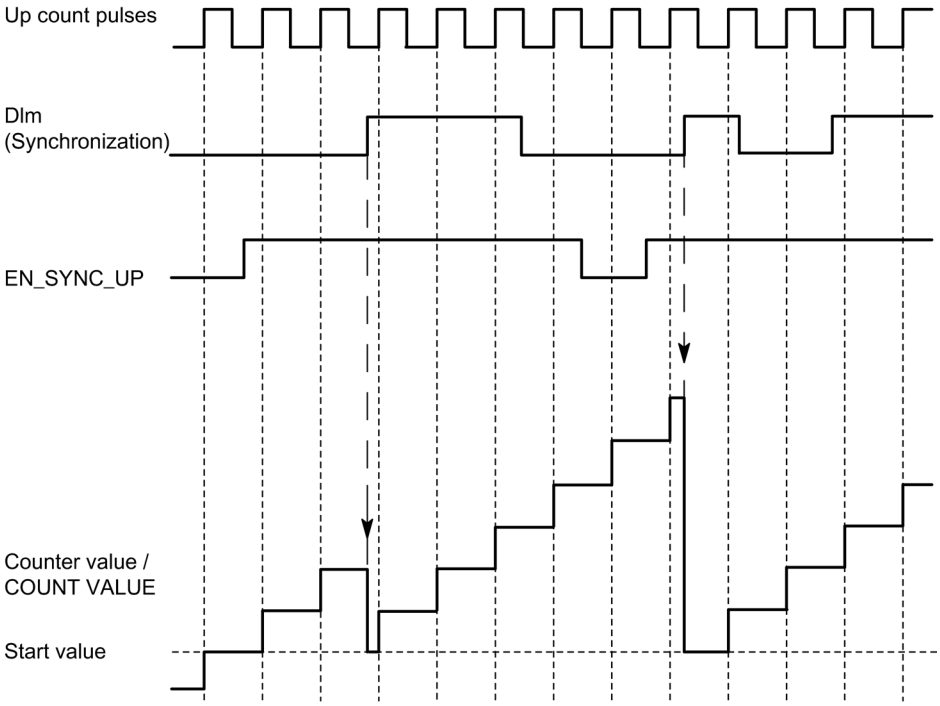
You can configure a hardware interrupt for the synchronization. The hardware interrupts will be lost if the interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.3.5.1 Synchronization by digital input

You can trigger synchronization by edges at a digital input.

Single synchronization

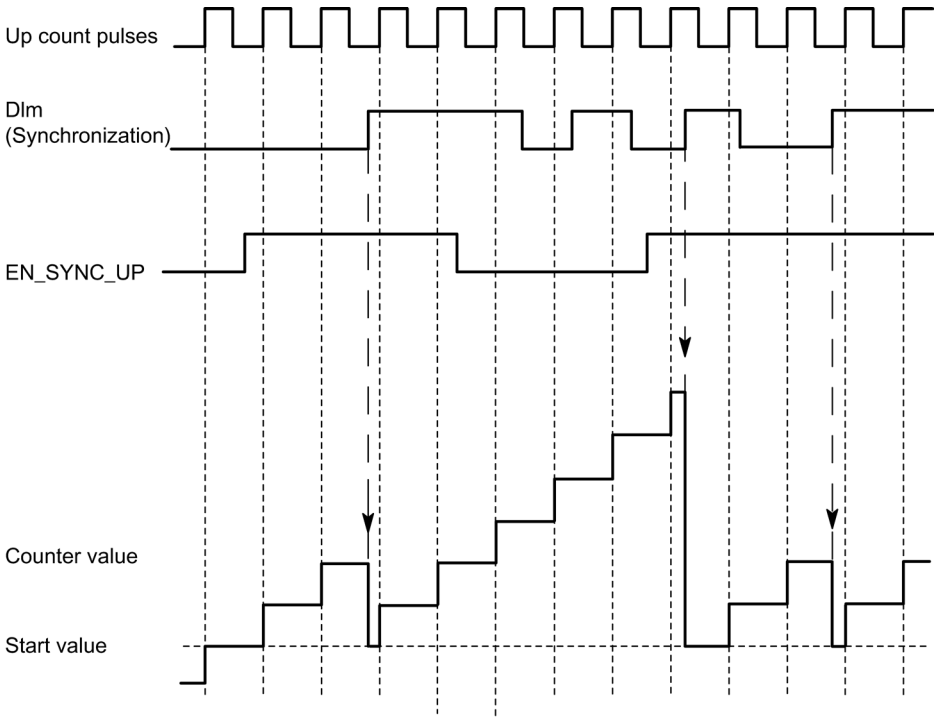
The figure below shows an example for single synchronization by an edge at a digital input:



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first rising edge at the configured digital input. Until the control bit (Page 130) EN_SYNC_UP has been reset and set again, any additional rising edge at the digital output is ignored. The counter can then be synchronized again.

Periodic synchronization

The figure below shows an example for periodic synchronization by an edge at a digital input:



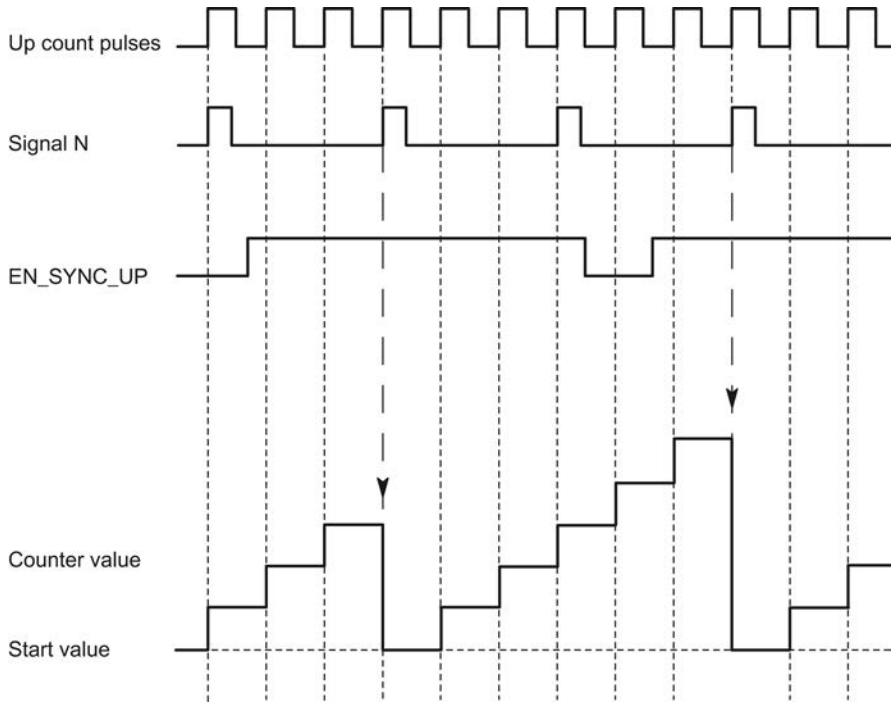
As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

2.3.5.2 Synchronization at signal N

You can trigger synchronization at signal N at the encoder input either directly or depending on the status of a digital input.

Single synchronization

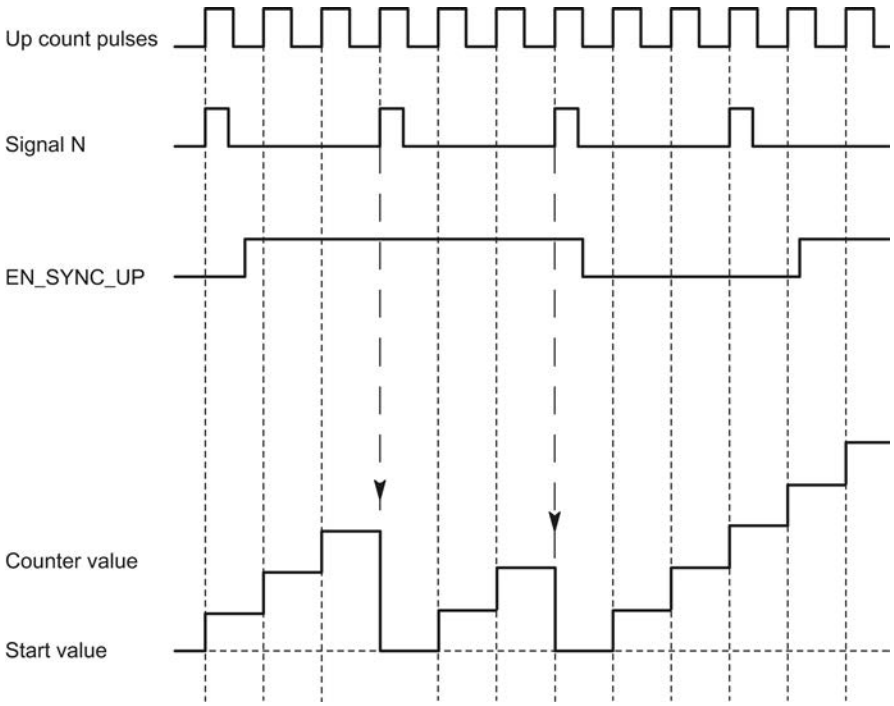
The figure below shows an example of single synchronization at signal N (not dependent on a digital input):



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first signal N. After resetting and setting the control bit (Page 130) EN_SYNC_UP once again, the counter can be synchronized again.

Periodic synchronization

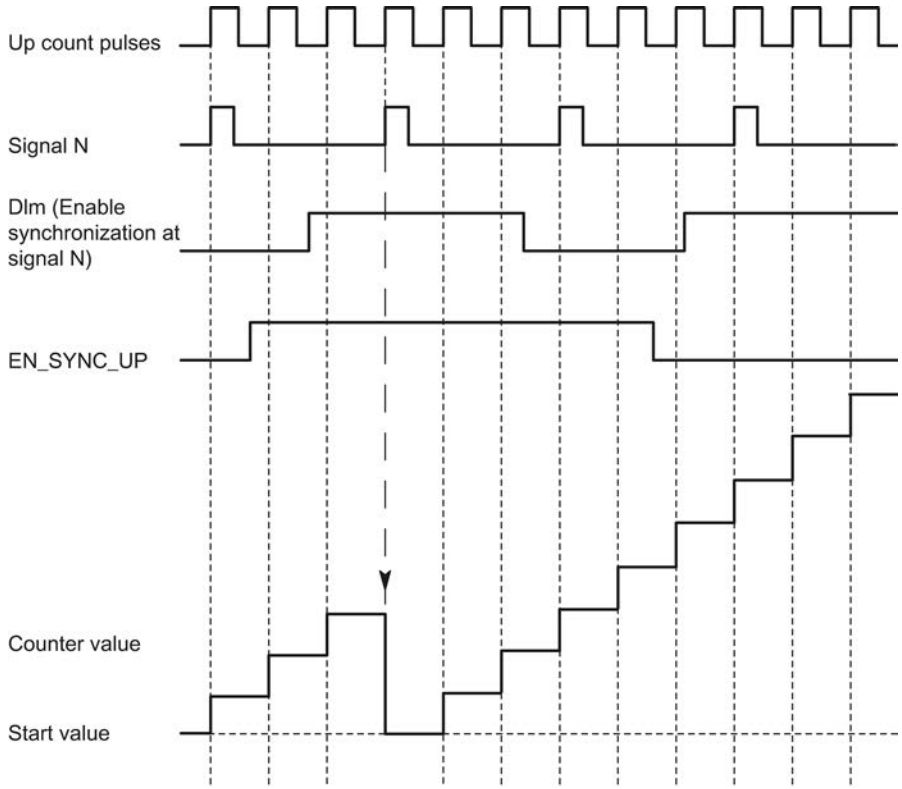
The figure below shows an example for periodic synchronization at signal N:



As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each signal N.

Enable by a digital input

The figure below shows an example for periodic synchronization at signal N depending on the status of a digital input:



As long as synchronization for counting up is enabled and the corresponding digital input is active, the counter is synchronized at each signal N. If one of the conditions is not met, the counter is not synchronized at the signal N.

2.3.6 Comparison values

2.3.6.1 Comparison values and outputs

Description

You can specify two comparison values to control both digital outputs of the channel:

- Comparison value 0 for digital output DQ0
- Comparison value 1 for digital output DQ1

The comparison values are compared with the current counter value. If the counter value meets the configured comparison condition and the technological function of the corresponding digital output is enabled, the digital output is set. Comparison value 1 must be greater than comparison value 0. If you configure "Set between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

Switching digital outputs from the user program

The control bits (Page 130) TM_CTRL_DQ0 and TM_CTRL_DQ1 are used to control use of the digital outputs.

If TM_CTRL_DQm is set to 0, you can control the relevant digital output from the user program with the control bit SET_DQm regardless of the configured technological function. If TM_CTRL_DQm is set to 1, the technological function of the controller of the respective digital output is enabled.

The status of a digital output is indicated by the respective STS_DQm feedback bit.

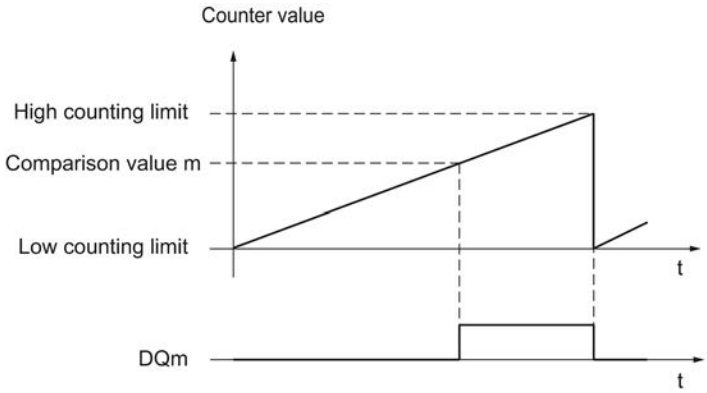
2.3.6.2 Switch at comparison values

You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high counter limit

The digital output is set to 1 if:

Comparison value <= counter value <= high counter limit

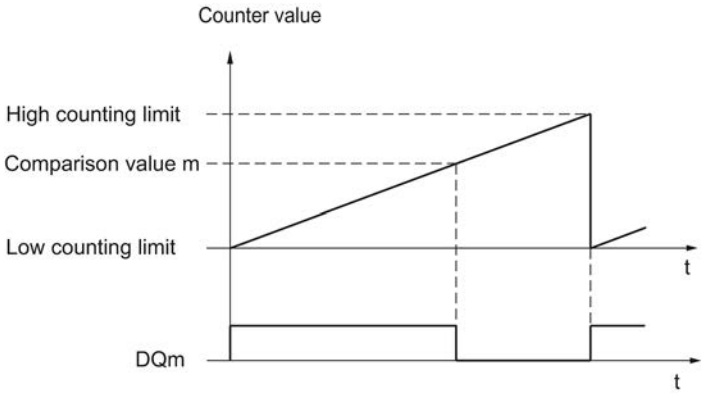


The comparison event is independent of the count direction.

Setting between comparison value and low counter limit

The digital output is set to 1 if:

Low counter limit <= counter value <= comparison value



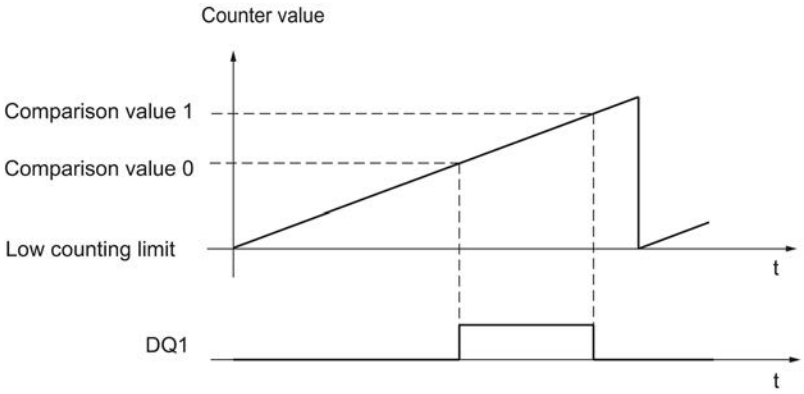
The comparison event is independent of the count direction.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= counter value <= comparison value 1



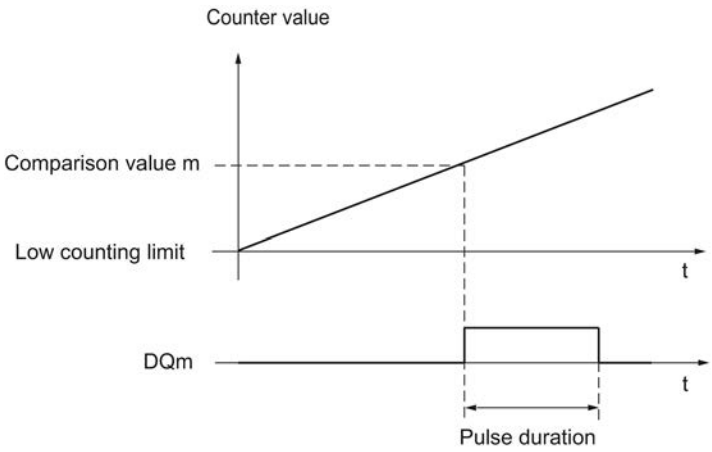
The comparison event is independent of the count direction.

Setting at comparison value for one pulse duration

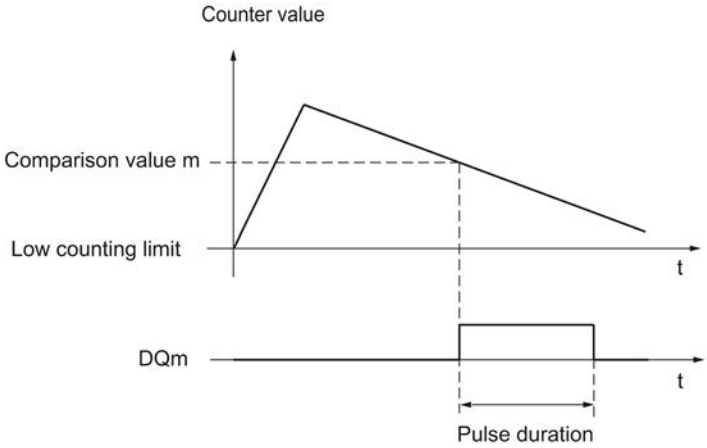
The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Counter value = comparison value
- Current count direction = configured count direction for the comparison event

The figure below shows an example of the comparison event when counting in an upwards direction:

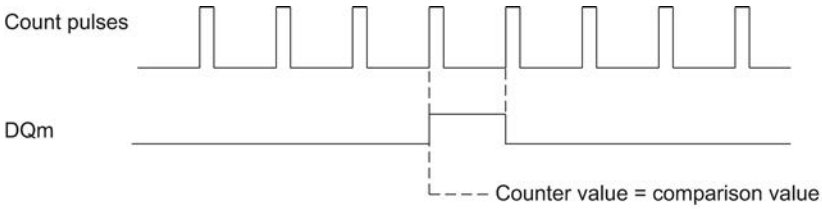


The figure below shows an example of the comparison event when counting in a downward direction:



To repeat the comparison event, the counter value must change and then correspond to the respective comparison value again.

If the pulse duration has been defined as "0" and the counter value is equal to the comparison value, the digital output is set to 1 until the next count pulse:



Note

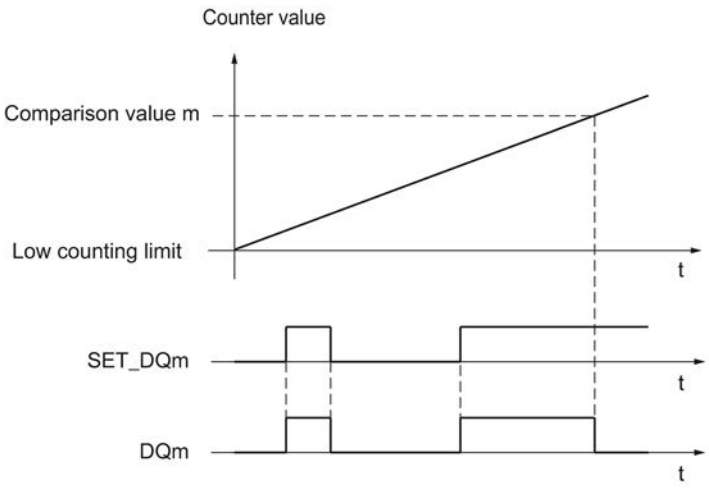
This comparison event switches the relevant digital output if a count pulse reaches the comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

Setting by the user program up to comparison value

You can set the respective digital output to 1 (edge) by setting the control bit (Page 130) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Match of the position value and the comparison value in the configured direction of the comparison event
- Reset of the corresponding SET_DQm control bit.

The figure below shows an example of the comparison event when counting in an upwards direction:



You can disable the digital output before the counter value reaches the comparison value by setting the control bit SET_DQm to 0.

Note

If the comparison value is reached in the configured counting direction, the feedback bit EVENT_CMPm is set independently of the state of the control bit SET_DQm.

The comparison event switches a digital output when a count pulse reaches the respective comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

2.3.7 Hysteresis

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the counter value has gone outside this range.

Slight movements by the encoder can result in the counter value fluctuating around a certain value. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a compare event occurs.

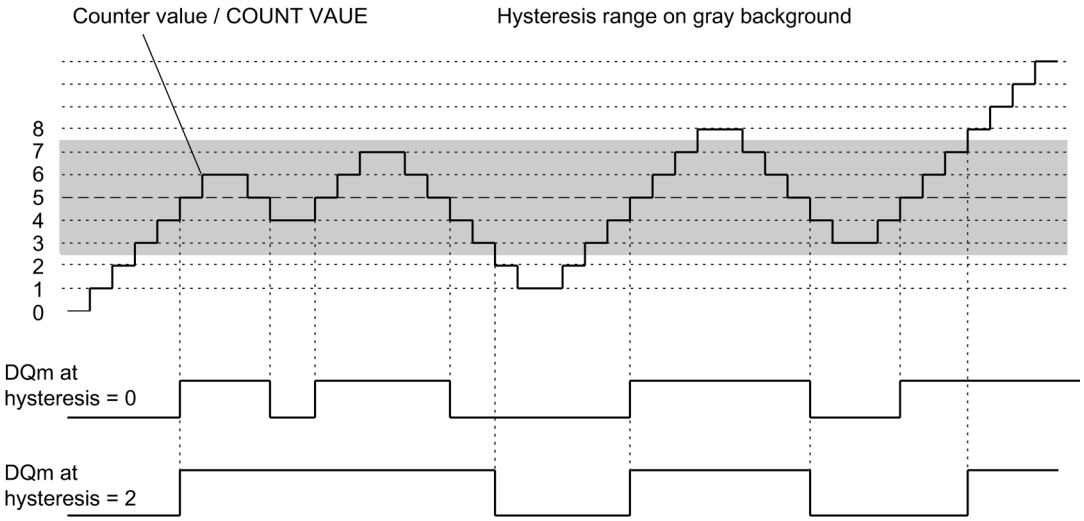
The Hysteresis becomes active when the respective comparison value is reached by a count pulse. If the counter value is set to the start value during an active Hysteresis, the Hysteresis becomes inactive.

Regardless of the hysteresis value, the hysteresis range ends at the low/high counting limits.

Function principle

The figure below shows an example for the hysteresis with the following configuration:

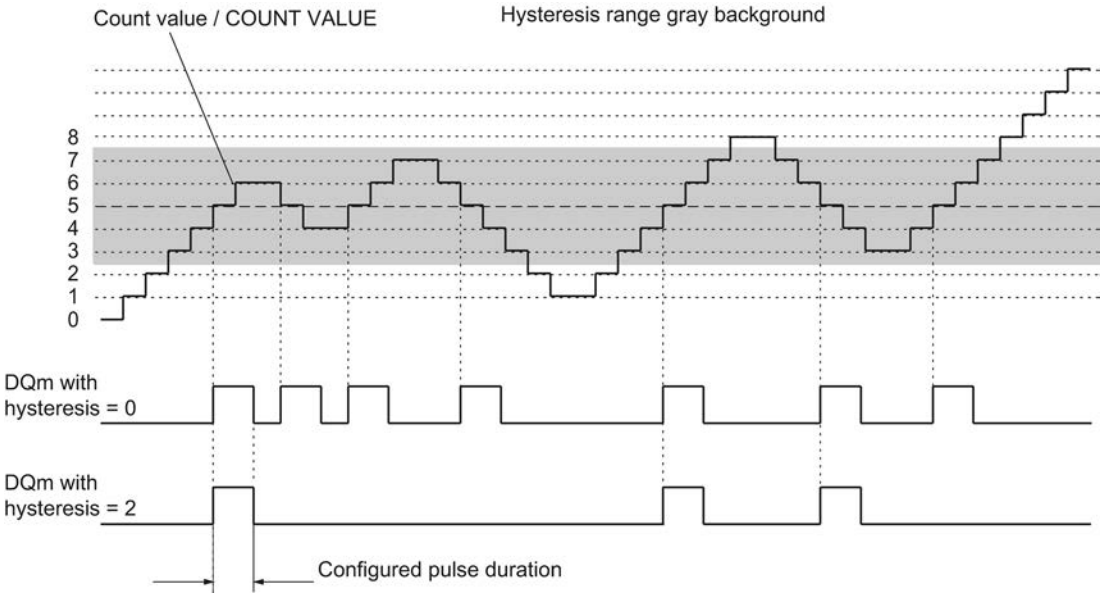
- Setting of a digital output between comparison value and high counting limit
- Comparison value = 5
- Hysteresis = 0 or 2



Hysteresis is enabled when the counter value 5 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the counter values 2 or 8 are reached.

The figure below shows an example for the hysteresis with the following configuration:

- Setting at comparison value for one pulse duration
- Comparison value = 5
- Comparison in both count directions
- Hysteresis = 0 or 2



2.4 Measuring functions

2.4.1 Overview of measuring functions

The following measuring functions are available:

Measurement type (Page 42)	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in Hertz as floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in seconds as the floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and other parameters, and returned in the configured unit of measurement.

Measured values and counter values are available concurrently in the feedback interface.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control for incremental and pulse encoders

Opening and closing the internal gate defines the period of time during which the count pulses are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After the internal gate is closed, the last measured value captured is still returned.

Comparison values

You can specify two comparison values to control the channel's two digital outputs. If the measured value meets the configured comparison condition, the corresponding digital output can be set to initiate control processes directly in the process. The comparison values are configurable and can be modified during runtime using the user program.

Hardware interrupt

The technology module can trigger a hardware interrupt in the CPU if, for example, a comparison event occurs; in the event of overflow or underflow; in the event of a zero crossing of the counter and/or of a change in count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts in the event of errors. You enable the diagnostic interrupts for certain errors in the device configuration. Refer to the device manual for the technology module to learn about the events that can trigger a diagnostic interrupt during operation.

2.4.2 Measuring ranges

Measuring ranges

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	800 kHz* / 4 MHz**
Period measurement	1.25 µs* / 0.25 µs**	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple" signal evaluation.

** Applies to RS422 incremental encoders and "quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

2.4.3 Measuring intervals

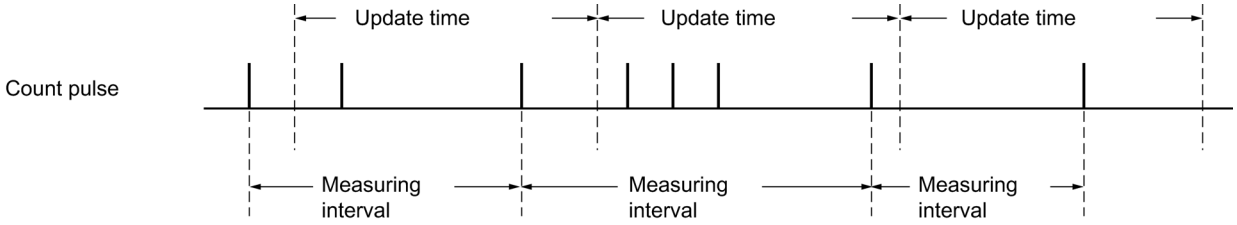
Measuring principle

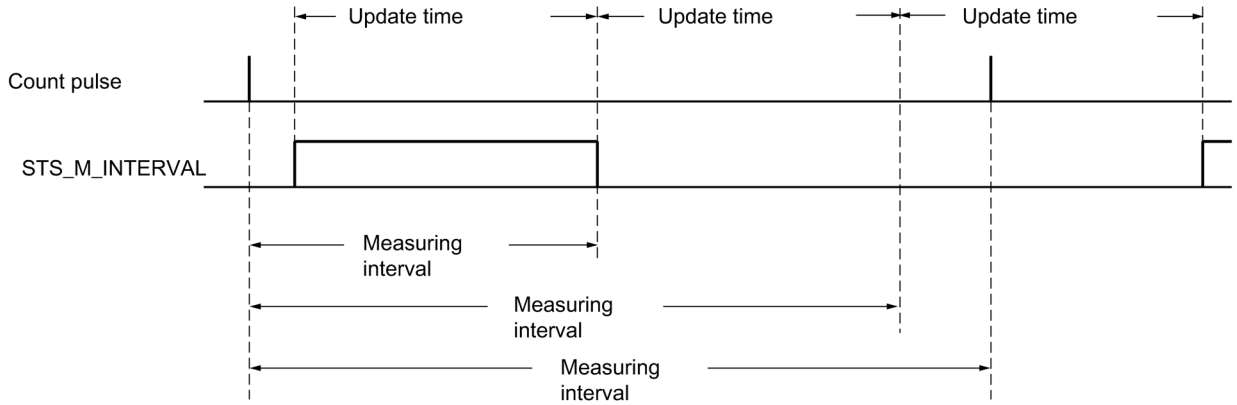
The technology module assigns a time value to each count pulse. The measuring interval is defined as the time between each last count pulse before and during the previous update time. The measuring interval and the number of pulses in the measuring interval are evaluated to calculate measured variables.

If there is no count pulse within an update time, the measuring interval is dynamically adjusted. In this case, a pulse is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last pulse which occurred. The number of pulses is then 1.

The feedback bit STS_M_INTERVAL indicates whether a count pulse occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual count pulse.

The following figures show the principle of measurement and the dynamic adjustment of the measuring interval:





2.4.4 Measuring types

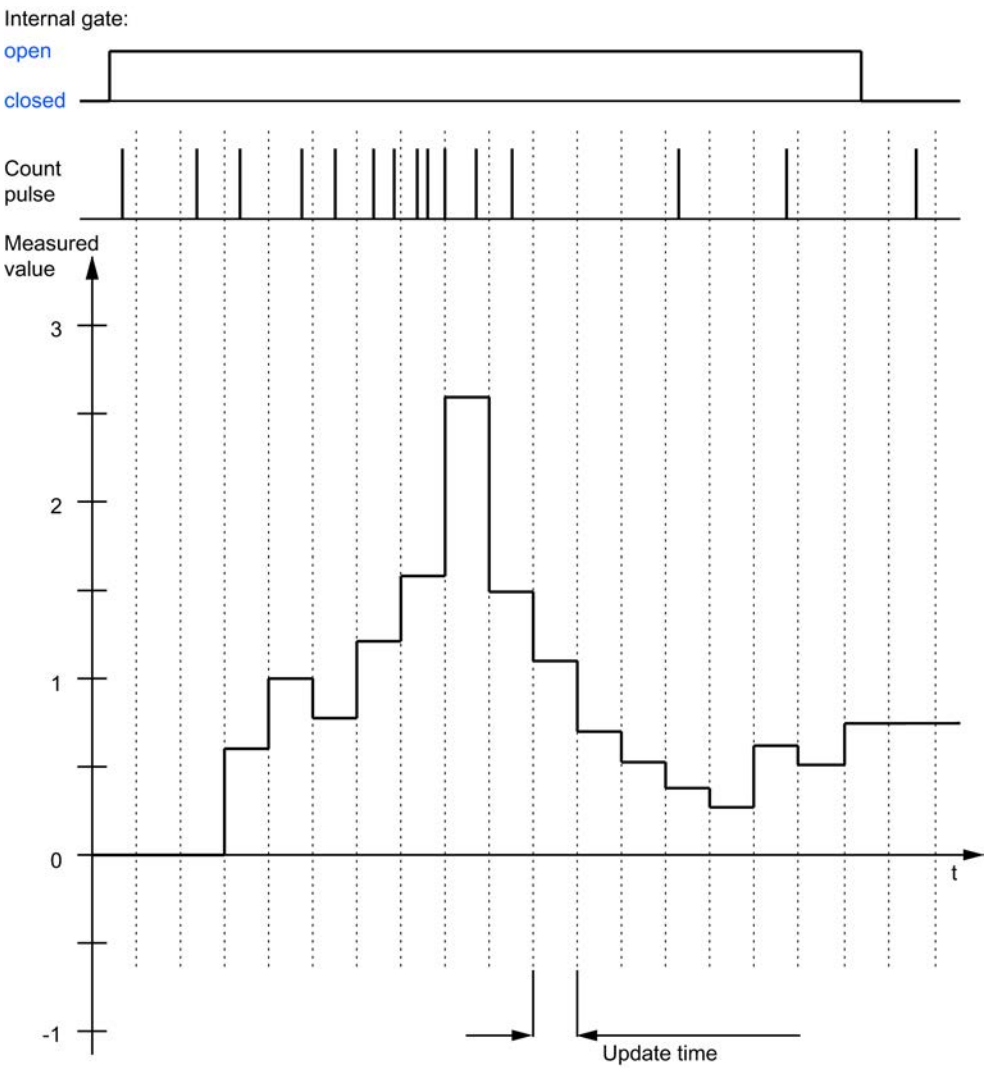
Frequency measurement

A value "0" is returned until the first measured value is available.

The measurement process begins with the first pulse detected once the internal gate has been opened. The first measured value can be calculated after the second pulse at the earliest.

The measured value is updated in the feedback interface (Page 133) upon completion of each update time. If the internal gate is closed, measuring stops and the measured value is no longer updated.

The figures below shows an example of frequency measurement with an update time of 1 s:



Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your encoder delivers 4000 increments per meter. The velocity is to be measured in meters per minute.

In this case, you need to configure 4000 Increments per unit and a time basis of one minute.

2.4.5 Comparison values

2.4.5.1 Comparison values and outputs

Description

You can specify two comparison values to control both digital outputs of the channel:

- Comparison value 0 for digital output DQ0
- Comparison value 1 for digital output DQ1

The comparison values are compared with the current measured value. If the measured value meets the configured comparison condition and the technological function of the corresponding digital output is enabled, the digital output is set. Comparison value 1 must be greater than comparison value 0. If you configure "Set between comparison value 0 and 1" for digital output DQ1 or "Not between comparison value 0 and 1", both comparison values are used.

Switching digital outputs from the user program

The control bits (Page 130) TM_CTRL_DQ0 and TM_CTRL_DQ1 are used to control use of the digital outputs.

If TM_CTRL_DQm is set to 0, you can control the relevant digital output from the user program with the control bit SET_DQm. If TM_CTRL_DQm is set to 1, the technological function of the controller of the respective digital output is enabled.

The status of a digital output is indicated by the respective STS_DQm feedback bit.

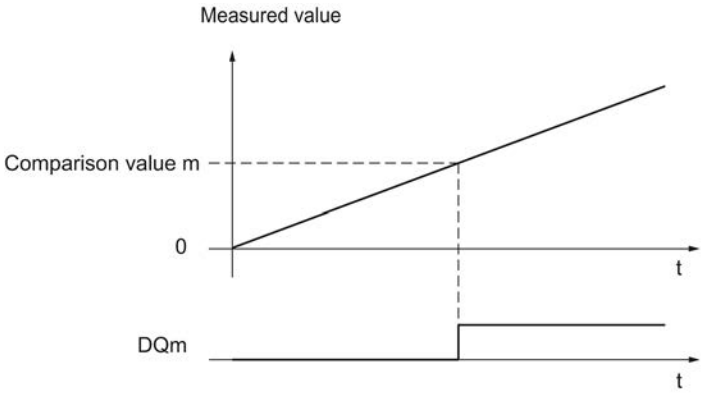
2.4.5.2 Switch at comparison values

You can make switching for a digital output dependent on one of the following compare events:

Setting above the comparison value

The digital output is set to 1 if:

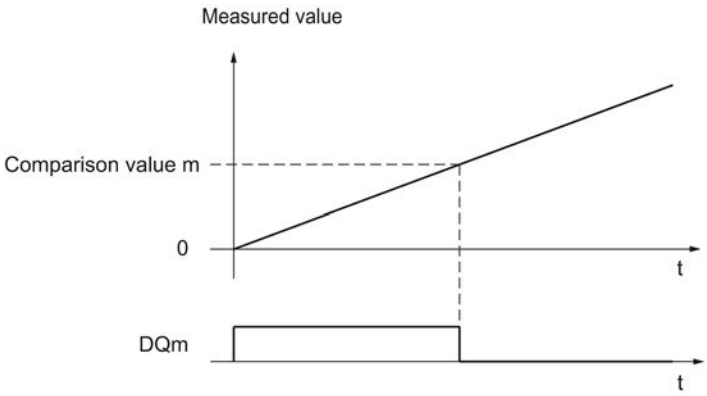
Measured value >= comparison value



Setting below the comparison value

The digital output is set to 1 if:

Measured value <= comparison value

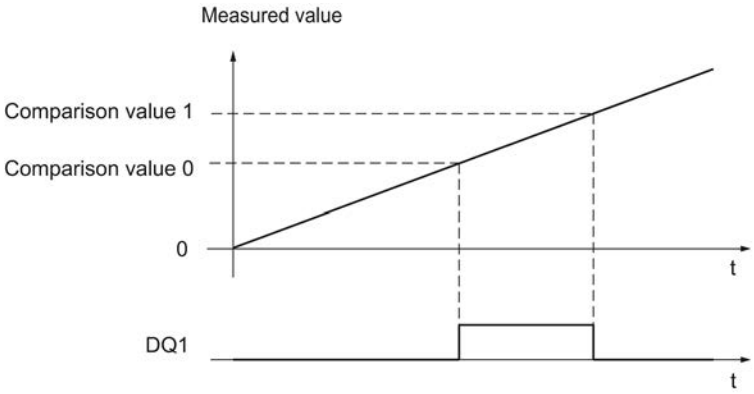


Setting between comparison value 0 and comparison value 1

The compare event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= measured value <= comparison value 1

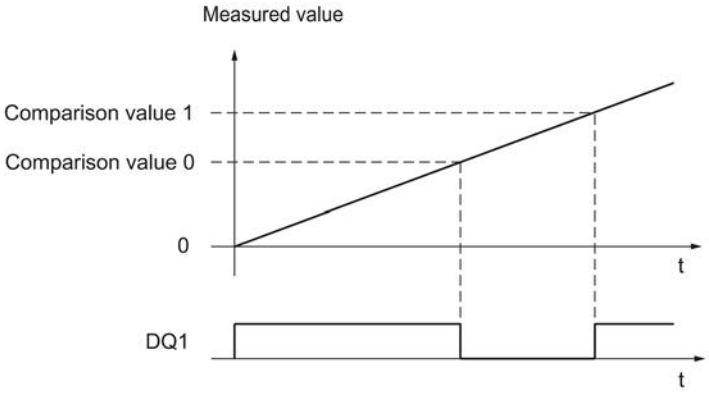


Not setting between comparison value 0 and comparison value 1

The compare event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 1 <= measured value <= comparison value 0



2.5 Position input

2.5.1 Position detection for Motion Control

Description

You can use the technology module with S7-1500 Motion Control for position detection.

In the Device configuration of the technology module in STEP 7 (TIA Portal), select "Position input for Motion Control" mode. This reduces the configuration options to the parameters that are essential. The mode automatically applies to all channels of the technology module.

When using an incremental or pulse encoder, the position input is based on the counting function of the technology module. With an SSI absolute encoder, the absolute value is transferred via a synchronous, serial interface and prepared according to the parameter assignment to be made available for S7-1500 Motion Control.

2.5.2 Position input with SSI absolute encoder

2.5.2.1 Overview of the functions

Description

You can use the TM PosInput technology modules with an SSI absolute encoder for position detection. The technology module reads the position value via a synchronous serial interface from the SSI absolute encoder and makes it available to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, regardless of the user program. Position input with an SSI absolute encoder does not involve gate control.

To do this, select the signal type "Absolute encoder (SSI)" in the parameter setting (HWCN) of the technology module in STEP 7 (TIA Portal).

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Capture

You can configure one or both edges of a digital input that triggers a saving of the current position value as Capture value.

Comparison values

You can specify two comparison values to control the channel's two digital outputs. If the position value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process. The comparison values are configurable and can be modified during runtime using the user program.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the position value fluctuate around this position. If a comparison value lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read a position value with a maximum length of31 bits and communicate it to the controller. The position value is treated as unsigned positive value and can assume values between 0" and "$2^{(MSB-LSB+1)-1}$".

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bits of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

Hardware interrupt

The technology module can trigger hardware interrupts in the CPU. You specify which events are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts in the event of errors. You enable the diagnostic interrupts for certain errors in the device configuration. Refer to the device manual for the technology module to learn about the events that can trigger a diagnostic interrupt during operation.

2.5.2.2 Capture

Description

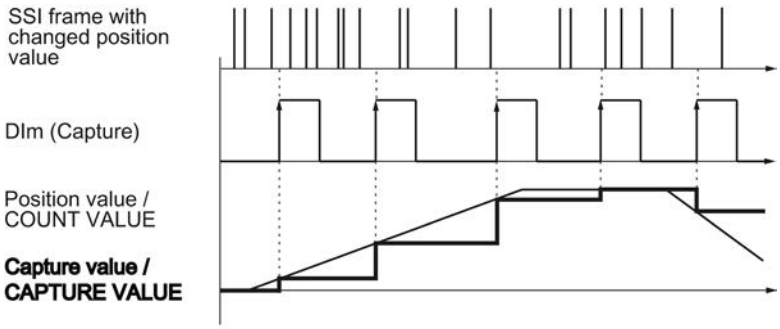
The "Capture" function is used to save the current position value using an external reference signal. You can configure the Capture function for the following reference signals:

- Rising or falling edge at a digital input
- Rising and falling edge at a digital input

Function principle

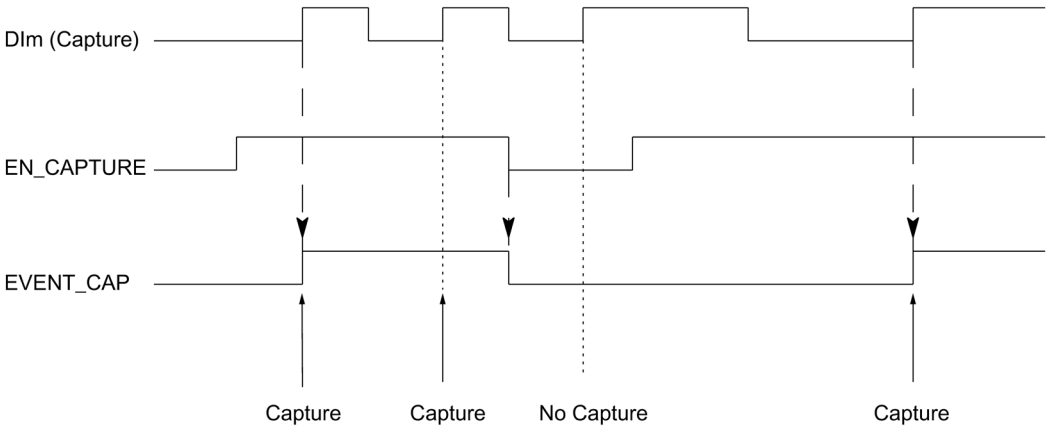
At the time of each edge, the position value of the last valid SSI frame is stored in the Capture value.

The figure below shows an example of the Capture event by a rising edge at the configured digital input:



The control bit (Page 130) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 133) EVENT_CAP indicates that a position value has been saved as Capture value in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 133) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the Capture function by the rising edge at a digital input:



Note

The configured input filters delay the control signal of the corresponding digital input.

Hardware interrupt

You can configure a hardware interrupt for the Capture function. Individual hardware interrupts may be lost if the hardware interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.5.2.3 Comparison values

Comparison values and outputs

Description

You can specify two comparison values to control both digital outputs of the channel:

- Comparison value 0 for digital output DQ0
- Comparison value 1 for digital output DQ1

The comparison values are compared with the current position value. If the position value meets the configured comparison condition and the technological function of the corresponding digital output is enabled, the digital output is set. Comparison value 1 must be greater than comparison value 0. If you configure "Between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

Switching digital outputs from the user program

The control bits (Page 130) TM_CTRL_DQ0 and TM_CTRL_DQ1 are used to control use of the digital outputs.

If TM_CTRL_DQm is set to 0, you can control the relevant digital output from the user program with the control bit SET_DQm regarless on the configured technological function. If TM_CTRL_DQm is set to 1, the technological function for controlling the respective digital output is enabled.

The status of a digital output is indicated by the respective STS_DQm feedback bit.

Switch at comparison values

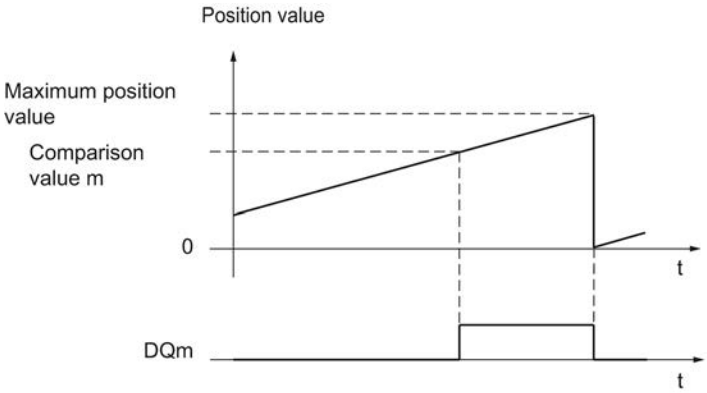
You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high limit

The high limit corresponds to the maximum position value.

The digital output is set to 1 if:

Comparison value <= position value <= maximum position value



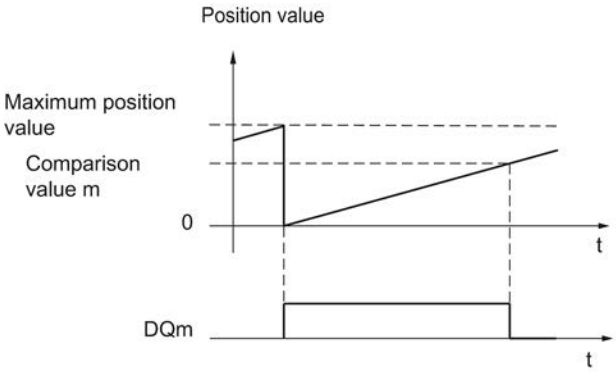
The comparison event is independent of the direction of the position value change. The maximum position value depends on the resolution of the SSI absolute encoder.

Setting between comparison value and low limit

The low limit corresponds to the position value "0".

The digital output is set to 1 if:

0 <= position value <= comparison value



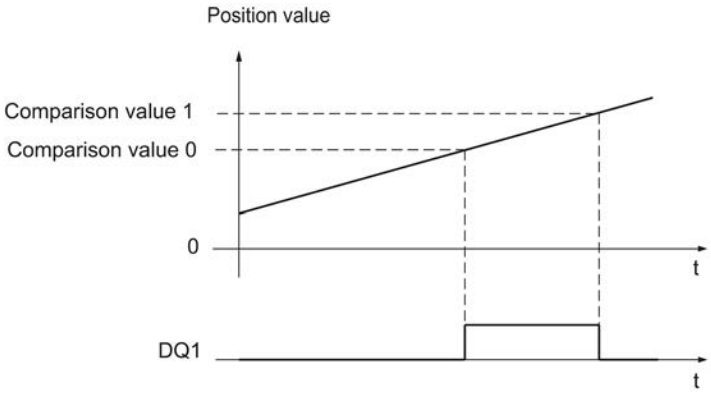
The comparison event is independent of the direction of the position value change.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= position value <= comparison value 1



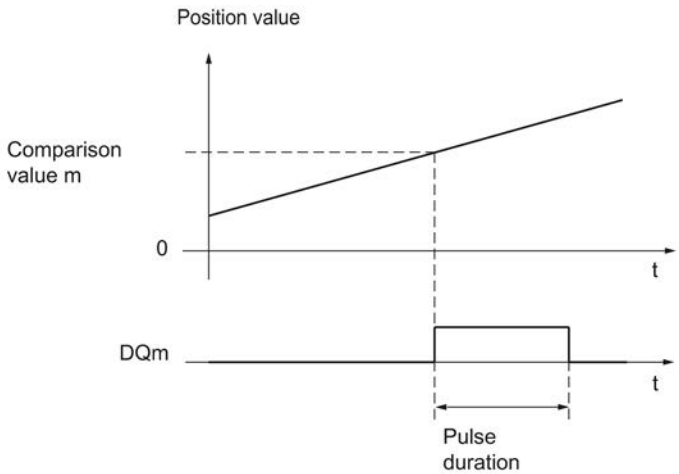
The comparison event is independent of the direction of the position value change.

Setting at comparison value for one pulse duration

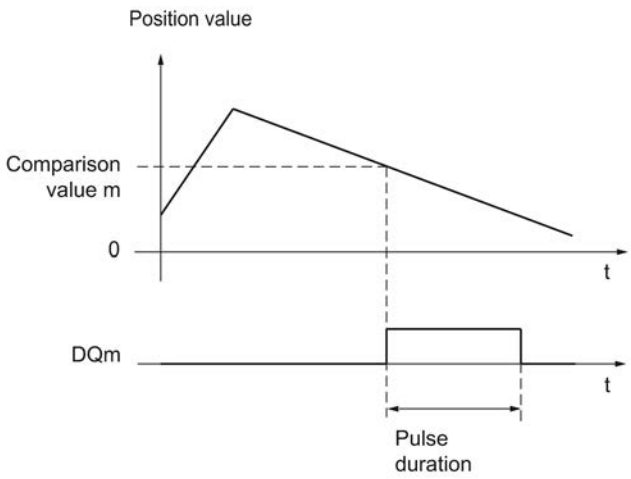
The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Matching of the position value and comparison value or crossing of the comparison value
- Current direction of the position value change = assigned direction for the comparison event

The figure below shows an example of the comparison event when counting up:



The figure below shows an example of the comparison event when counting down:



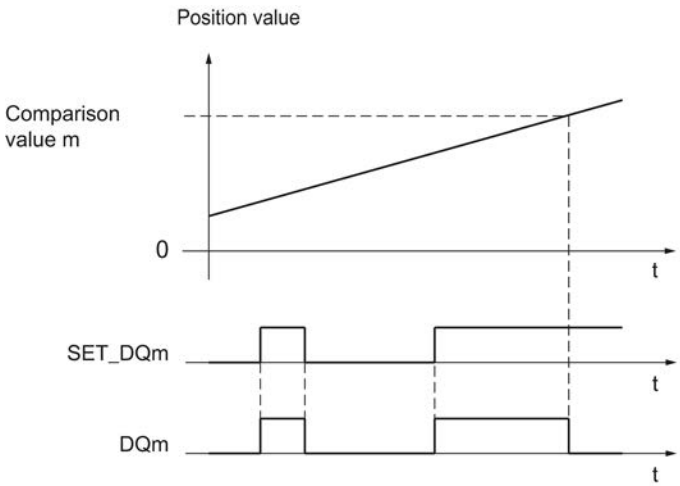
To repeat the comparison event, the position value must change and then correspond to or cross the respective comparison value again.

Setting by the user program up to comparison value

You can set each digital output to 1 (edge) by setting the control bit (Page 130) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Matching of the position value and the comparison value or crossing of the comparison value in the configured direction of the comparison event
- Resetting of the SET_DQm control bit.

The figure below shows an example of the comparison event when counting up:



You can disable the digital output before the position value corresponds to or exceeds the comparison value by setting the control bit SET_DQm to 0.

Note

If the comparison value is reached or exceeded in the assigned direction, feedback bit EVENT_CMPm is set independently of the status of control bit SET_DQm.

2.5.2.4 Hysteresis

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the position value has gone outside this range.

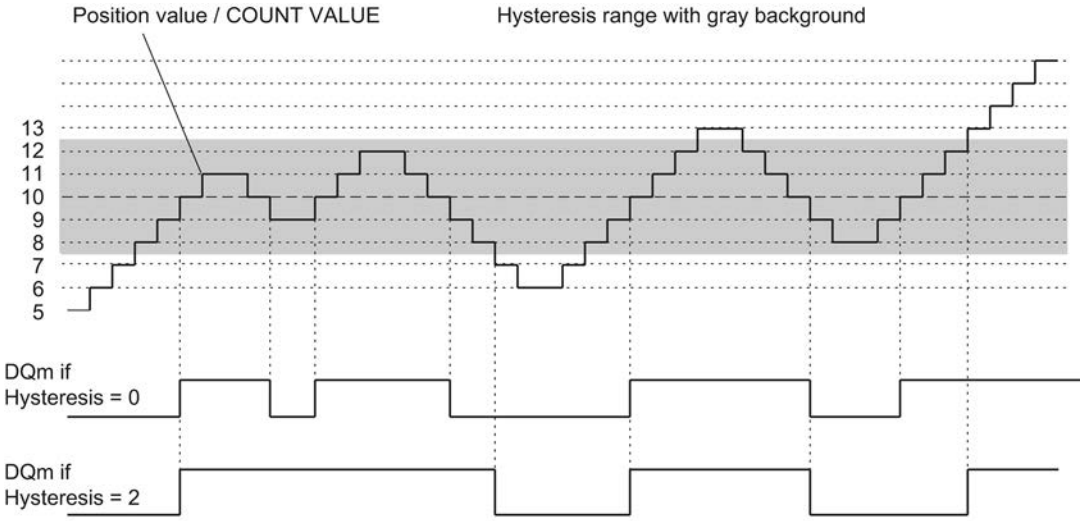
Slight movements by the encoder can result in the position value fluctuating around a certain value. If a comparison value, "0", or the respective maximum position value lies within this fluctuation range, the associated digital output is switched on and off with corresponding frequency if a hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a compare event occurs.

Regardless of the hysteresis value, the hysteresis range ends at "0" and at the respective maximum position value.

Function principle

The figure below shows an example for the hysteresis with the following parameter assignment:

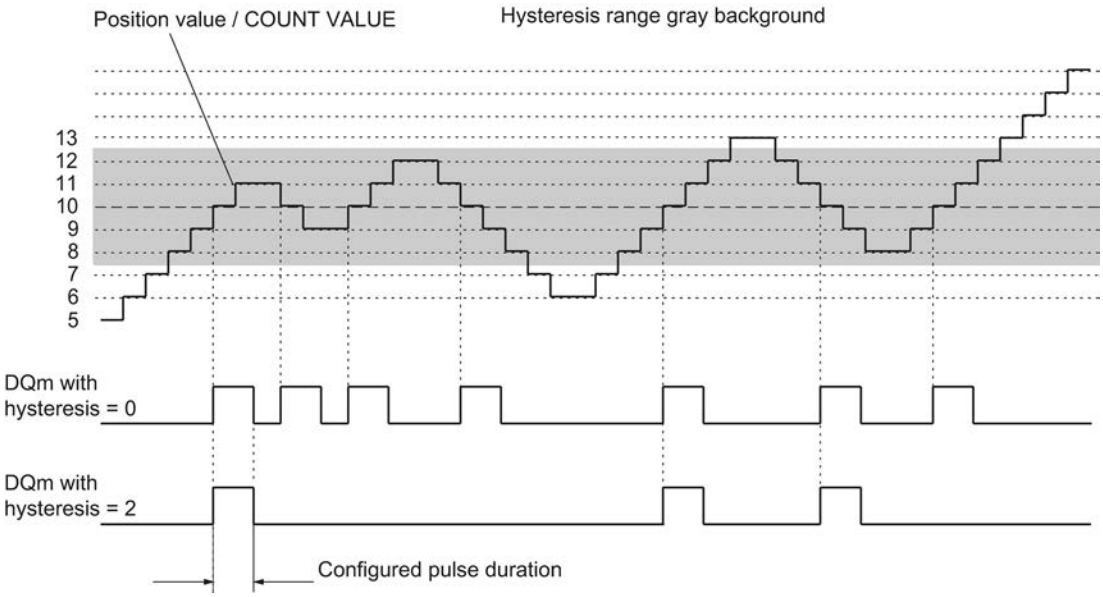
- Setting of a digital output between comparison value and high limit
- Comparison value = 10
- Hysteresis = 0 or 2



Hysteresis is enabled when the position value 10 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the position values 7 or 13 are reached.

The figure below shows an example for the hysteresis with the following parameter assignment:

- Setting at comparison value for one pulse duration
- Comparison value = 10
- Comparison in both directions of position value changes
- Hysteresis = 0 or 2



2.5.2.5 Measured value

The measured value is based on the timing of the incremental changes of the position value.

Measuring ranges

Measuring range SSI absolute encoder

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	4 MHz
Period measurement	0.25 µs	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

All measured values are returned as signed values. The sign indicates whether the position value increased or decreased during the relevant time period.

Measuring intervals

Measuring principle

The technology module assigns a time value to each SSI frame. The measuring interval is defined as the time between the last SSI frame with a change of position value before and during the previous update time. The measuring interval and the total change in position value in the measuring interval are evaluated to calculate a measured variable. The total change in position value in a measuring interval corresponds to the number of encoder increments in the same measuring interval.

If there is no change in position value within an update time, the measuring interval is dynamically adjusted. In this case, a change in position value is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last SSI frame with a change in position value. The change in position value is then 1.

The feedback bit STS_M_INTERVAL indicates whether a change in position value occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual change in position value. If the technology module cannot calculate measured values because the measuring range limit has been violated, the feedback bit STS_M_INTERVAL is not set.

Measuring types

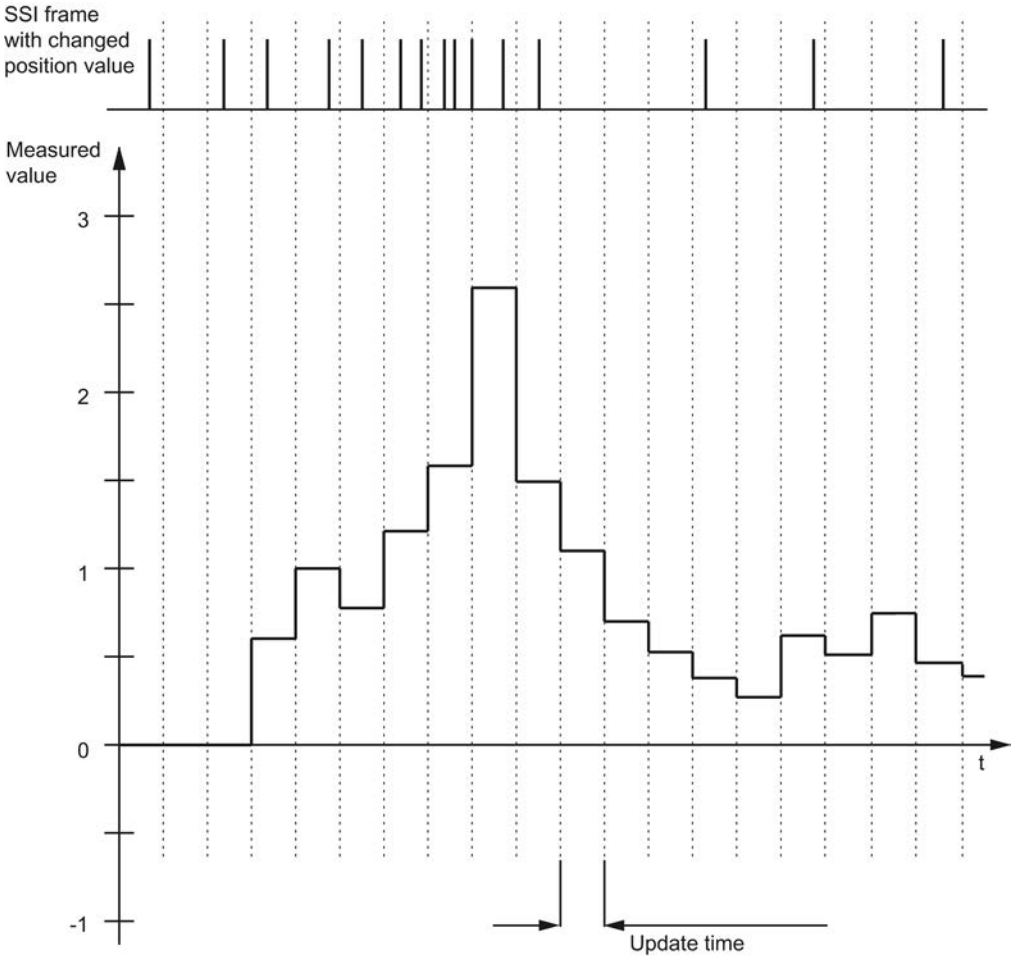
Frequency measurement

The value "0.0" is reported in the time up to the first available measured value.

The measuring process begins with the first detected change in position value. The first measured value can be calculated after the second change in position value at the earliest.

The measured value is updated in the feedback interface (Page 133) upon completion of each update time.

The figures below shows an example of frequency measurement with an update time of 1 s:



Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your SSI absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to configure 4096 Increments per unit and a time basis of one minute.

2.6 Encoder signals

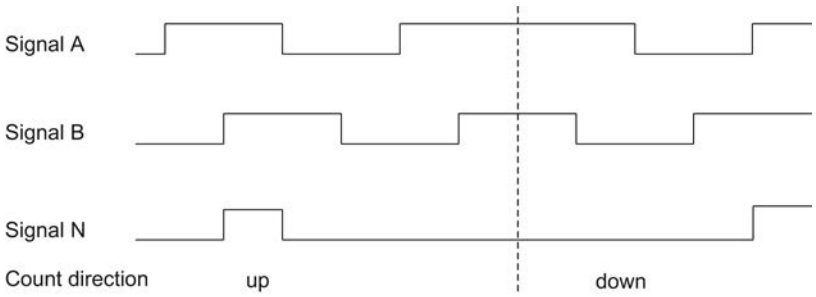
2.6.1 24 V count signals

24 V incremental encoder count signals

The 24 V incremental encoder returns the 24 V signals A, B, and N to the technology module. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

A 24 V incremental encoder uses the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value to the Capture value.

The figure below shows an example of the time profile of the signals of a 24 V incremental encoder:



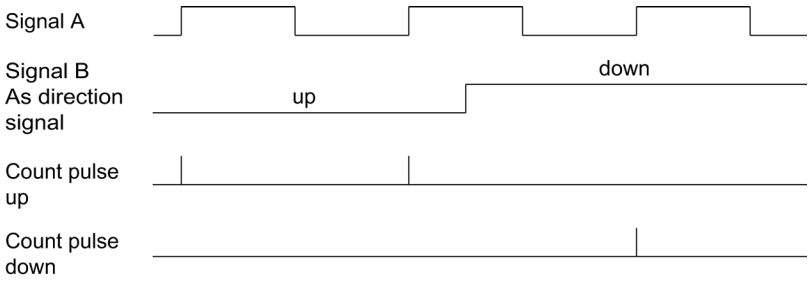
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of 24 V pulse encoders without/with direction signal

The encoder, for example an initiator (BERO) or a light barrier, returns only a count signal that is connected to terminal A of the counter.

In addition, you can connect a signal for direction detection to terminal B of the counter. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

The figure below shows an example of the time profile of the signals of a 24 V pulse encoder with direction signal and the resulting count pulses:



Count signals of 24 V pulse encoders with Up/Down count signal

The Up count signal is connected to terminal A. The Down count signal is connected to terminal B.

Sourcing output/sinking output

You can connect the following encoders/sensors to the counter inputs:

- Sourcing output:
  The A, B, and N inputs are wired to 24VDC .
- Sinking output:
  The A, B, and N inputs are wired to ground M .
- Push-pull (sourcing and sinking output):
  The A, B, and N inputs are wired alternately to 24VDC and ground M .

Monitoring of encoder signals

The signals of push-pull sensors are monitored for wire breaks by the technology module.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

2.6.2 RS422 count signals

RS422 incremental encoder count signals

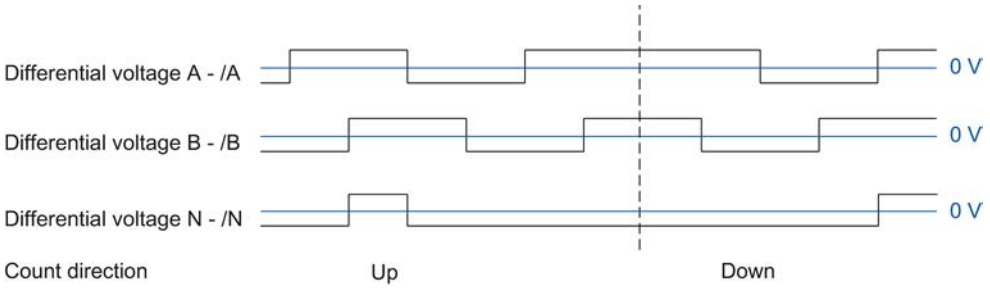
The RS422 incremental encoder sends the following differential signals to the technology module:

- A and /A
- B and /B
- N and /N

The signal information for RS422 signals is encoded in the differential voltage between A and /A, B and /B or N and /N. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

RS422 incremental encoders use the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value as the Capture value.

The figure below shows an example of the time profile of the signals of an RS422 incremental encoder:



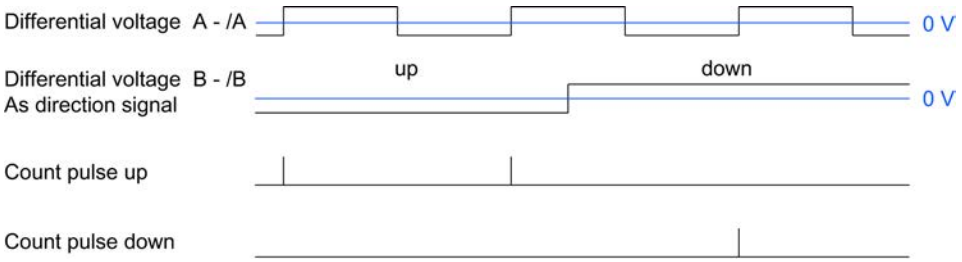
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of RS422 pulse encoders without/with direction signal

The encoder, for example a light barrier, only returns a count signal that is connected to terminal A.

You can also connect a signal for direction detection to terminal B. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

The figure below shows an example of the time profile of the signals of an RS422 pulse encoder with direction level and the resulting count pulses:



Count signals of RS422 pulse encoders with Up/Down count signal

The Up count signal is connected to terminals A and /A. The Down count signal is connected to terminals B and /B.

Monitoring of encoder signals

The technology module monitors RS422 signals for wire breaks, short-circuits, and offset voltages.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

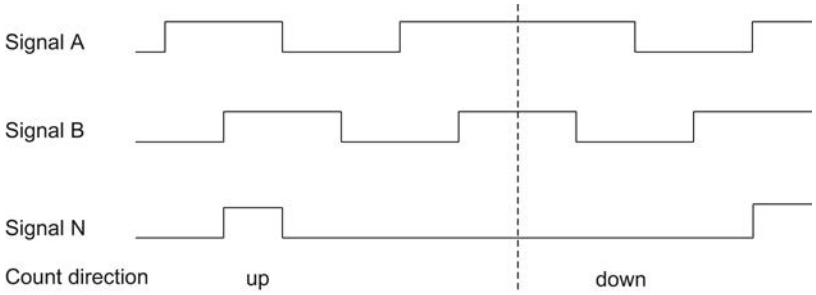
2.6.3 TTL count signals

TTL incremental encoder count signals

The TTL incremental encoder returns the TTL signals A, B, and N to the technology module. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

A TTL incremental encoder uses the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value to the Capture value.

The figure below shows an example of the time profile of the signals of a TTL incremental encoder:



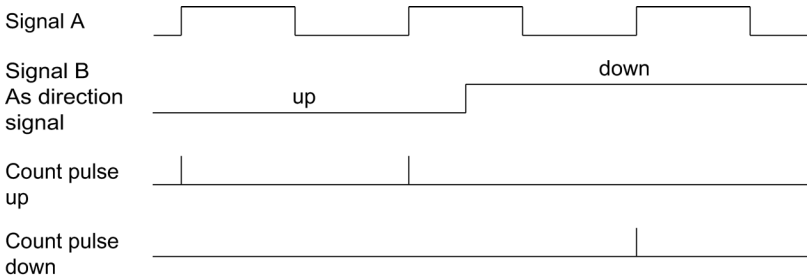
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of TTL pulse encoders without/with direction signal

The encoder, for example an initiator (BERO) or a light barrier, returns only a count signal that is connected to terminal A of the counter.

In addition, you can connect a signal for direction detection to terminal B of the counter. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

The figure below shows an example of the time profile of the signals of a TTL pulse encoder with direction signal and the resulting count pulses:



Count signals of TTL pulse encoders with Up/Down count signal

The Up count signal is connected to terminal A. The Down count signal is connected to terminal B.

Monitoring of encoder signals

The technology module monitors TTL signals for offset voltages.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

2.6.4 SSI signals

Signals from SSI absolute encoders

The SSI absolute encoder and the technology module communicate via SSI data signals DAT and /DAT (D) and the SSI clock signals CLK and /CLK (C). SSI uses the RS422 signal standard. The signal information is coded in the respective differential voltage between C and /C as well as D and /D.

Monitoring of the encoder signals and the SSI frames

The technology module monitors the signals of an SSI absolute encoder for wire breaks, short-circuits, and offset voltages. The technology module also monitors SSI frames for errors.

If you enable the diagnostic interrupts in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal or SSI frame errors.

2.7 Signal evaluation of incremental signals

2.7.1 Overview

The technology module counter counts the edges of encoder signals A and B. For incremental encoders with phase-shifted signals A and B, you can select either single or multiple evaluation to improve the resolution.

You can configure the following signal evaluations:

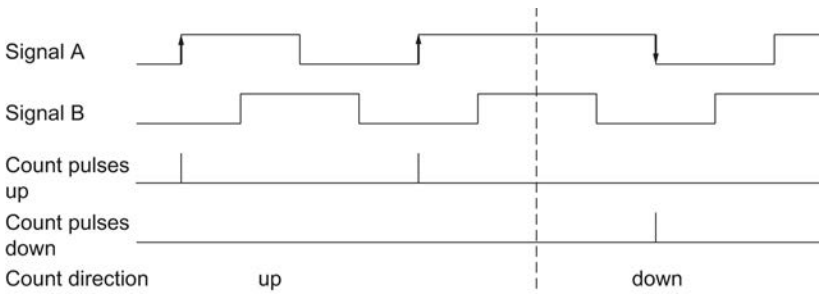
- Single evaluation (Page 64)
- Double evaluation (Page 65)
- Quadruple evaluation (Page 65)

2.7.2 Single evaluation

Single evaluation evaluates the rising and falling edge at signal A when signal B has a low level.

Count pulses in an upwards direction are generated with a rising edge at signal A during a low level at signal B. Count pulses in a downwards direction are generated with a falling edge at signal A during a low level of signal B.

The following figure shows an example for single evaluation:

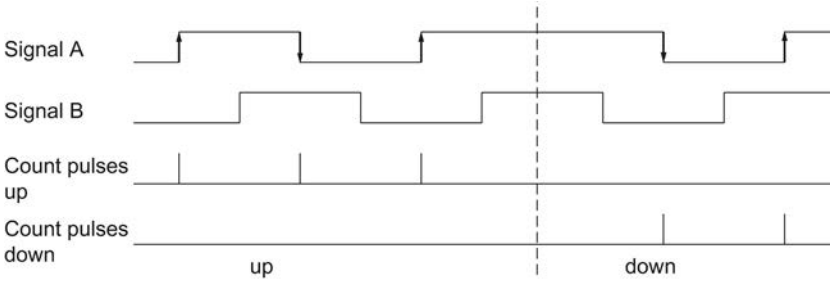


2.7.3 Double evaluation

With double evaluation, the rising and falling edges of signal A are evaluated.

The edge direction of signal A and the level at signal B determines whether count pulses are generated in an upward or downward direction.

The following figure shows an example for double evaluation:

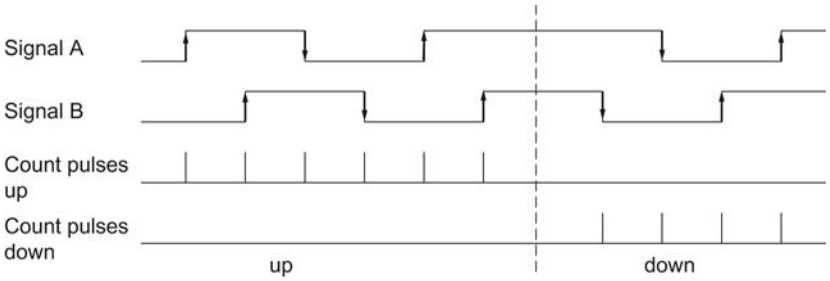


2.7.4 Quadruple evaluation

With quadruple evaluation, the rising and falling edges of signals A and B are evaluated.

The edge direction of one signal and the level of the other signal determines whether count pulses are generated in an upward or downward direction.

The following figure shows an example for quadruple evaluation:



2.8 Isochronous mode

The technology module supports the "isochronous mode" system function in distributed mode. This system function enables position, counter and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle.

The position value/count value and measured value and the status bits are captured at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

In isochronous mode, there is always data consistency across all bytes in the feedback interface.

Using the High_Speed_Counter 3

3.1 High_Speed_Counter technology object

STEP 7 (TIA Portal) helps you with the configuration of the counting and measuring functions for the technology modules with the "Technology objects" function in the project navigator ("Project > S7-1500 PLC > Technology objects"):

- You configure the High_Speed_Counter technology object in STEP 7 (TIA Portal) with the settings for the counting and measuring functions.
- The corresponding High_Speed_Counter instruction is programmed in the user program. This instruction supplies the control and feedback interface of the technology module.

The High_Speed_Counter technology object corresponds to the instance DB of the High_Speed_Counter instruction. The configuration of the counting and measuring functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects". It is implemented by an instance DB of the instruction.

The High_Speed_Counter technology object can be used for technology modules of both the S7-1500 and ET 200SP systems.

Counting operating mode

Counting mode is automatically defined if the technology object High_Speed_Counter is being used. The measured values are available concurrently.

Measuring mode

No technology object is available for the Measuring mode. The parameters of the Measuring mode are assigned using the parameter setting (HWCN) (Page 111) of the technology module. The technology module is controlled by direct access to the control and feedback interface.

Position input

- The parameter assignment of the SSI absolute encoder (Page 118) is performed using the parameter setting (HWCN) (Page 111) of the technology module. No technology object is available for position detection using an SSI absolute encoder.
- The parameter assignment of the encoder signals for position input for Motion Control (Page 106) is performed using the device configuration of the technology module. You can perform additional configuration for this application using the "TO_ExternalEncoder" technology object of S7-1500 Motion Control .

3.2 Overview of the configuration steps

Introduction

The overview below shows the basic procedure for configuring the counting and measuring functions of the technology module with the High_Speed_Counter technology object.

Requirement

Before you can use the High_Speed_Counter technology object, a project must be created in STEP 7 (TIA Portal) with an S7-1500 CPU.

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configuring the technology module and specifying use with technology object (Page 101)
2	Add technology object (Page 69)
3	Working with the configuration dialog (Page 71)
4	Call instruction in the user program (Page 88)
5	Load to CPU
6	Commissioning the technology object (Page 96)
7	Diagnostics of the technology object (Page 98)

3.3 Add technology object

Add technology object in the project navigator

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement

A project with an S7-1500 CPU has been created.

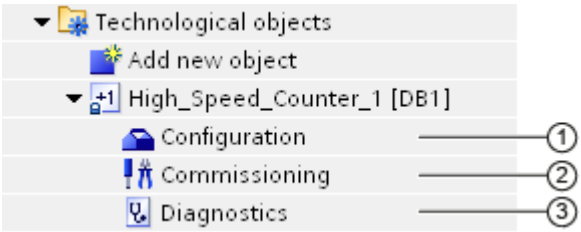
Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the "Counting and measurement" technology.
5. Select the "High_Speed_Counter" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Select the "Manual" option if you want to change the suggested data block number of the instance DB.
8. Click "Additional information" if you want to add your own information to the technology object.
9. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.



	Object	Description
①	Configuration (Page 71)	In the configuration dialog: • Assignment of technology module and channel • Technology object parameter settings for counting and measurement functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
②	Commissioning (Page 96)	Commissioning and function test of the technology object: Simulating parameters of the High_Speed_Counter instruction and monitoring the effects
③	Diagnostics (Page 98)	Monitoring the counting and measuring functions

3.4 Configuring the High_Speed_Counter

3.4.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

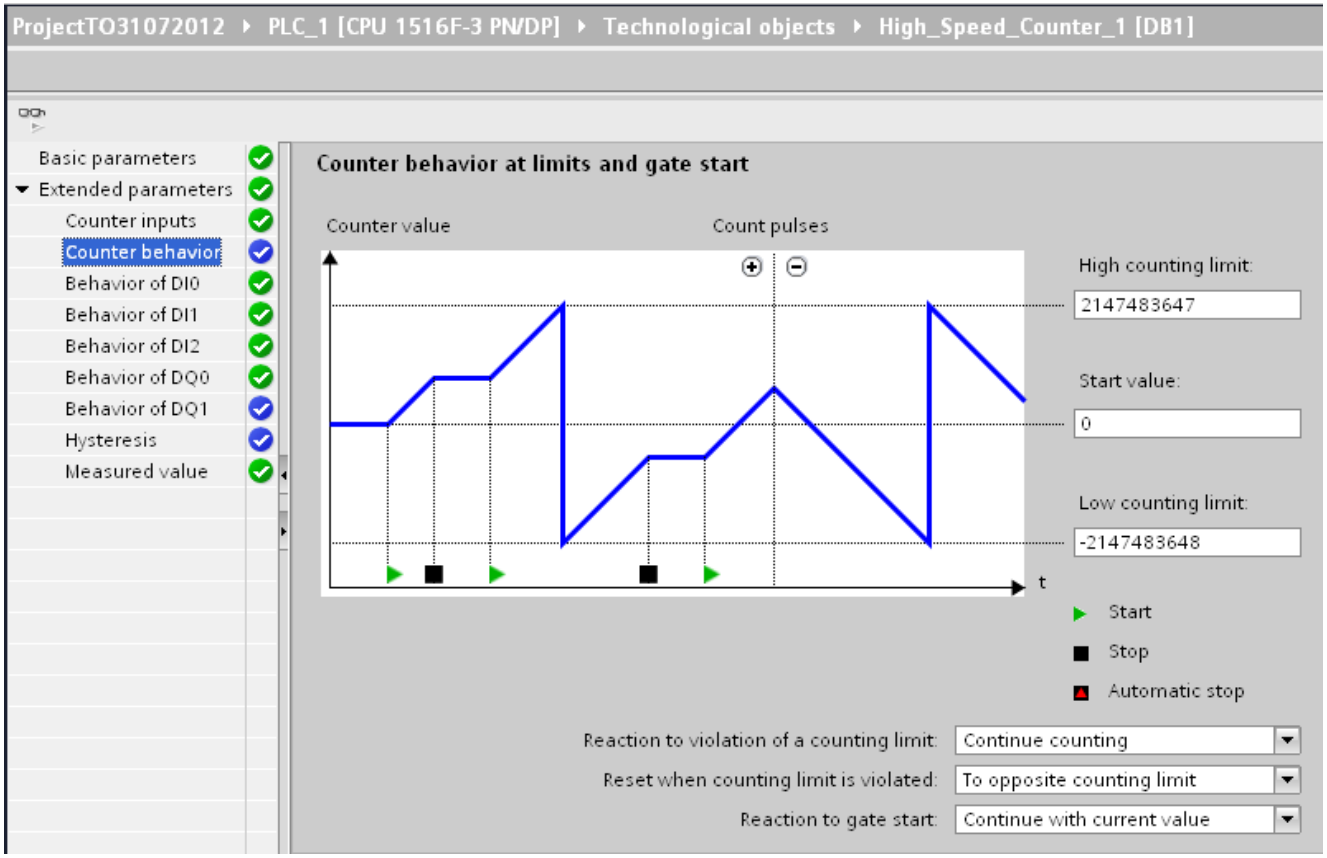
The configuration is divided into the following categories:

- **Basic parameters**

  The basic parameters include the selection of the technology module and the number of the counting channel for which the technology object is configured.

- **Extended parameters**

  The extended parameters include the parameters for adapting the counting and measuring functions and for setting the characteristics of the digital inputs and digital outputs.



Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user and is complete. All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

3.4.2 Basic parameters

You can establish the connection between the High_Speed_Counter technology object and the technology module under "Basic parameters".

Module

You select the technology module in a subsequent dialog box. You can choose any of the technology modules (central or distributed) which are configured in the S7-1500 CPU for use with a technology object from "Counting and measuring".

After selecting the technology module, you can open the device configuration associated with the technology module by clicking the"Device configuration" button.

The technology module parameter settings required for the use of the technology object are made in the "Extended parameters" of the technology object.

Channel

For a technology module with several counting channels, you can also select the number of the counting channel for which the High_Speed_Counter technology object is to be valid.

Synchronization of the parameter values

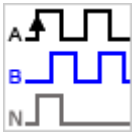
If there is an inconsistency between the parameter values under "Parameters" (HWCN) and in the technology object after assigning the count channel to the technology object, a button appears: "Overwrite technology module parameters". When you click the button, the parameter values under "Parameters" (HWCN) are overwritten (after a prompt) with the parameter values of the technology object in STEP 7 (TIA Portal). The current parameter values (read only) of the technology object are displayed under "Parameters" (HWCN).

3.4.3 Counter inputs

3.4.3.1 Specifying input signals/encoder type

Signal type

You can choose from the following signal types (Page 58):

Symbol	Signal type	Meaning
	Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.
	Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.
	Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.
	Pulse (A)	A pulse encoder (signal A) without direction signal is connected. You can specify the counting direction by means of the control interface (Page 130).
	Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.

Invert direction

You can invert the count direction to adapt it to the process.

Inversion of direction can only be configured and become effective if signal type "Incremental encoder (A, B phase-shifted)" or "Incremental encoder (A, B, N)" is selected.

3.4.3.2 Additional parameters

Signal evaluation

By configuring signal evaluation (Page 64), you can specify which edges of the signals are counted.

You can select from the following options:

Icon	Signal evaluation	Meaning
	Single (Page 64) (default)	The edges of signal A are evaluated during a low level of signal B.
	Double (Page 65)	Each edge of signal A is evaluated.
	Quadruple (Page 65)	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counter inputs A, B and N.

The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This produces a set minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Table 3- 1 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz (default at TM Count)	2.0 µs
500 kHz*	0.8 µs
1 MHz* (default at TM PosInput)	0.4 µs

* only with TM PosInput

Sensor type

By configuring the sensor type, you specify how the counter inputs are wired for the TM Count.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor switches the inputs A, B and N to 24VDC.
Sinking output	The encoder/sensor switches the inputs A, B and N to M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately switches the inputs A, B and N to M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "sourcing output" or "sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

Note

If you use a push-pull encoder, you can monitor the encoder signals for wire break.

Interface standard

You use this parameter to specify whether the encoder outputs symmetric (RS422) or asymmetric (TTL) signals for the TM PosInput.

You can select from the following options:

Interface standard	Meaning
RS422, symmetric	The encoder outputs symmetric signals according to the RS422 standard (Page 60).
TTL (5 V), asymmetric	The encoder outputs asymmetric 5 V signals according to the TTL standard (Page 62).

Note

The RS422 standard provides greater interference immunity than the TTL standard. If your incremental or pulse encoder supports the RS422 standard **and** the TTL standard, we recommend using the RS422 standard.

Reaction to signal N

You use this parameter to specify which reaction is triggered at signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 29)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.
Capture at signal N (Page 22)	The counter value is stored in the Capture value at signal N.

Note

You can only select the reaction at signal N if you have selected the signal type (Page 73) "Incremental encoder (A, B, N)".

Note

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 80).

Frequency

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

3.4.4 Counter behavior

3.4.4.1 Counting limits and start value

High counting limit

You limit the counting range by setting the high counting limit. You can enter a value up to 2147483647 (2^{31}-1). You must enter a value that lies above the low counting limit.

The default setting is "2147483647".

Low counting limit

You limit the counting range by setting the low counting limit. You can enter a value up to -2147483648 (-2^{31}). You must enter a value below the high counting limit.

The default setting is "-2147483648".

Start value

By configuring the start value, you specify the value at which counting is to start and where it is to continue in the case of defined events. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Additional information

For more information, see Behavior at the counting limits (Page 17) and Counter behavior at gate start (Page 21).

3.4.4.2 Counter behavior at limits and gate start

Reaction to violation of a counting limit

You can configure the following characteristics for violation of a counting limit (Page 17):

Reaction	Meaning
Stop counting	If a counting limit is violated, counting is stopped and the internal gate is closed. To restart counting, you must also close and reopen the software/hardware gate.
Continue counting (default)	Counting continues either with the start value or at the opposite counting limit, depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter to the following values when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit (default)	The counter value is set to the opposite counting limit.

Reaction to gate start

You can set the following Reaction to gate start (Page 21):

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value (default)	When the gate is opened, counting is continued with the last counter value.

3.4.5 Behavior of a DI

3.4.5.1 Function of a DI

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 19).
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 19).
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 19).
Synchronization (Page 24)	The configured edge at the respective digital input sets the counter to the start value.
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 29).
Capture (Page 22)	The configured edge at the respective digital input saves the current counter value as a Capture value.
Digital input without function	No function is assigned to the respective digital input. The signal status of the digital input can be read by the CPU by means of the feedback interface (Page 133).

Note

With the exception of "Digital input without function", each function can only be used once, and if used for one digital input is not available to the others.

Filter time

By configuring the filter time, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured filter time are suppressed.

You can select from the following filter times:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the option "None" or "0.05 ms", you have to use shielded cables for connecting the digital inputs.

Note

You can only configure the filter time under "Behavior of DI0" for all digital inputs together.

3.4.5.2 Function options

Certain functions require additional parameters which allow you to specify characteristics in more detail. These can be configured for each of the relevant functions.

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

The following options may be available depending on the function selected:

- At rising edge (default)
- At falling edge
- At rising and falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization
- Capture

"At rising and falling edge" can only be configured for the function "Capture".

Behavior of counter value after Capture

You can configure the following characteristics for the counter after a capture event (Page 22):

	Meaning
Continue counting (default)	After saving the current count value as Capture value, counting is continued unchanged.
Set to start value and continue counting	After saving the current count value as Capture value, counting is continued with the start value.

See also

Function of a DI (Page 80)

3.4.6 Function of a DQ

Set output

By configuring a digital output, you can specify the condition (Page 33) upon which the digital output switches.

You can select from the following options:

Function of a digital output	Meaning
Between comparison value and high limit (default)	The respective digital output is active if the counter value is between the comparison value and the high counting limit.
Between comparison value and low counting limit	The respective digital output is set to active if the counter value is between the comparison value and the low counting limit.
Between comparison value 0 and 1	The digital output DQ1 is active if the counter value is between the comparison value 0 and the comparison value 1.
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the count value reaches the comparison value.
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active until the counter value is equal to the comparison value.
Use by user program	The respective digital output (Page 32) can be switched by the CPU via the control interface (Page 130).

Note

You can select the function "Between comparison value 0 and 1" if the function "Use by user program" is selected for digital output DQ0.

Note

The "At comparison value for a pulse duration" and "After set command from CPU until comparison value" functions only switch the digital output in question if a count pulse reaches the comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

Comparison value 0

By configuring the comparison value (Page 32), you can specify the counter value at which the digital output DQ0 is to switch as a result of the selected compare event.

You must enter a value which is greater than or equal to the low counting limit and smaller than comparison value 1.

The default setting is "0".

Comparison value 1

By configuring the comparison value (Page 32), you can specify the counter value at which the digital output DQ1 is to switch as a result of the selected compare event.

You must enter a value which is greater than comparison value 0 and smaller than or equal to the high counting limit.

The default setting is "10".

Count direction

You use this parameter to specify the count direction for which the selected function is valid.

You can select from the following options:

Count direction	Meaning
In both directions (default)	The comparison and switching of the respective digital output take place regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

If you enter "0" and the counter value corresponds to the comparison value, the digital output remains active until the next count pulse.

You can enter a value between 0.0 and 6553.5.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

3.4.7 Hysteresis

Set hysteresis range

By configuring hysteresis (Page 37), you can define a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again until the counter value is outside the range.

Regardless of the hysteresis value, the hysteresis range ends at the low/high counting limits. If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

Hysteresis can only be configured in Counting mode.

3.4.8 Specifying the measured value

Measured variable

This parameter is used to specify the measured variable (Page 42) to be provided by the technology module.

You can select from the following options:

Measured variable	Meaning
Frequency (default)	The measured variable is a frequency. The unit is Hz.
Period	The measured variable is a period. The unit is s.
Velocity	The measured variable is a velocity. You configure the time basis for the velocity measurement and the Increments per unit separately.

Update time

By configuring the update time (Page 41) in milliseconds, you can specify the time interval between two measured value updates.

The update time and the signal type (Page 73) effect the accuracy of the measurement. In the case of update times of at least 100 ms, the effect of the signal type is negligible.

In the case of update times of less than 100 ms, you achieve maximum measurement accuracy using the following signal types:

- Incremental encoder (A, B phase-shifted) with Signal evaluation "Single"
- Incremental encoder (A, B, N) with Signal evaluation "Single"
- Pulse (A) and direction (B)
- Pulse (A)

In the case of other signal types, measurement accuracy depends on the encoder and cable used.

If you enter "0", the measured value is updated in each cycle. Up to three decimal places can be entered. You can enter a value between 0.000 and 25000.000. The default setting is "10.000".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s/1 min
- The default setting is "60 s/1 min".

Increments per unit

This parameter defines the number of increments per relevant unit.

You can enter a value between 1 and 65535.

Example:

Your encoder delivers 4000 increments per meter. The velocity is to be measured in meters per minute.

In this case, you need to assign the following parameters:

- Increments per unit: 4000
- Time base for velocity measurement: 60 s/1 min

3.5 Programming the High_Speed_Counter

3.5.1 High_Speed_Counter instruction

High_Speed_Counter

The High_Speed_Counter instruction is part of the High_Speed_Counter technology object. It supplies the control and feedback interface of the technology module.

The High_Speed_Counter instruction therefore forms the software interface between the CPU and the technology module. It is called cyclically from the user program to synchronize the input and output data.

The High_Speed_Counter instruction can be used for the technology modules of both S7-1500 and ET 200SP.

Additional information

Description High_Speed_Counter (Page 89)

High_Speed_Counter input parameters (Page 92)

High_Speed_Counter output parameters (Page 93)

ErrorID parameter (Page 94)

High_Speed_Counter static variables (Page 95)

3.5.2 Call instruction in the user program

The High_Speed_Counter instruction can be called once for each counter in the cycle or, alternatively, in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.
4. In the "Instructions" window, open the "Technology" group and the "Counting and measurement" folder.
   The instructions are located in the folder.
5. Select an instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

3.5.3 Description High_Speed_Counter

Description

The High_Speed_Counter instruction is used to control the technology module counting and measuring functions via the user program.

Call

The instruction High_Speed_Counter must be called once per counter, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Functional description

Counter value: The counter value is available at the output parameter CountValue. The counter value is updated at every call of the High_Speed_Counter instruction.

Measured value: The measured value is available at the output parameter MeasuredValue. The measured value is updated at every call of the High_Speed_Counter instruction.

The measured value and the counter value are available concurrently in the feedback interface.

Capture: The output parameter CaptureStatus = TRUE indicates a valid Capture value at the output parameter CapturedValue.

- A Capture value is captured under the following conditions:
  - A digital input has the parameter assignment "Capture"
  - CaptureEnable = TRUE
  - Edge at digital input with the Capture function
- The output parameter CaptureStatus is reset by a falling edge at input parameter CaptureEnable.

Synchronization: The output parameter SyncStatus = TRUE indicates that a synchronization has occurred.

- The counter value is synchronized under the following conditions:
  - A digital input has the parameter assignment "Synchronization" **or** the incremental encoder has the parameter assignment "Synchronization at signal N"
  - SyncEnable = TRUE
  - SyncUpDirection (or SyncDownDirection) = TRUE
  - Edge at digital input with the synchronization function **or** rising edge of the signal N at the encoder input
- The output parameter SyncStatus is reset by a falling edge at
  - the input parameter SyncEnable or
  - the static tag SyncDownDirection or
  - the static tag SyncUpDirection

Parameter changes via the user program

Proceed as follows to modify parameters using the user program:

1. Check the relevant Set tag to establish whether the technology object is ready for the parameter change (Set tag = FALSE) or whether a change command is still running (Set tag = TRUE).
2. If the technology object is ready for the parameter change, modify the relevant static tag.
3. Set the relevant Set tag for execution of the change command.
4. Use the output parameter Error to check whether an error has occurred.
   If no errors have occurred and the Set tag has been automatically reset by the technology object, the parameter change was successful.

Low or high counter limit: The two limits are changed as follows via the user program:

1. Checking the static tag SetUpperLimit (or SetLowerLimit) = FALSE
2. Changing the static tag NewUpperLimit (or NewLowerLimit)
3. SetUpperLimit (or SetLowerLimit) = TRUE
4. Checking the new counter limit in the static tags CurUpperLimit or CurLowerLimit

---

Note

If the new high counting limit is less than the current count value, the count value is set to the low counting limit or the start value, depending on the configuration. If the new low counting limit is greater than the current count value, the count value is set to the high counting limit or the start value, depending on the configuration.

Comparison values: The two comparison values are changed as follows via the user program:

1. Checking the static tag SetReferenceValue0 (or ReferenceValue1) = FALSE
2. Changing the static tag NewReferenceValue0 (or NewReferenceValue1)
3. SetReferenceValue0 (or SetReferenceValue1) = TRUE
4. Checking the new comparison value in the static tag CurReferenceValue0 (or CurReferenceValue1)

Counter value: You can set the current counter value to a new counter value from the user program. The current counter value is changed as follows:

1. Checking the input parameter SetCountValue = FALSE
2. Changing the static tag NewCountValue
3. SetCountValue = TRUE
4. Checking the new counter value in the output parameter CountValue

Start value: The start value is changed as follows using the user program:

1. Checking the static tag SetStartValue = FALSE
2. Changing the static tag NewStartValue
3. SetStartValue = TRUE
4. Checking the new start value in the static tag CurStartValue

Acknowledgment of events

Acknowledgment of signaled events can be performed via the rising edge of the input parameter EventAck . EventAck must stay set until the technology object has reset the status bits of the following events of the counting channel:

- CompResult0
- CompResult1
- ZeroStatus
- PosOverflow
- NegOverflow

Status of the digital inputs

You can obtain the status of the digital inputs with the static tags StatusDI0, StatusDI1 or StatusDI2.

Use digital outputs by user program

You can set the digital outputs with the High_Speed_Counter instruction,

- if the setting "Use by user program" is configured for "Set output".
- if the setting "After set command from CPU until comparison value" is configured for "Set output" .
- if you set the corresponding static tag ManualCtrlDQm (temporary overwrite).

The static tags SetDQ0 and SetDQ1 are only effective in these cases. In the first and third case, DQm follows the value of SetDQm. In the second case, DQm is set with an edge (rising or falling) by SetDQm. DQm is reset when the counter value equals the comparison value.

Reaction to error

If an error has occurred during the call of the instruction or in the technology module, the output parameter Error is set. More detailed error information can be read at the output parameter ErrorID.

Eliminate the cause of the error and acknowledge the error message by setting the input parameter ErrorAck. When no more errors are pending, the technology object resets the output parameter Error . No new error is signaled until you acknowledge the previous error.

Changing the count direction

The count direction can only be changed by the user program if "Pulse (A)" is configured as the signal type. In all other cases, the count direction is determined by the input signals of the technology module. The count direction is controlled by the static tag NewDirection:

- +1: Upward count direction
- -1: Downward count direction

To execute the change command, you need to set the tag SetNewDirection = TRUE.

3.5.4 High_Speed_Counter input parameters

Parameter	Data type	Default	Description
SwGate	BOOL	FALSE	Control software gate: • Rising edge: Software gate opens • Falling edge: Software gate closes Together with the hardware gate, the SwGate enables the internal gate.
SetCountValue	BOOL	FALSE	A rising edge starts the transmission of the new counter value in the static tag NewCountValue to the technology module. The counter value is effective as soon as transmission is complete.
CaptureEnable	BOOL	FALSE	Enabling the Capture function A Capture event occurs after enabling at the next configured edge at the relevant digital input. A falling edge at CaptureEnable resets the output parameter CaptureStatus. A falling edge at CaptureEnable resets the enable even if no Capture event has occurred.
SyncEnable	BOOL	FALSE	Enable synchronization The direction enabled for synchronization is indicated in the static tags SyncUpDirection and SyncDownDirection. A falling edge at SyncEnable resets the output parameter SyncStatus .
ErrorAck	BOOL	FALSE	A rising edge acknowledges the error status reported.
EventAck	BOOL	FALSE	A rising edge resets the following output parameters: • CompResult0 • CompResult1 • ZeroStatus • PosOverflow • NegOverflow

3.5.5 High_Speed_Counter output parameters

Parameter	Data type	Default	Description
StatusHW	BOOL	FALSE	Status bit technology module: The module is configured and ready for operation. The module data is valid.
StatusGate	BOOL	FALSE	Status bit: Internal gate is released if parameter is set
StatusUp	BOOL	FALSE	Status bit: The last count pulse has incremented counter and took place no more than 0.5 s ago
StatusDown	BOOL	FALSE	Status bit: The last count pulse has decremented the counter and took place no more than 0.5 s ago
CompResult0	BOOL	FALSE	Status bit: Compare event for DQ0 has occurred The rising edge of the input parameter EventAck is used to reset CompResult0 .
CompResult1	BOOL	FALSE	Status bit: Compare event for DQ1 has occurred The rising edge of the input parameter EventAck is used to reset CompResult1 .
SyncStatus	BOOL	FALSE	Status bit: Synchronization has occurred If the input parameter SyncEnable is set, the configured edge sets the status bit SyncStatus at the respective digital input. SyncStatus is reset with falling edge at • SyncEnable (input parameter) or • SyncUpDirection (static tag) or • SyncDownDirection (static tag)
CaptureStatus	BOOL	FALSE	Status bit: Capture event has occurred If the input parameter CaptureEnable is set, the configured edge sets the status bit CaptureStatus. at the respective digital input. Falling edge of input parameter CaptureEnable resets CaptureStatus .
ZeroStatus	BOOL	FALSE	Status bit: CountValue has reached "0" value The rising edge of the input parameter EventAck is used to reset ZeroStatus.
PosOverflow	BOOL	FALSE	Status bit: CountValue has violated high counting limit The rising edge of the input parameter EventAck is used to reset PosOverflow.
NegOverflow	BOOL	FALSE	Status bit: CountValue has violated low counting limit The rising edge of the input parameter EventAck is used to reset NegOverflow.
Error	BOOL	FALSE	An error has occurred. Refer to the output parameter ErrorID for the cause of the error.
ErrorID	WORD	0	The ErrorID (Page 94) parameter displays the number of the error message. ErrorID = 0000_H: No error pending.
CountValue	DINT	0	Current counter value
CapturedValue	DINT	0	Last captured Capture value; CaptureStatus = TRUE, if new Capture event has occurred
MeasuredValue	REAL	0.0	Current measured value for frequency, period or velocity (depending on configuration)

3.5.6 ErrorID parameter

Error code (W#16#...)	Description
0000	No error
Error messages from technology module	
80A1	POWER_ERROR from feedback interface: Incorrect supply voltage L+
80A2	ENC_ERROR from feedback interface: Incorrect encoder signal
80A3	LD_ERROR from feedback interface: Error when loading via control interface
Error messages of the instruction High_Speed_Counter	
80B1	Invalid count direction
80B4	New low counting limit does not meet the following conditions: • Low counting limit < high counting limit • Low counting limit <= comparison value/counter value/start value
80B5	New high counting limit does not meet the following conditions: • Low counting limit < high counting limit • High counting limit >= comparison value/counter value/start value
80B6	New start value does not meet the following condition: • Low counting limit <= start value <= high counting limit
80B7	New counter value does not meet the following condition: • Low counting limit <= counter value <= high counting limit
80B8	New comparison value 0 does not meet the following conditions: • Low counting limit <= comparison value 0 <= high counting limit • Comparison value 0 < comparison value 1
80B9	New comparison value 1 does not meet the following conditions: • Low counting limit <= comparison value 1 <= high counting limit • Comparison value 0 < comparison value 1
80C0	Instruction High_Speed_Counter was called multiple times with the same instance (DB)
80C1	Communication with technology module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
80C2	Communication with technology module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
80C3	Access to input data (feedback interface) failed: Error information of internal instruction GETIO_PART saved in static tag AdditionalErrorID
80C4	Access to output data (control interface) failed: Error information of internal instruction SETIO_PART saved in static tag AdditionalErrorID
80C5	Reading of the current start information of the OB failed: Error information of internal instruction RD_SINFO saved in static tag AdditionalErrorID
80C6	Failed to get I/O addresses of the technology module: Error information of internal instruction RD_ADDR saved in static tag AdditionalErrorID

3.5.7 High_Speed_Counter static variables

Tag		Data type	Default	Access	Description
NewCountValue		DINT	L#0	Writing	New counter value
NewReferenceValue0		DINT	L#0	Writing	New comparison value 0
NewReferenceValue1		DINT	L#10	Writing	New comparison value 1
NewUpperLimit		DINT	L#2147483647	Writing	New high counting limit
NewLowerLimit		DINT	L#-2147483648	Writing	New low counting limit
NewStartValue		DINT	L#0	Writing	New start value
CurReferenceValue0		DINT	L#0	Read	Current comparison value 0
CurReferenceValue1		DINT	L#10	Read	Current comparison value 1
CurUpperLimit		DINT	L#2147483647	Read	Current high counting limit
CurLowerLimit		DINT	L#-2147483648	Read	Current low counting limit
CurStartValue		DINT	L#0	Read	Current start value
NewDirection		INT	0	Writing	New count direction: +1: Upward count direction -1: Downward count direction
AdditionalErrorID		WORD	W#16#0000	Read	Error information of an internal instruction, e.g.,RDREC
UserCmdFlags		STRUCT	-		
	SetNewDirection	BOOL	FALSE	Writing	Setting a new count direction
	SetUpperLimit	BOOL	FALSE	Writing	Set high counting limit
	SetLowerLimit	BOOL	FALSE	Writing	Set low counting limit
	SetReferenceValue0	BOOL	FALSE	Writing	Set comparison value 0
	SetReferenceValue1	BOOL	FALSE	Writing	Set comparison value 1
	SetStartValue	BOOL	FALSE	Writing	Set start value
	SyncDownDirection	BOOL	TRUE	Writing	Enable synchronization in downward count direction
	SyncUpDirection	BOOL	TRUE	Writing	Enable synchronization in upward count direction
	SetDQ0	BOOL	FALSE	Writing	Set digital output DQ0
	SetDQ1	BOOL	FALSE	Writing	Set digital output DQ1
	ManualCtrlDQ0	BOOL	FALSE	Writing	Enable setting of digital output DQ0: TRUE: • SetDQ0 sets DQ0 • Control bit TM_CTRL_DQ0 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ0 = TRUE

Tag		Data type	Default	Access	Description
	ManualCtrlDQ1	BOOL	FALSE	Writing	Enable setting of digital output DQ1: TRUE: • SetDQ1 sets DQ1 • Control bit TM_CTRL_DQ1 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ1 = TRUE
UserStatusFlags		STRUCT	-		
	StatusDI0	BOOL	FALSE	Read	Current status of digital input DI0
	StatusDI1	BOOL	FALSE	Read	Current status of digital input DI1
	StatusDI2	BOOL	FALSE	Read	Current status of digital input DI2
	StatusDQ0	BOOL	FALSE	Read	Current status of digital output DQ0
	StatusDQ1	BOOL	FALSE	Read	Current status of digital output DQ1

3.6 Commissioning the High_Speed_Counter

3.6.1 Commissioning the technology object

The commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the High_Speed_Counter instruction in CPU/IM online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding High_Speed_Counter instruction is called cyclically from the user program.
- The parameters of the technology object are not overwritten by the user program.

Procedure

To open the commissioning editor of a technology object, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the High_Speed_Counter technology object are displayed.
4. Click the button "Launch display".
   The parameters (online values) of the High_Speed_Counter technology object are loaded and displayed.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- New counter value (NewCountValue)
- New high counting limit (NewUpperLimit)
- New low counting limit (NewLowerLimit)
- New comparison value 0 (NewReferenceValue0)
- New comparison value 1 (NewReferenceValue1)
- New start value (NewStartValue)
- Start and stop counter (SwGate)
- Enable Capture (CaptureEnable)
- Enable synchronization (SyncEnable)
- Acknowledgment of signaled error states (ErrorAck)
- Resetting the status flag (EventAck)

Modified values become effective as new parameters of the technology object when the text box is closed, when you press ENTER or by additionally setting the relevant set variable.

3.7 High_Speed_Counter diagnostics

3.7.1 Monitoring counter values, measured values, DIs and DQs

You use the diagnostic functions to monitor the counting and measuring functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

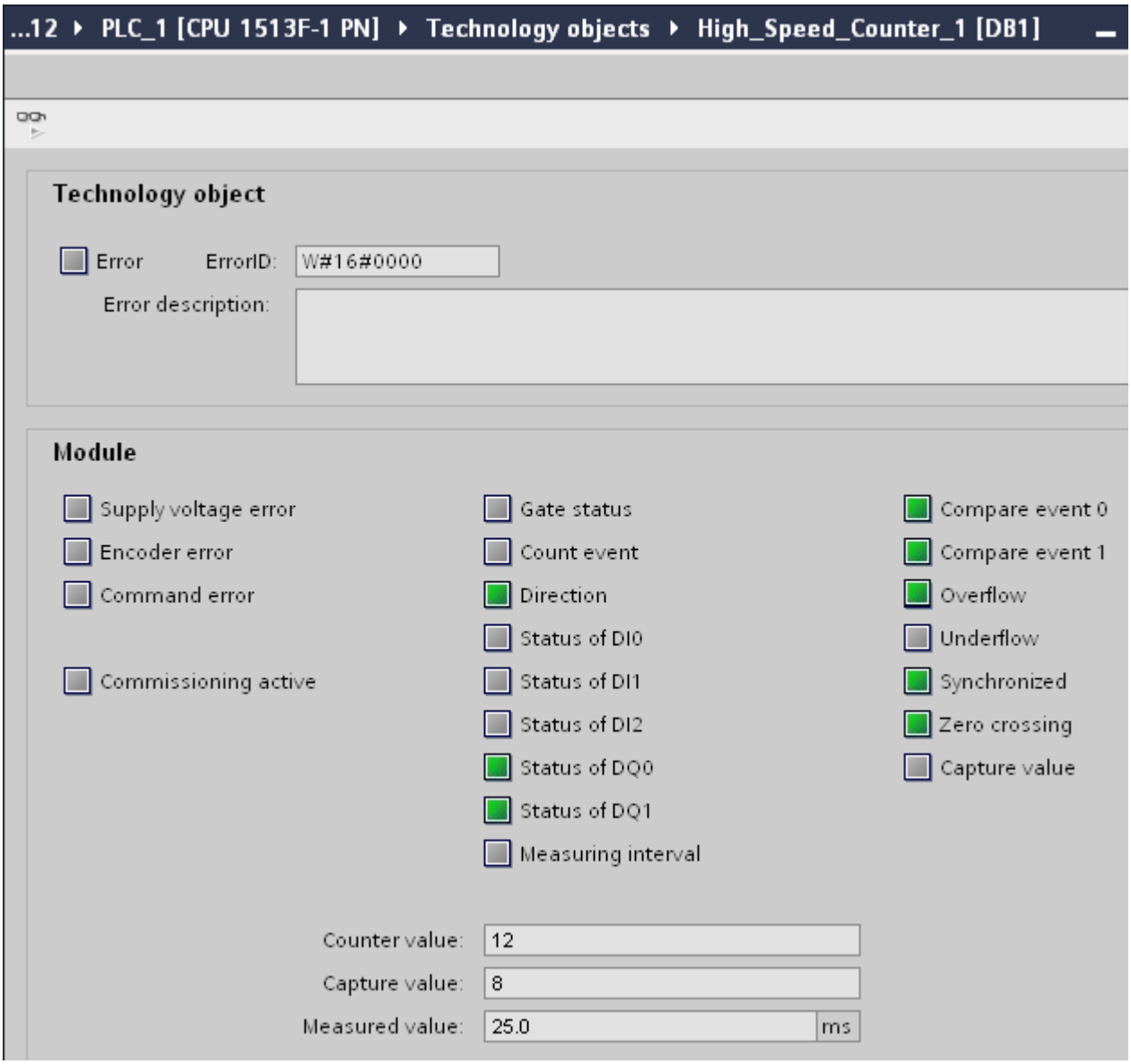
1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Diagnostics" object.

Display

The following values are read out from the technology object and displayed:

- Event display/diagnostics information
- Signal states of the digital inputs and digital outputs
- Counter value
- Capture value
- Measured value

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.



Using the technology module 4

4.1 Configuring a module

4.1.1 Adding a technology module to hardware configuration

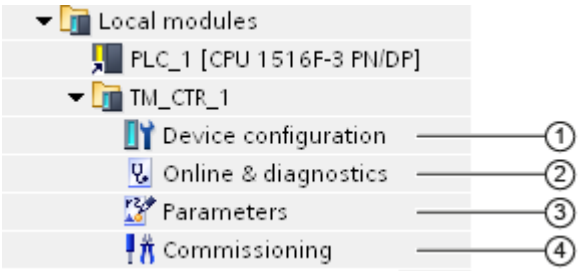
Procedure

A technology module can only be configured if you have set up a project in which the configuration can be saved.

1. Open the device configuration of the CPU or IM.
2. Select a module rack.
3. Select the technology module from the module catalog:
   "TM > Counting or Position feedback> Technology module > Order number".
4. Drag the technology module to the required slot in the module rack.

Result

The new technology module is now displayed with the following objects under "Local modules" or "Distributed I/O" in the project tree. Double-click to open the required editor.



	Object	Description
①	Device configuration (Page 103)	In the Inspector window (per channel): • Setting the reaction to CPU STOP • Enable diagnostic interrupt • Setting the operating mode (Page 105) • Enable hardware interrupts (Page 108) • Setting the module addresses
②	Online & Diagnostics (Page 126)	• Hardware diagnostics • Obtain information on technology module • Run firmware update
③	Parameter (Page 110)	Display and, if applicable, parameter settings for the counting and measuring functions in HWCN, if parameter assignment and control are not implemented using the High_Speed_Counter technology object.
④	Commissioning (Page 127)	Commissioning and function test of the technology module: Simulate counter values and DIs in CPU or IM online mode and monitor their effects.

4.1.2 Basic parameters

4.1.2.1 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module for each channel to CPU STOP in the basic parameters of the device configuration.

Table 4- 1 Reaction of the technology module to CPU STOP depending on parameter assignment (by channel)

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the actual position is read. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

Substitute value for DQ0

This parameter lets you specify which value the technology module is to output to the digital output DQ0 in the event of a CPU STOP under "Output substitute value".

Substitute value for DQ1

This parameter lets you specify which value the technology module is to output to the digital output DQ1 in the event of a CPU STOP under "Output substitute value".

4.1.2.2 Diagnostic interrupts

The technology module can trigger additional diagnostic interrupts when you enable the diagnostic interrupts in the basic parameters. These diagnostic interrupts are processed in an interrupt OB.

Enabling diagnostic interrupts for wire break

You use this parameter to specify whether a diagnostic interrupt is to be triggered in the event of wire breaks of the utilized signals for the following encoders:

- Push-pull 24 V encoder (Page 58)
- RS422 encoder (Page 60) (also monitored for short-circuits and offset voltages)
- SSI absolute encoder (Page 63) (also monitored for short-circuits and faulty voltages)

Note

If you use an encoder with a different sensor type or interface standard, wire break cannot be detected.

Enabling additional diagnostic interrupts

You use this parameter to specify whether diagnostic interrupts are to be triggered for additional errors.

See the device manual for the technology module to find out which errors during operation can trigger a diagnostic interrupt.

4.1.2.3 Operating mode

Selecting the mode for the channel

This setting defines how the channel counting and measuring functions are to be configured and controlled.

Operating mode	Description
Operating with technology object	The channel is configured using the High_Speed_Counter technology object. Access to the control and feedback interface of the technology module is provided by the corresponding High_Speed_Counter instruction in the user program. Technology module/channel assignment to a technology object is defined at the start of technology object configuration: see Basic parameters technology object (Page 72) Counting mode is automatically defined if the technology object High_Speed_Counter is being used.
Position input for Motion Control	The technology module is used for position input for a higher-level Motion Control controller. All channels of the technology module for Motion Control are then available. Parameter assignment is implemented via the Device configuration of the technology module. Parameter assignment of the encoder signals is implemented by means of the Module parameters (Page 106).
Manual operation	The channel is configured using the parameter setting (HWCN) (Page 111) of the technology module. You have direct access to the control and feedback interface of the technology module from the user program.

Selects the channel operating mode

You can use this parameter in "Manual operation" to specify the function for which the channel of the technology module is used. This defines the settings options under "Parameters" (HWCN).

Operating mode	Description
Counting (Page 14) / Position input (Page 46)	The main function of the technology module is counting or position input. The comparison functions and hardware interrupts work with the counter value or position value. The measured value is available concurrently.
Measuring (Page 39)	The main function of the technology module is measuring. The comparison functions (Page 117) and hardware interrupts for compare events work with the measured value. The counter value is available concurrently.

4.1.2.4 Module parameters (position input for Motion Control)

In the operating mode "Position input for Motion Control" mode, the parameters for the encoder signals of the channel are assigned under "Module parameters". The parameters depend on the encoder used.

Module parameters for incremental encoders and pulse encoders

If you use an incremental or pulse encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Signal evaluation
- Filter frequency
- Sensor type (for TM Count)
- Interface standard (for TM PosInput)
- Signal selection for reference mark 0
- Increments per unit and
- Reference speed

You can find a description of the first six parameters in section Counter inputs (Page 73).

Module parameters for SSI absolute encoders

If you use an TM PosInput with an SSI absolute encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Frame length
- Type of code
- Transmission rate
- Monoflop time
- Parity
- LSB bit number of position setpoint
- MSB bit number of position setpoint
- Increments per unit and
- Reference speed

You can find additional information on the first new parameters in section Configure position detection with SSI absolute encoder (Page 118).

Signal selection for reference mark 0

When S7-1500 Motion Control is used, this parameter specifies the external reference signal upon which a new reference mark is saved for the encoder position.

You can select from the following options:

Option	Meaning
DI0	The current counter value is saved as the new encoder position reference mark upon a rising edge at digital input DI0.
Signal N of incremental encoder	The current counter value is saved as the new encoder position reference mark upon a rising edge of the signal N of incremental encoder.

Increments per unit

This parameter defines the number of increments per relevant unit.

You can enter a value between 1 and 65535.

Reference speed

When an S7-1500 Motion Control is used, the encoder transmits the process value of the speed as a percentage of the reference speed. This parameter defines the speed in rpm which is to be correspond to the value 100 % . The reference speed must be identical to the setting in the controller.

You can enter a value between 6.00 and 210000.00. The default setting is "3000.00".

Further configuring

You can perform additional configuration using the "TO_ExternalEncoder" technology object of S7-1500 Motion Control . See the S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) function manual for further details on configuring and commissioning position input.

4.1.2.5 Hardware interrupts

You can set for each channel the events which are to trigger a hardware interrupt during operation when assigning the basic parameters of the technology module.

In an S7-1500 system, you enter a matching event name for each enabled hardware interrupt and assign a corresponding hardware interrupt OB to each hardware interrupt. If a hardware interrupt is triggered, the corresponding OB is started to evaluate the hardware interrupt data.

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but the previous, identical event has not yet been processed, no further hardware interrupt is triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Hardware interrupts that can be activated

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in position input for Motion Control mode	Description	Event Type number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
New Capture value available	Yes	Yes	No	No	No	Hardware interrupt when current count value or position value is saved as Capture value.	8
Synchronization of the counter by an external signal	Yes	No	Yes	No	No	Hardware interrupt upon synchronization of the counter by signal N or DI edge	9
Gate start	Yes	No	Yes	No	No	Hardware interrupt when internal gate opens	1
Gate stop	Yes	No	Yes	No	No	Hardware interrupt when internal gate closes	2
Overflow (high counter limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when count value violates high counting limit	3
Underflow (low counter limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when count value violates low counting limit	4

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in position input for Motion Control mode	Description	Event Type number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
Direction reversal*	Based on counter value	Based on position value	Based on counter value	Based on position value	No	Hardware interrupt when count value or position value changes direction	10
Zero pass	Based on counter value	Based on position value	Based on count value	Based on position value	No	Hardware interrupt with zero pass of count value or position value	7
Comparison event for DQ0 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ0 occurs as a result of the selected comparison condition. No hardware interrupt when the change of the count value for an incremental or pulse encoder was not caused by a count pulse	5
Comparison event for DQ1 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ1 occurs as a result of the selected comparison condition No hardware interrupt when the change of the count value for an incremental or pulse encoder was not caused by a count pulse	6

* The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first change to the counter value or position value immediately after the technology module is switched on is in the down direction.

Default setting

No hardware interrupts are enabled in the default setting.

4.2 Parameter assignment of module

4.2.1 Parameter assignment options

Counting mode — Parameter assignment options

You have two options for technology module counting function parameter assignment and control:

- Configuration of a High_Speed_Counter technology object and control with a corresponding High_Speed_Counter instruction

  Note

  Configuration via technology object

  We recommend the simple configuration with graphic support using the High_Speed_Counter technology object. A detailed description of this configuration can be found in section High_Speed_Counter technology object (Page 67) and below.

  You start technology object parameter assignment (Page 72) by assigning the technology object the configured technology module and counting channel.

- Parameter settings via HWCN (Page 111) and control via the control and feedback interface of the technology module

  Note

  Parameter setting via HWCN

  Additional support for parameter settings via HWCN is available in the context-sensitive help for the parameters in STEP 7 (TIA Portal). A description of the control and feedback interface is available in the following sections:

  Assignment of the control interface (Page 130)

  Assignment of the feedback interface (Page 133)

Measuring mode

No technology object is available for the measuring mode. The parameters of the measuring mode are assigned using the parameter setting (HWCN) (Page 111) of the technology module:

- Counter inputs (Page 112)
- Specifying the measured value (Page 85)
- Behavior of a DI (Page 115)
- Function of a DQ (Page 117)
- Counter behavior (Page 78)

The technology module is controlled by direct access to the control and feedback interface.

Position input with SSI absolute encoder

No technology object is available for position input with SSI absolute encoder.

- In "Manual operation", the parameter assignment (Page 118) of the SSI absolute encoder, the digital inputs and digital outputs is implemented by means of the Parameter setting (HWCN) (Page 111) of the technology module.
- In operating mode "Position input for Motion Control", the parameter assignment of the SSI absolute encoder is implemented by means of the module parameters (Page 106) during the device configuration of the technology module.

Feedback from the technology module is returned by means of the feedback interface.

4.2.2 Opening the parameter settings (HWCN)

Opening via the project tree

Proceed as follows:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Open the technology module in the project tree.
3. Double-click on the "Parameters" object.

Opening from the device view

Proceed as follows:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Right-click on the technology module and select "Parameters".

4.2.3 Measuring mode

4.2.3.1 Counter inputs

Specifying input signals/encoder type (measuring mode)

Signal type

You can choose from the following signal types:

Signal type	Meaning
Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.
Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.
Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.
Pulse (A)	A pulse encoder (signal A) without direction signal is connected. You can specify the counting direction by means of the control interface (Page 130).
Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.
Absolute encoder (SSI)	An SSI absolute encoder is connected (only applicable if TM PosInput is being used): see Configure position detection with SSI absolute encoder (Page 118)

Invert direction

You can invert the count direction or position values to adapt them to the process.

Inversion can be configured and become effective for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)
- Absolute encoder (SSI)

Additional parameters (measuring mode)

Signal evaluation

By configuring signal evaluation (Page 64), you can specify which edges of the signals are counted.

You can select from the following options:

Signal evaluation	Meaning
Single (default)	The edges of signal A are evaluated during a low level of signal B.
Double	Each edge of signal A is evaluated.
Quadruple	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counter inputs A, B and N.

The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This produces a set minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Table 4- 2 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz (default at TM Count)	2.0 µs
500 kHz*	0.8 µs
1 MHz* (default for TM PosInput)	0.4 µs

* only with TM PosInput

Sensor type

By configuring the sensor type, you specify how the counter inputs are switched for the TM Count.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor activates the inputs A, B and N after 24VDC.
Sinking output	The encoder/sensor activates the inputs A, B and N after M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately activates the inputs A, B and N after M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "sourcing output" or "sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

Note

If you use a push-pull incremental encoder, you can monitor the encoder signals for wire break.

Reaction to signal N

You use this parameter to specify which reaction is triggered at signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 29)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.

Note

You can only select the reaction at signal N if you have selected the signal type (Page 112) "Incremental encoder (A, B, N)".

Note

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 115).

Frequency

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

4.2.3.2 Behavior of a DI

Function of a DI (measuring mode)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 19).
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 19).
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 19).
Synchronization (Page 24)	The configured edge at the respective digital input sets the counter to the start value.
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 29).
Digital input without function	No function is assigned to the respective digital input. The signal status of the digital input can be read by the CPU by means of the feedback interface (Page 133).

Note

With the exception of "Digital input without function", each function can only be used once, and if used for one digital input is not available to the others.

Filter time

By configuring the filter time, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured filter time are suppressed.

You can select from the following filter times:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the option "None" or "0.05 ms", you have to use shielded cables for connecting the digital inputs.

Note

You can only configure the filter time under "Behavior of DI0" for all digital inputs together.

Function options (measuring mode)

Certain functions require additional parameters which allow you to specify characteristics in more detail. These can be configured for each of the relevant functions.

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

You can select from the following options:

- At rising edge (default)
- At falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization

4.2.3.3 Function of a DQ (Measuring operating mode)

Set output

By configuring a digital output, you can specify the condition (Page 44) upon which the digital input switches.

You can select from the following options:

Function of a digital output	Meaning
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.
Measured value <= comparison value	The respective digital output is active if the measured value is smaller than or equal to the comparison value.
Between comparison value 0 and 1	The digital output DQ1 is active if the measured value is between the comparison value 0 and the comparison value 1.
Not between comparison value 0 and 1	The digital output DQ1 is active if the measured value is less than comparison value 0 or greater than comparison value 1.
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 130).

Note

You can select the function "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" if the function "Use by user program" is selected for digital output DQ0.

Comparison value 0

By configuring the comparison value (Page 43), you can specify the measured value at which the digital output DQ0 switches as a result of the selected compare event.

You must enter a value that is smaller than comparison value 1. Up to six decimal places can be entered.

The default setting is "0.000000". The unit of the comparison value depends on the measured variable.

Comparison value 1

By configuring the comparison value (Page 43), you can specify the measured value at which the digital output DQ1 switches as a result of the selected compare event.

You must enter a value that is greater than comparison value 0. Up to six decimal places can be entered.

The default setting is "10.000000". The unit of the comparison value depends on the measured variable.

4.2.4 Configure position detection with SSI absolute encoder

4.2.4.1 Counter inputs

Specifying input signals/encoder type (SSI)

Signal type

If an SSI absolute encoder (Page 46) is connected, select the signal type "Absolute encoder (SSI)".

Invert direction

You can invert the values delivered by the SSI absolute encoder to adapt them to the process.

Additional parameters (SSI)

Frame length

By configuring the frame length, you can define the number of bits for an SSI frame. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. A parity bit does not count in the frame length.

A frame length of between 10 bits and 40 bits is permitted. The default setting is "13 Bit".

Type of code

You use the parameter assignment of the code type to specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Type of code	Meaning
Gray (default)	The gray-coded position value returned by the SSI absolute encoder is converted to dual code.
Dual	The value returned by the SSI absolute encoder is not converted.

Transmission rate

By configuring the transmission rate, you can specify the rate of data transmission between the SSI absolute encoder and the technology module. You can select from several options between 125 khz and 2 Mhz. The default setting is "125 kHz".

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, please refer to the encoder description.

Monoflop time

By configuring the monoflop time, you can specify the break time between two SSI frames.

The configured monoflop time must be greater than the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

You can select from the following options:

- Automatic (default)
- 16 µs
- 32 µs
- 48 µs
- 64 µs

Note

If you use the system function "Isochronous mode", the "Automatic" option corresponds to a Monoflop time of 64 µs.

Parity

When you configure the parity, you specify if a parity bit is to be transferred to the SSI absolute encoder.

If, for example, a 25-bit encoder with parity is assigned, the technology module reads 26 bits. The bit following the LSB (least significant bit) in the SSI frame is evaluated as a parity bit. A parity error is reported in the feedback interface (Page 133) by means of the ENC_ERROR bit.

LSB bit number of position setpoint

This parameter is used to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. This restricts the resolution of the SSI absolute encoder. The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 31.

The default setting is "0".

MSB bit number of position setpoint

This parameter is used to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. This restricts the resolution of the SSI absolute encoder. The value must be less than the frame length and higher than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 31.

The default setting is "12".

Note

If you have selected the Code type "Gray", only the values in the range between LSB and MSB of the position value are converted to dual code.

4.2.4.2 Behavior of a DI

Function of a DI (SSI)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning
Capture (Page 48)	The configured edge at the respective digital input saves the current position value as a Capture value. The function can only be used for a digital input.
Digital input without function	No function is assigned to the respective digital input. The signal status of the digital input can be read by the CPU by means of the feedback interface (Page 133).

Filter time

By configuring the filter time, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured filter time are suppressed.

You can select from the following filter times:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Note

You can only configure the filter time under "Behavior of DI0" for all digital inputs together.

Function options (SSI)

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered for the "Capture" function.

You can select from the following options:

- At rising edge (default)
- At falling edge
- At rising and falling edge

4.2.4.3 Behavior of a DQ

Function of a DQ (SSI, counting mode)

Set output

By configuring a digital output, you can specify the condition (Page 50) upon which the digital output switches.

You can select from the following options:

Function of a digital output	Meaning
Between comparison value and high limit (default)	The respective digital output is active if the position value is between the comparison value and the high limit.
Between comparison value and low counter limit	The respective digital output is active if the position value is between "0" and the comparison value.
Between comparison value 0 and 1	The digital output DQ1 is active if the position value is between comparison value 0 and comparison value 1.
At comparison value for a pulse duration	The respective digital output is active once for the assigned time and direction of the position value change when the position value is equal to the comparison value or has fallen below or exceeded it.
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active for the assigned direction of the position value change until the position value is equal to the comparison value or has fallen below or exceeded it.
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 130).

Note

You can select the function "Between comparison value 0 and 1" if the function "Use by user program" is selected for digital output DQ0.

Comparison value 0

By configuring the comparison value (Page 49), you specify the position value at which the digital output DQ0 is to switch as a result of the selected comparison event.

You must enter a value that is less than comparison value 1.

The default setting is "0".

Comparison value 1

By configuring the comparison value (Page 49), you specify the position value at which the digital output DQ1 is to switch as a result of the selected comparison event.

You must enter a value that is greater than comparison value 0.

The default setting is "10".

Count direction

You use this parameter to specify the direction of position value change for which the selected function is valid.

You can select from the following options:

Direction of position value change	Meaning
In both directions (default)	The comparison and switching of the respective digital output is carried out regardless of whether the position value becomes larger or smaller.
Up	The comparison and switching of the respective digital output only takes place when the position value becomes larger.
Down	The comparison and switching of the respective digital output only takes place when the position value becomes smaller.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

You can enter a value between 0.5 and 6553.5 s.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Function of a DQ (SSI, measuring mode)

In measuring mode, you specify the parameters described in the section Function of a DQ (Measuring operating mode) (Page 117) for the digital outputs of the channel.

4.2.4.4 Hysteresis (SSI)

Set hysteresis range

By configuring the hysteresis (Page 53), you can define a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again until the position value has left this range once.

If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

Hysteresis can only be configured in Counting mode.

4.2.4.5 Specifying measured value (SSI)

Measured variable

This parameter is used to specify the measured variable (Page 56) to be provided by the technology module.

You can select from the following options:

Measured variable	Meaning
Frequency (default)	The measured variable is a frequency. The unit is Hz. The incremental changes of the position value are measured.
Period	The measured variable is a period of time corresponding to the reciprocal value of the frequency. The unit is s.
Velocity	The measured variable is a velocity. You configure the time basis for the velocity measurement and the Increments per unit separately.
Complete SSI frame	The first 32 bits of the SSI frame are returned instead of a measured variable. Extra bits that do not belong to the actual position information are supplied in this case. A configured inversion of the direction is ignored.

Update time

By configuring the update time (Page 55) in milliseconds, you can specify the time interval between two measured value updates.

The update time influences the accuracy of the measurement.

If you enter "0", the measured value is updated in each cycle. Up to three decimal places can be entered. You can enter a value between 0.000 and 25000.000. The default setting is "10.000".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s/1 min

The default setting is "60 s/1 min".

Increments per unit

This parameter defines the number of increments per unit.

You can enter a value between 1 and 65535.

Example:

Your absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s/1 min

4.3 Online & diagnostics module

4.3.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the technology module (e.g., Firmware version and serial number)
- Execute a firmware update if required

Procedure

To open the display editor for the diagnostic functions, follow these steps:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Open the technology module in the project tree.
3. Double-click on the "Online & diagnostics" object.
4. Select the required display in the diagnostics navigation.

Additional information

Additional information on the diagnostic alarms and possible remedies can be found in the technology module device manual.

Note

Position input for Motion Control

In the operating mode "Position input for Motion Control", channel diagnostics is not available for the technology module.

4.4 Commissioning the module

The commissioning editor assists you in the commissioning and the function test of the technology module.

You can simulate the count signals and the control of digital input states without process wiring. This allows you to monitor and test the characteristics of the user program technology module during counting.

Note

The digital output functions and hardware interrupts which have been configured are triggered in line with the simulated counter value.

Note

The commissioning editor is not used in the operating mode "Position input for Motion Control".

See also

Assignment of the feedback interface (Page 133)

4.4.1 Monitoring counter values, measured values, DIs and DQs

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the commissioning editor of a technology module, follow these steps:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Open the technology module in the project tree.
3. Double-click on the "Commissioning" object.

The commissioning editor automatically switches to online mode. The CPU operator panel is displayed on the right in the "Test" task card to control the CPU mode.

Monitor values

The following values are read from the technology module cyclically and displayed under "Monitor values":

- Counter value
- Measured value
- Capture value
- Error code

The following values are read from the technology module once and displayed under "Monitor values":

- Comparison value 0
- Comparison value 1
- High counting limit
- Low counting limit
- Start value

You can toggle between the decimal and hexadecimal format of the displayed values in the "Display format" column. The display format "Floating point number" is also available for the measured value.

Monitor status flags

The status information from the technology module is read and displayed online. When the CPU is in STOP, the status display is not updated.

Monitor DIs & DQs

The technology module digital input and digital output signal states are displayed under "Monitor/control DI & DQ". The function currently configured is displayed in the "Comment" column. You can manually change the values with the control panel above the table and thus simulate the counting and measuring functions: see Manually controlling counter values, DIs and DQs (Page 129)

4.4.2 Manually controlling counter values, DIs and DQs

With manual control, you can modify the technology module digital input states online and specify a counter value without process wiring. You can use a simulation function and specify a simulation velocity to monitor the effects on the measuring and counting functions. The digital outputs are switched in accordance with the simulated counter value, and the corresponding hardware interrupts are triggered.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The commissioning window "Monitor/control DI & DQ" for the technology module is open. The current values of the technology module are displayed.

Manual control

WARNING

Warning of personal injury and material damage

Incorrect manual control can cause serious injury and damage plants and equipment:

- Check all entries before you switch to manual control and before you apply changed values during manual control.
- Manual control may only be carried out by trained personnel.

Basic procedure - manually controlling counter values, DIs and DQs

1. Activate manual control in the operator panel using the "Activate" button.
2. Enter new values in the empty "Control value" column.
   The check box to the right is automatically selected. The yellow warning triangle indicates that this value has not been transmitted to the technology module yet.
3. Enter a value for the "Velocity for simulation". For a TM Count the limits of the value range are ±800000.00. For a TM PosInput, the limits of the value range are ±4000000.00. The value determines the speed of the simulated count signals.
4. Apply the modified values with the selected check box by clicking the Change" button. The yellow warning triangle goes out. The changed values are updated in the technology module.
5. Control the simulation of the counting or measuring function with the "Start" and "Stop" buttons.
6. You can monitor the displays under "Monitor values", "Monitor status flags" and "Monitor/control DIs & DQs" and check how your user program responds.
7. If necessary, you can adapt the values in the column "Control value" by repeating steps 2 to 4.

4.5 Control and feedback interface

Information on using the control and feedback interface can be found under Overview of application options.

4.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the significance of the value in Slot 0				
		Bit 3	Bit 2	Bit 1	Bit 0	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load start value (with incremental or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counter limit (with incremental or pulse encoder)
		0	1	1	1	Load high counter limit (with incremental or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1*	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load start value (with incremental or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit (with incremental or pulse encoder)
		0	1	1	1	Load high counting limit (with incremental or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable downward synchronization (with incremental or pulse encoder)				
	EN_SYNC_UP	Bit 5: Enable upward synchronization (with incremental or pulse encoder)				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate (with incremental or pulse encoder)				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is taken internally from Slot 0 and then the value from Slot 1 is taken. This may lead to unexpected intermediate states.

Notes on the control bits

Control bit	Notes
EN_CAPTURE	Use this bit to enable the Capture function. Resetting this bit resets a set EVENT_CAP in the feedback interface.
EN_SYNC_DN	Use this bit to enable the synchronization of the counter when counting in downward direction with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
EN_SYNC_UP	Use this bit to enable the synchronization of the counter when counting in upward direction with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
RES_EVENT	Use this bit to trigger the reset of the saved events in the EVENT_ZERO, EVENT_OFLW, EVENT_UFLW, EVENT_CMP0, EVENT_CMP1 feedback bits.
RES_ERROR	Use this bit to trigger the reset of the saved error states LD_ERROR and ENC_ERROR .
SET_DIR	Use this bit to specify the count direction for signal type "Pulse (A)". 0 means: Up 1 means: Down
SET_DQ0	Use this bit to set digital output DQ0 when TM_CTRL_DQ0 is set to 0. In the case of the function "After set command from CPU until comparison value",SET_DQ0 is effective regardless of TM_CTRL_DQ0 as long as the counter value is not equal to the comparison value.
SET_DQ1	Use this bit to set digital output DQ1 when TM_CTRL_DQ1 is set to 0. In the case of the function "After set command from CPU until comparison value",SET_DQ1 is effective regardless of TM_CTRL_DQ1 as long as the counter value is not equal to the comparison value.
SW_GATE	Use this bit to open and close the software gate when using an incremental encoder or pulse encoder. Together, the software gate and the hardware gate form the internal gate. The technology module only counts when the internal gate is open. 0 means: Software gate closed 1 means: Software gate open
TM_CTRL_DQ0	Use this bit to enable the technological function of digital output DQ0. 0 means: SET_DQ0 defines the state of DQ0 1 means: assigned function defines the state of DQ0
TM_CTRL_DQ1	Use this bit to enable the technological function of digital output DQ1. 0 means: SET_DQ1 defines the state of DQ1 1 means: assigned function defines the state of DQ1

4.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current counter value or position value
Bytes 4 to 7	CAPTURED VALUE	The last acquired Capture value
Bytes 8 to 11	MEASURED VALUE	Current measured value or complete SSI frame
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Faulty encoder signal or SSI frame
	POWER_ERROR	Bit 0: Incorrect supply voltage L+
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status (with incremental or pulse encoder)
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and executed (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and executed (toggling)
	RES_EVENT_ACK	Bit 1: Resetting of status bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2 (TM Count)	Bit 7: TM Count: Status DI2 / TM PosInput: Reserve; set to 0
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Internal gate status (with incremental or pulse encoder)
	STS_CNT	Bit 1: Counting operation or position value change within the last 0.5 s
	STS_DIR	Bit 0: Direction of last counter value or position value change
Byte 15	STS_M_INTERVAL	Bit 7: Pulse or position value change occurred in previous measurement interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred (with incremental or pulse encoder)
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A zero pass has occurred

Notes on the feedback bits

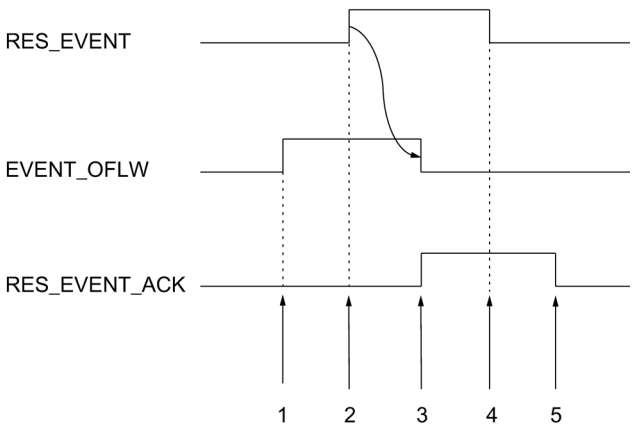
Feedback bit	Notes
ENC_ERROR	This bit indicates that one of the following errors has occurred at the encoder signals (retentive) for the respective technology module: TM Count: • Wire break of digital input A, B, or N (with push-pull encoder) • Invalid transition of A/B signals (with incremental encoder) TM PosInput: • Invalid transition of A/B signals (with incremental encoder) • RS422/TTL error (with incremental or pulse encoder) • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the manual for the respective technology module. The bit is reset once you have acknowledged the error with RES_ERROR .
EVENT_CAP	This bit indicates that a Capture event has occurred and a counter value has been saved in CAPTURED VALUE . You reset the status by resetting EN_CAPTURE .
EVENT_CMP0	This bit indicates the saved status that a comparison event has occurred for the digital output DQ0. You reset the status by acknowledgment with RES_EVENT. The EVENT_CMP0 bit is not set when you set the counter value to the start value.
EVENT_CMP1	This bit indicates the saved status that a comparison event has occurred for the digital output DQ1. You reset the status by acknowledgment with RES_EVENT. The EVENT_CMP1 bit is not set when you set the counter value to the start value.
EVENT_OFLW	This bit indicates the saved state which shows that there was a count value overflow. You reset the status by acknowledgment with RES_EVENT.
EVENT_SYNC	This bit indicates the saved status for which the counter was loaded with the start value by an external reference signal (synchronization) when using an incremental or pulse encoder. You reset the state by resetting EN_SYNC_UP or EN_SYNC_DN .
EVENT_UFLW	This bit indicates the saved state which shows that there was a count value underflow. You reset the status by acknowledgment with RES_EVENT.
EVENT_ZERO	This bit indicates the saved status with which the counter value or position value experienced a zero crossing. You reset the status by acknowledgment with RES_EVENT.
POWER_ERROR	This bit indicates that the supply voltage L+ is not available or too low, or that the front plug is not plugged in. If the supply voltage L+ is available at a sufficient level once again, POWER_ERROR is automatically set to 0.

Feedback bit	Notes
LD_ERROR	This bit indicates that an error occurred (latching) during loading via the control interface. The loaded values were not applied. When using an incremental or pulse encoder, one of the following conditions is not fulfilled: • Low counting limit <= count value <= high counting limit (with incremental or pulse encoder) • Low counting limit <= start value <= high counting limit (with incremental or pulse encoder) • Low counting limit <= comparison value 0/1 <= high counting limit (with incremental or pulse encoder) • Comparison value 0 < comparison value 1 When using an SSI absolute encoder, one of the following conditions is not fulfilled: • 0 <= position value <= maximum position value • 0 <= comparison value 0/1 <= maximum position value • Comparison value 0 < comparison value 1 The bit is reset once you have acknowledged the error with RES_ERROR .
LD_STS_SLOT_0	This bit indicates by a status change (toggling) that the load request for Slot 0 (LD_SLOT_0) has been detected and executed.
LD_STS_SLOT_1	This bit indicates by a status change (toggling) that the load request for Slot 1 (LD_SLOT_1) has been detected and executed.
RES_EVENT_ACK	This bit indicates that the reset of status bit EVENT_SYNC, EVENT_CMP0, EVENT_CMP1, EVENT_OFLW, EVENT_UFLW, EVENT_ZERO is active.
STS_CNT	This bit indicates that at least one count pulse or a position value change has occurred in the last 0.5 s.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.
STS_DI2	This bit indicates the status of digital input DI2 of the TM Count .
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. 0 means: Down 1 means: Up
STS_DQ0	This bit indicates the status of digital output DQ0.
STS_DQ1	This bit indicates the status of digital output DQ1.
STS_GATE	This bit indicates the status of the internal gate when using an incremental or pulse encoder. 0 means: Gate closed 1 means: Gate open
STS_M_INTERVAL	This bit indicates that at least one count pulse or a position value change was detected in the previous measurement interval.
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
STS_SW_GATE	This bit indicates the status of the software gate. 0 means: Gate closed 1 means: Gate open

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

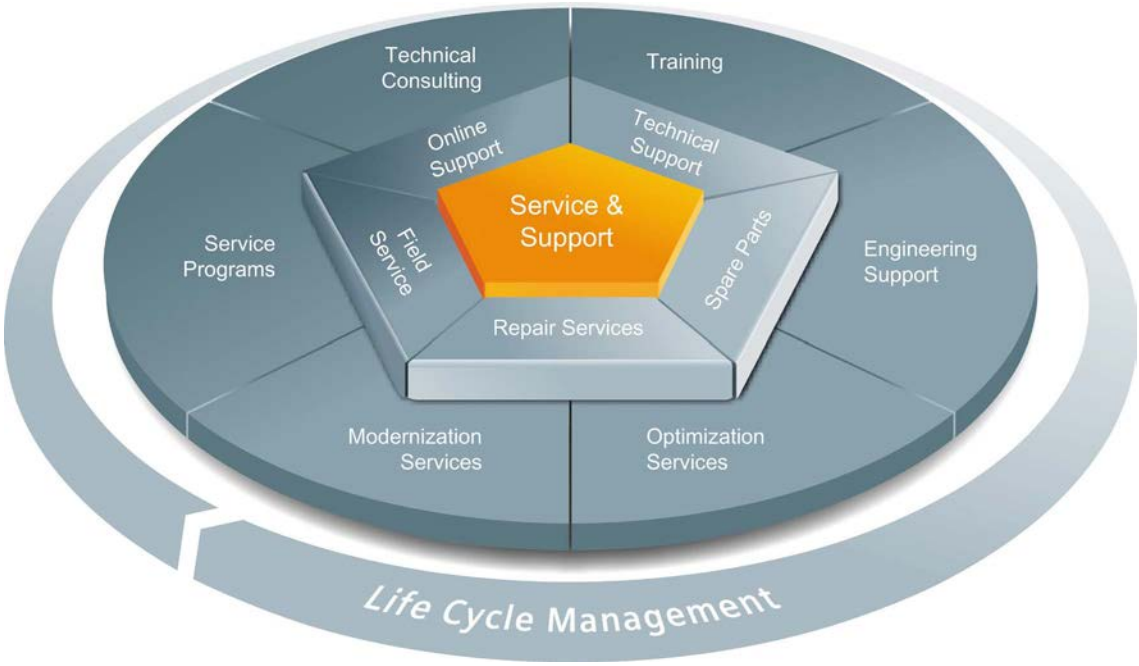
The figure below illustrates the complete acknowledgment principle in the event of an overflow:



① The EVENT_OFLW feedback bit is set as a saving event upon overflow.
② You set the RES_EVENT control bit to trigger EVENT_OFLW reset.
③ The RES_EVENT_ACK feedback bit is set when reset of EVENT_OFLW is detected.
④ You then rest the control bit RES_EVENT .
⑤ The RES_EVENT_ACK feedback bit is reset.

Service & Support

A



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SIMATIC

S7-1500
S7-1500 Motion Control

Function Manual

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Appendix A

01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- For the path settings in the project navigation it is presumed that the "Technology objects" object is opened in the CPU subtree. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

Note

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Further support

- The range of technical documentation for the individual SIMATIC products and systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the online ordering system is available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 system consists of the system manual, function manuals, and user manuals.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Documentation overview

The following table lists additional references that supplement this description of "Motion Control".

Table 1- 1 "Motion Control" documentation

Topic	Documentation	Most important contents
STEP 7 (TIA Portal)	STEP 7 Professional V12 online help	Configuring and programming with the engineering software
System description	Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Basics • Function • Operation • Diagnostics via web server
Modules of the S7-1500 automation system	Manuals for the S7-1500 product range (http://support.automation.siemens.com/WW/view/en/56926743/130000)	• Interrupt, error and system alarms • Technical specifications (incl. diagnostic functions)

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Introduction 2

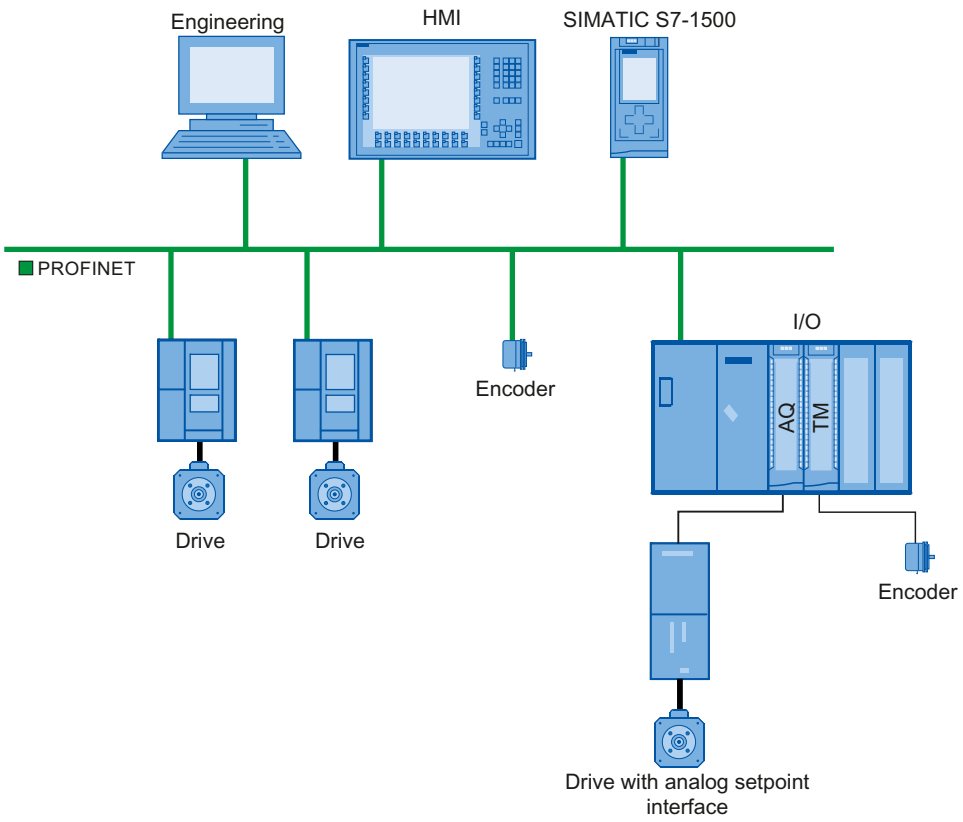
2.1 Motion Control Functionality of the CPU S7-1500

The Motion Control functionality supports the controlled positioning and movement of axes, and is a component of each CPU S7-1500.

Configuration options

You can connect drives and encoders using PROFIBUS DP and PROFINET IO.
You can connect drives with analog setpoint interfaces using an analog output (AQ).
You can additionally read encoders in by means of a technology module (TM).

The following figure shows an example configuration:

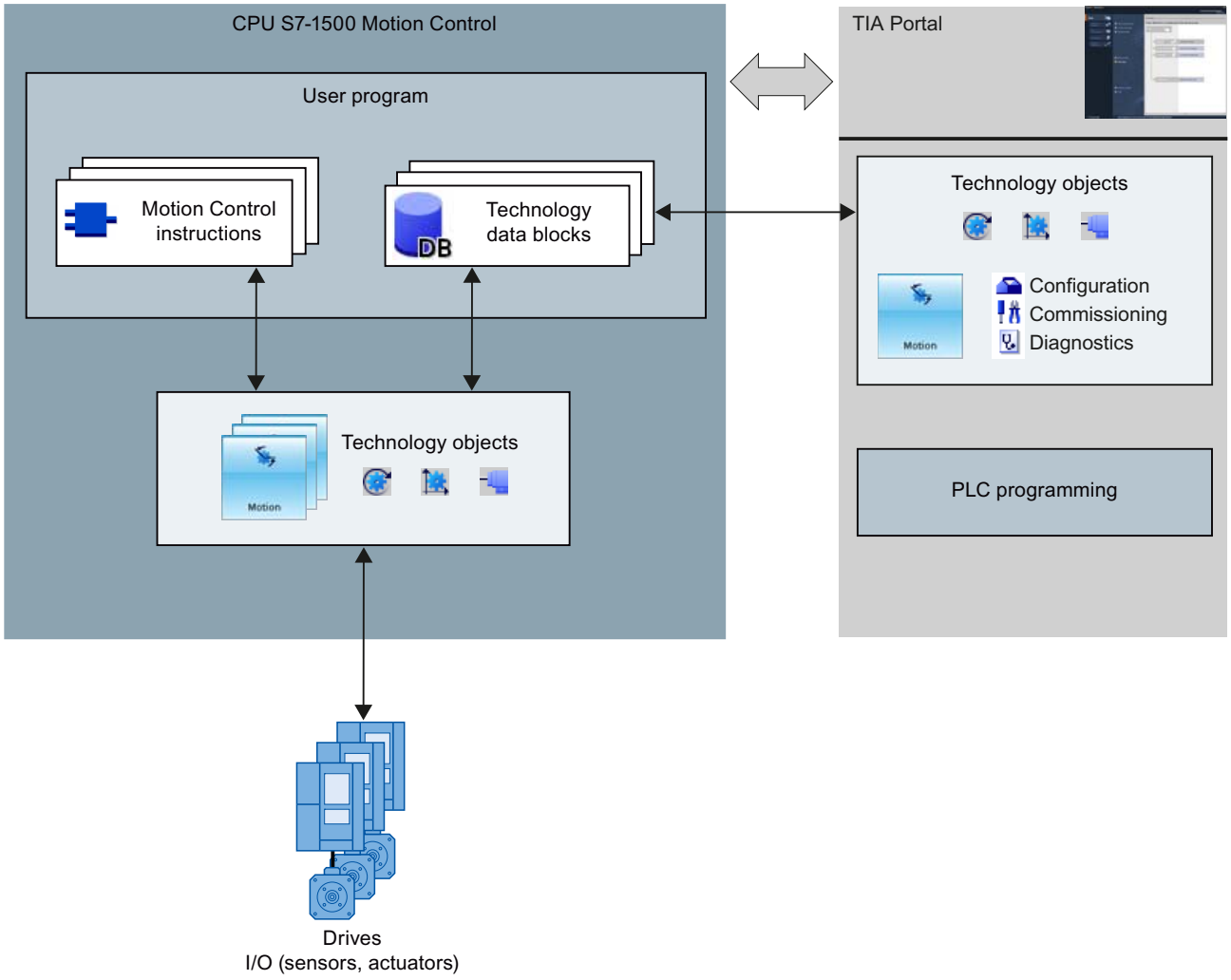


2.2 Principle of operation of Motion Control

Overview

With the TIA Portal you create a project, configure technology objects, and load the configuration into the CPU. The processing of the Motion Control functionality occurs in the CPU.
You control the technology objects by using the Motion Control instructions in your user program.
The TIA portal provides additional functions for commissioning, optimization (Page 167), and diagnostics (Page 185).

The following figure shows schematically the user interfaces and the integration of Motion Control into the CPU S7-1500. The concepts are then briefly explained:



TIA Portal

The TIA Portal supports you in the planning and commissioning of Motion Control functionality:

- Integrating and configuring hardware
- Creating and configuring technology objects
- Creating the user program
- Diagnostics

Motion Control instructions

With the Motion Control instructions you perform the desired functionality in the technology objects. The Motion Control instructions are available in the TIA Portal under "Instructions > Technology > Motion Control > S7-1500 Motion Control".

The Motion Control instructions conform to PLCopen (version 2.0).

Technology objects

Technology objects represent each of the real objects (e.g. a drive) in the controller.
You can call the functions of the technology objects by means of Motion Control instructions in your user program. The technology objects provide open- and closed-loop control of the movement of the real objects, and report status information (e.g. the current position).

The configuration of the technology objects reflects the properties of the real object.
The configuration data are stored in a technology data block.

The following technology objects are available for Motion Control:

- **Speed-controlled axis technology object**

  The speed-controlled axis technology object ("SpeedAxis") permits the specification of the speed for a drive. The movement of the axis can be programmed with Motion Control instructions.

- **Positioning axis technology object**

  The positioning axis technology object ("PosAxis") permits the position-controlled positioning of a drive. Positioning jobs can be assigned to the axis with Motion Control instructions in the user program.

- **External encoder technology object**

  The external encoder technology object ("ExternalEncoder") detects a position, and makes it available to the controller. The detected position can be evaluated in the user program.

Scale

For information on the number of technology objects that may be used, refer to the technical specifications of the utilized CPU.

Technology data block

The technology data block represents the technology object and contains all configuration data, setpoint and actual values, and status information of the technology object.
The technology data block is automatically created when the technology object is created.
In your user program, you can access the technology data block's data.

User program

The Motion Control instructions and the technology data block represent the programming interfaces for the technology objects. Using the Motion Control instructions, your user program can initiate and track Motion Control jobs in technology objects. The technology data block represents the technology object.

Drives and encoders

Drives permit the movement of the axis. They are integrated into the hardware configuration as slaves.

When you perform a Motion Control job in your user program, the technology object takes over the control of the drive and the reading in of values from position encoders.

Drives and encoders are connected by means of PROFIdrive frames.
The following interfaces are possible:

- PROFIBUS DP
- PROFINET IO
- Technology module (TM)

For an analog drive connection, the setpoint can be specified via an analog output with an enabling signal. Analog inputs and outputs are made available by means of corresponding IO modules.

A drive is also called an actuator, and an encoder is also called a sensor.

Basics 3

3.1 Functions

You can perform the Motion Control function by means of Motion Control instructions in your user program or the TIA portal (under Commissioning).

The following table shows the functions that are supported by technology objects:

Function	Speed-controlled axis	Positioning axis	External encoder
Motion Control instructions (user program)			
"MC_Power (Page 205)" Enable, disable technology objects	X	X	X
"MC_Home (Page 210)" Homing technology objects, setting home position	-	X	X
"MC_MoveJog (Page 215)" Moving axes in jog mode	X	X	-
"MC_MoveVelocity (Page 220)" Moving axes with the specified speed	X	X	-
"MC_MoveRelative (Page 226)" Position axis relatively	-	X	-
"MC_MoveAbsolute (Page 231)" Position axis absolutely	-	X	-
"MC_Halt (Page 236)" Stop axis	X	X	-
"MC_Reset (Page 240)" Acknowledging alarms, restarting technology objects	X	X	X
TIA Portal			
"Axis control panel (Page 170)" Moving and homing axes using the TIA portal	X	X	-
"Optimization (Page 176)" Optimization of position control ("Kv" factor)	-	X	-

See also

Reference (Page 205)

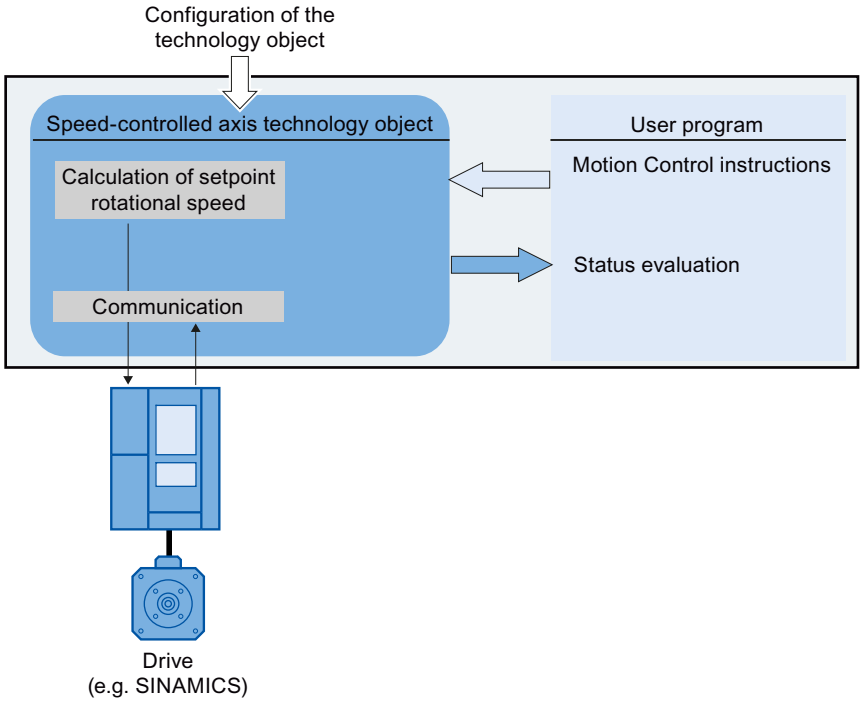
3.2 Speed-controlled axis technology object

The speed-controlled axis technology object calculates speed setpoints, taking account of the specified dynamics, and outputs them to the drive. All movements of the speed-controlled axis occur under speed control. The system takes account of an existing load gear.

A drive is assigned to each speed-controlled axis by means of a PROFIdrive message frame, or by means of an analog setpoint interface.

The speed is specified in revolutions per unit of time.

The following figure shows the basic principle of operation of the speed-controlled axis technology object:



3.3 Positioning axis technology object

The positioning axis technology object calculates position setpoints, taking account of the specified dynamics, and outputs corresponding speed control setpoints to the drive. All movements of the positioning axis occur under position control. For absolute positioning, the physical position must be known to the positioning axis technology object.

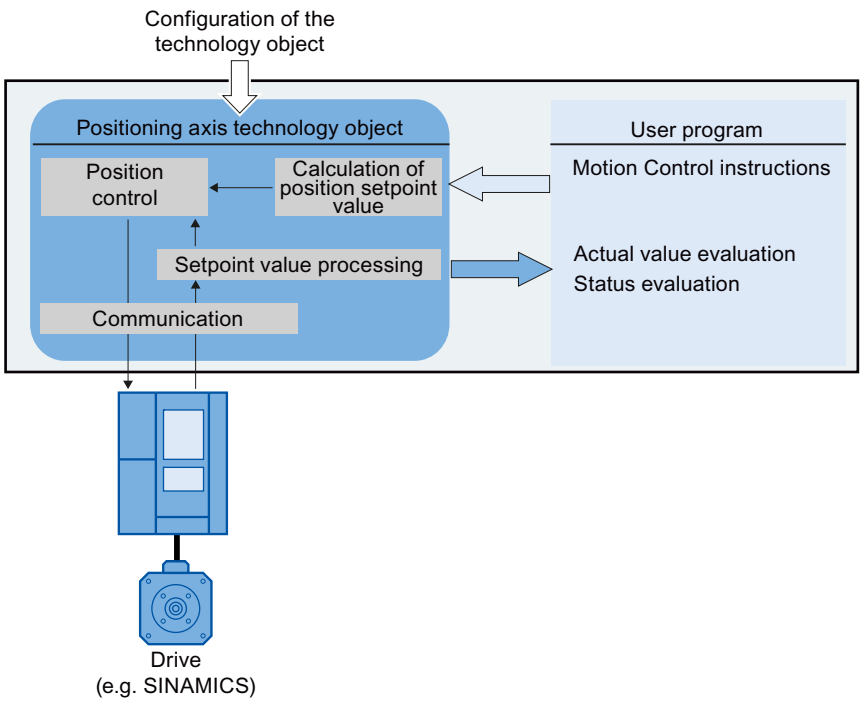
Each positioning axis is assigned a drive by means of a PROFIdrive message frame or by means of an analog setpoint interface, and an encoder by means of a PROFIdrive message frame.

The relationship between the encoder values and a defined position is created by assigning parameters for the mechanical properties and the encoder settings, as well as a homing process. The technology object can also perform movements without a position relationship, and relative position movements, even without being in a homed status.

Note

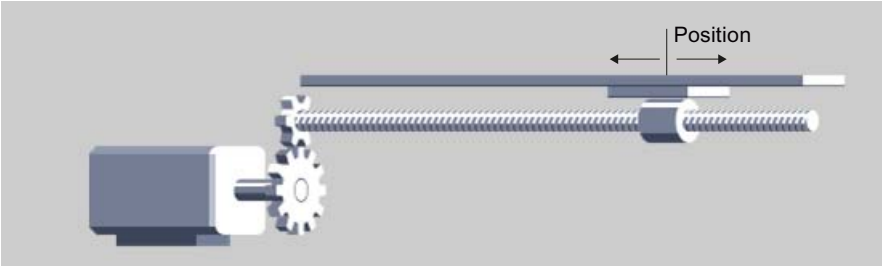
The positioning axis technology object and external encoder are independent of each other, and cannot be coupled to each other. The actual position of an external encoder cannot influence a positioning axis in its position control.

The following figure shows the basic principle of operation of the positioning axis technology object:



Depending on the execution of the mechanics, a positioning axis is implemented as a linear axis or rotational axis:

- Linear axis



For linear axes, the position of the axis is specified as a linear measure, e.g. millimeters (mm).

- Rotary axis

For rotary axes, the position of the axis is specified as an angular measure, e.g. degrees (°).

See also

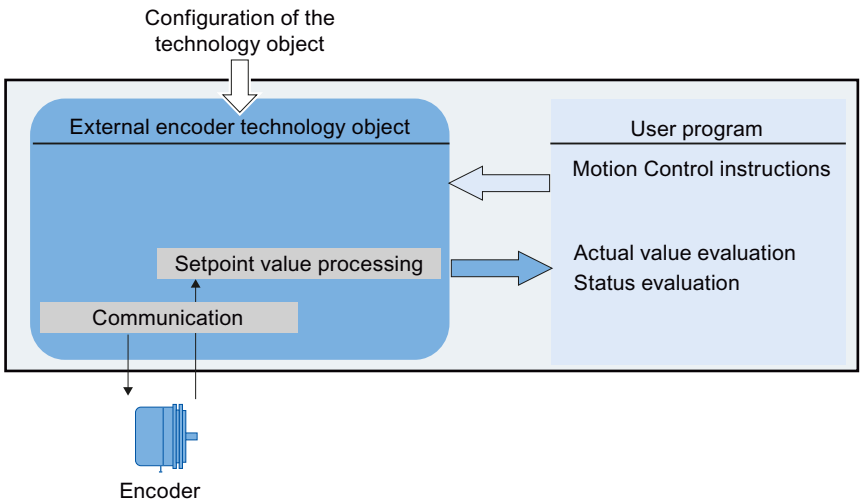
Modulo setting (Page 24)

3.4 External encoder technology object

The external encoder technology object detects a position, and makes it available to the controller.

The relationship between the encoder values and a defined position is created by assigning parameters for the mechanical properties and the encoder settings, as well as a homing process.

The following figure shows the basic principle of operation of the external encoder technology object:



Specification of the position occurs according to the selected system of units:

- **Linear system of units**

  The position is specified as a linear measure, e.g. millimeters (mm).

- **Rotary system of units**

  The position is specified as an angular measure, e.g. degrees (°).

3.5 Modulo setting

The positioning axis technology object and external encoder can be configured with the "modulo" setting.

When "modulo" is enabled, the position value of the technology object is represented by means of a recurring modulo range.

The modulo range is defined by the initial modulo value and the modulo length.

As an example, the position value of a rotary axis with an initial value = 0° and length = 360° can be represented in the modulo range from 0° to 359.9°. In this example, the resolution of the encoder is assumed to have a value of 0.1° / encoder step.

3.6 Units of measure

The following table shows the supported units of measure for distance and velocity:

Distance	Velocity
nm, µm, mm, m, km	mm/s, mm/min, mm/h, m/s, m/min, m/h, km/min, km/h
in, ft, mi	in/s, in/min, ft/s, ft/min, mi/h
°, rad, ', ", gon	°/s, °/min, rad/s, rad/min, gon/s, gon/min

- The acceleration is correspondingly configured as a distance/s².
- Jerk is correspondingly configured as a distance/s³.
- The speed is configured as revolutions per unit of time: 1/s, 1/min, 1/h

Note

When setting or changing the units of measurement, note the effect on the depiction and the user program:

- Depiction in the technology data block
- Supply to the parameters in the user program
- Input and display of the position in the TIA Portal

All information and displays are output in the selected unit of measure.

3.7 Drive and encoder connection

3.7.1 Brief description

A speed-controlled axis is assigned a drive.
A positioning axis is assigned a drive and an encoder.
An external encoder is assigned an encoder value.

The setpoint value at the drive is specified either with PROFIdrive message frames, or with an analog output.

The following connection options are available for an encoder:

- Encoder to drive
- Encoder on technology module
- PROFIdrive-Geber directly to PROFIBUS DP / PROFINET IO

The encoder value is transmitted exclusively via PROFIdrive message frames.

PROFIdrive

PROFIdrive is the standardized standard profile for drive technology in the connection of drives and encoders via PROFIBUS DP and PROFINET IO.

Drives that support the PROFIdrive profile are connected according to the PROFIdrive standard.

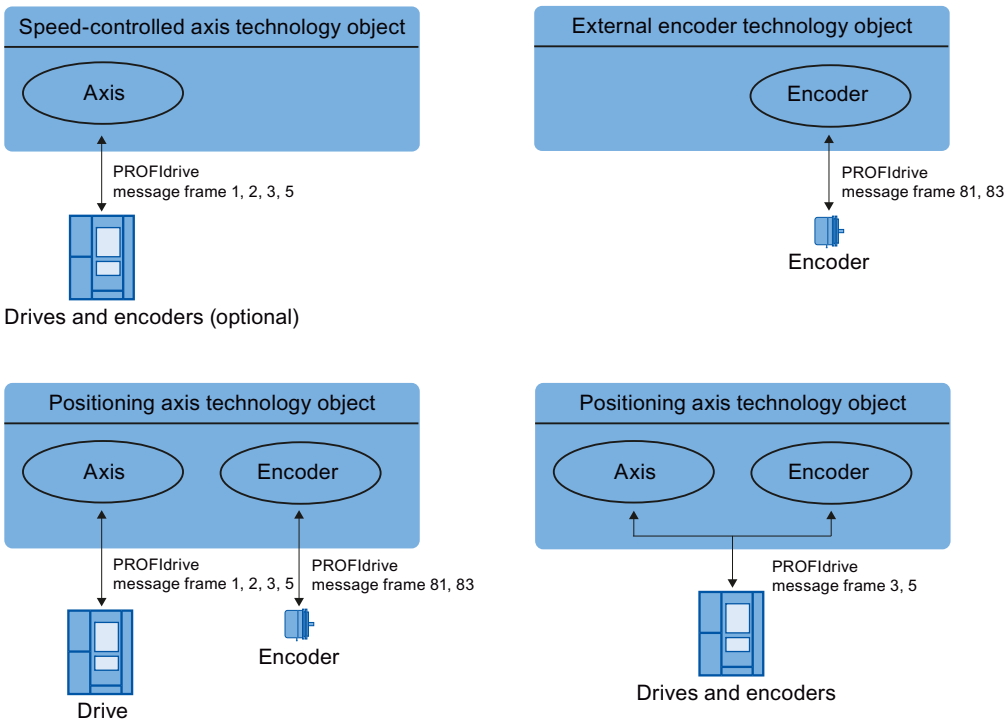
Communication between controller and drive/encoder is by means of various PROFIdrive message frames. Each of the message frames has a standardized structure. Depending on the application, you can select the applicable message frame. Control words and status words as well as setpoints and actual values are transmitted in the PROFIdrive message frames.

The PROFIdrive profile likewise supports the "Dynamic Servo Control" (DSC) control concept. DSC uses rapid position control in the drive. This can be used to solve highly dynamic positioning jobs.

3.7.2 Frames

The transmission of the encoder value occurs either in a frame together with the setpoint (frame 3 or frame 5), or in a separate encoder frame (frame 81 or frame 83).

The following figure represents the relationship between the technology objects and the drives / encoders:



Explanation of the figure:

- The setpoint of a speed-controlled axis is transmitted to a drive via PROFIdrive frame 1, 2, 3 or 5.
- The encoder value of an external encoder is transmitted via PROFIdrive frame 81 or 83.
- The setpoint of a positioning axis is transmitted to a drive via PROFIdrive frame 1, 2, 3 or 5.
- Encoder value of the positioning axis

  The encoder value can be transmitted in the following PROFIdrive frames:

  – Transmission in the same PROFIdrive frame, in which the setpoint is also transmitted. For example, with PROFIdrive frame 3 or 5

  – Transmission in PROFIdrive frame 81 or 83.

Frame types

The following table shows the supported PROFIdrive frame types for the assignment of drives and encoders:

Frame	Brief description
Standard frames	
1	• 16 bit speed setpoint (NSET), • 16 bit actual speed value (NACT),
2	• 32 bit speed setpoint (NSET), • 32 bit actual speed value (NACT), • Signs of life
3	• 32 bit speed setpoint (NSET), • 32 bit actual speed value (NACT), • Actual encoder value, • Signs of life
5	• 32 bit speed setpoint (NSET), • 32 bit actual speed value (NACT), • Dynamic Servo Control (DSC), • Actual encoder value, • Signs of life
Standard encoder frames	
81	• Actual encoder value, • Signs of life
83	• 32 bit actual speed value (NACT), • Actual encoder value, • Signs of life

When connecting by means of a PROFIdrive frame, the drives and encoders are handled and switched on in accordance with the PROFIdrive profile.

3.7.3 Setting reference values

The reference values for the drive connection and encoder connection must be set identically in the controller, and in the drive or encoder.

The setpoint speed setpoint NSET and the actual speed value NACT are transmitted in the PROFIdrive message frame as a percentage value relative to the reference speed. The reference value for the speed must be set identically in the controller and in the drive.

The resolution of the actual value in the PROFIdrive message frame must likewise be set identically in the controller and in the drive or encoder.

Message frame settings

The controller settings are set in the TIA Portal under "Technology object > Configuration > Hardware interface > Data transmission".

The settings for drive and encoder are set in the configuration for the respective hardware.

The following table contrasts the controller settings and corresponding PROFIdrive parameters (<TO> stands for the applicable technology object):

Setting in the TIA Portal	Controller tag in the technology data block	PROFIdrive parameter
Message frame	<TO>.Actor.Interface.Telegram	P922
Reference speed in [rpm]	<TO>.Actor.DriveParameter.ReferenceSpeed	(SINAMICS drives: P2000)
Maximum speed of the motor in [rpm]	<TO>.Actor.DriveParameter.MaxSpeed	(SINAMICS drives: P1082)
Encoder message frame	<TO>.Sensor[n].Interface.Telegram	P922
Encoder system (linear or rotary encoder)	<TO>.Sensor[n].System	P979[1] Bit0
Encoder type (0: incremental, >0: absolute or cyclically absolute)	<TO>.Sensor[n].Type	P979[5]
Resolution (linear encoder) The grid spacing is specified on the nameplate of the sensor as a separation distance of the marks on the linear measuring system.	<TO>.Sensor[n].Parameter.Resolution	P979[2]
Increments per revolution (rotary encoder)	<TO>.Sensor[n].Parameter.StepsPerRevolution	P979[2]
Number of bits for fine resolution XIST1 (cyclical actual encoder value, linear or rotary encoder)	<TO>.Sensor[n].Parameter.FineResolutionXist1	P979[3]
Number of bits for fine resolution XIST2 (absolute encoder value, linear or rotary encoder)	<TO>.Sensor[n].Parameter.FineResolutionXist2	P979[4]
Differentiable encoder revolutions (rotary absolute value encoder)	<TO>.Sensor[n].Parameter.DeterminableRevolutions	P979[5]

3.7.4 Tags

The following technology object tags are relevant for the connection of drives and encoders:

Drive frame	
<TO>.Actor.Interface.Telegram	Frame number
<TO>.Actor.DriveParameter.Reference Speed	Reference velocity / reference speed for the velocity / speed (NSET), which is transmitted as a percentage value
<TO>.Actor.DriveParameter.MaxSpeed	Maximum value for the setpoint speed of the drive (N-set)(PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
Encoder frame	
<TO>.Sensor[n].Interface.Telegram	Frame number
<TO>.Sensor[n].System	Encoder system linear or rotary
<TO>.Sensor[n].Type	Encoder type, incremental, absolute or cyclically absolute
<TO>.Sensor[n].Parameter.StepsPer Revolution	Increments per revolution for rotary encoder
<TO>.Sensor[n].Parameter.Determinable Revolutions	Number of differentiable encoder revolutions for a multi-turn absolute value encoder
<TO>.Sensor[n].Parameter.Resolution	Resolution for linear encoder The grid spacing corresponds to the interval between two marks
Fine resolution	
<TO>.Sensor[n].Parameter.FineResolution Xist1	Number of bits for fine resolution XIST1 (cyclical actual encoder value)
<TO>.Sensor[n].Parameter.FineResolution Xist2	Number of bits for fine resolution XIST2 (absolute value of the encoder)

3.8 Actual values

3.8.1 Brief description

For position-controlled motion and positioning, the controller must know the actual position value.

The actual position value is provided by a PROFIdrive frame. The actual value is updated after a one-off transition of the operating mode from STOP to RUN.

The actual values are represented incrementally or absolutely in the PROFIdrive frame, and standardized in the controller to the technological unit. Homing is used to convert the actual value to the physical position of the axis, or of the external encoder.

The controller supports the following types of actual values:

- Incremental actual value
- Absolute actual value with the setting absolute (measuring range > traversing range of the axis)
- Absolute actual value with the setting absolute (measuring range < traversing range of the axis)

3.8.2 Incremental actual value

The actual value in the PROFIdrive frame is based on an incremental value.

After POWER ON, position zero is displayed. The actual value is updated after a one-off transition of the operating mode from STOP to RUN. The relationship between the technology object and the mechanical position must be recreated by means of homing (Page 34).

3.8.3 Absolute actual value

The actual value in the PROFIdrive frame is based on an absolute value.

After POWER ON, position zero is displayed. The actual value is updated after a one-off transition of the operating mode from STOP to RUN. The supplied actual value is assigned to the associated mechanical axis position by means of absolute value adjustment (Page 49). The absolute value adjustment must be performed one time. The absolute value offset is retentively saved beyond the switching on/off of the controller.

Differentiation of absolute values:

- The measuring range of the encoder is larger than the traversing range of the axis:

  Absolute value with absolute setting
- The measuring range of the encoder is smaller than the traversing range of the axis:

  Absolute value with cyclically absolute setting

Absolute actual value with the setting absolute (measuring range > traversing range)

The axis position results directly from the actual encoder value. The traversing range must be within an encoder measuring range. This means that the zero point of the encoder must not be located in the traversing range.

When the controller is switched on, the axis position is determined from the absolute encoder value.

Absolute actual value with the setting absolute (measuring range < traversing range)

The encoder supplies an absolute value within its measuring range. The controller includes the traversed measuring ranges and thus determines the correct axis position beyond the measuring range.

When the controller is switched off, the traversed measuring ranges are saved in the retentive memory area of the controller.
At the next power-on, the stored overruns are taken into account in the calculation of the actual position value.

NOTICE
Movements of the axis while the controller is switched off can skew the actual value If the axis or the encoder is moved by more than half of the encoder measuring range while the controller is switched off, then the actual value in the controller is no longer in accord with the mechanical axis position.

3.8.4 Tags

The tags named in the Homing (Page 51) section are relevant for adapting actual values.

3.9 Mechanics

3.9.1 Brief description

For the application's view onto the position of the technology object, it is decisive, whether the position is represented as a unit of length (linear axis) or as a rotary unit (rotary axis).

Examples of units of length: mm, m, km

Examples of rotary units: °, rad

For the determination of the physical position from an actual encoder value, the system must know the various properties and configurations of the mechanics.

Positioning axis

The following configuration options for mechanics are supported:

- Load gear
- Leadscrew (linear axes only)
- Encoder configurations:
  - On the motor side (before the load gear)
  - On the load side (after the load gear and as applicable the leadscrew)
  - External (e.g. odometer)
- Inversion of the setpoint
- Inversion of the setpoint

External encoder

The following configuration options for mechanics are supported:

- Measuring gearbox (for rotary encoders)
- Leadscrew (only with linear system of units and rotatory encoders)
- Inversion of the setpoint

Speed-controlled axis

The following configuration options for mechanics are supported:

- Load gear
- Inversion of the setpoint

3.9.2 Tags

The following technology object tags are relevant for the configuration of the mechanics:

Type of motion	
<TO>.Properties.MotionType	Indication of linear or rotary motion 0: Linear motion 1: Rotary motion
Load gear	
<TO>.LoadGear.Numerator	Load gear counter
<TO>.LoadGear.Denominator	Load gear denominator
Leadscrew pitch	
<TO>.Mechanics.LeadScrew	Leadscrew pitch
Type of encoder mounting	
<TO>.Sensor[n].MountingMode	Type of encoder mounting
<TO>.Sensor[n].Parameter.Distance PerRevolution	Load distance per encoder revolution with an externally mounted encoder
Inversion	
<TO>.Actor.InverseDirection	Setpoint inversion
<TO>.Sensor[n].InverseDirection	Actual value inversion
Modulo	
<TO>.Modulo.Enable	Enable modulo
<TO>.Modulo.Length	Modulo length
<TO>.Modulo.StartValue	Modulo start value

3.10 Homing

3.10.1 Brief description

With homing, you create the relationship between the position in the technology object and the mechanical position. The position value in the technology object is assigned to a reference mark at the same time. This reference mark represents a known mechanical position.

With incremental actual values this process is called homing; with absolute actual values it is called absolute value adjustment.

Homing is a requirement for the indication of the correct position in the technology object, and for absolute positioning.

Homing is enabled with the Motion Control instruction "MC_Home", and is enabled for a single homing process each time.

Homing status

The technology object tag <TO>.StatusWord.HomingDone indicates whether the technology object has been homed to an axis or external encoder.

Type of homing

Homing can occur by means of an independent movement for homing (active homing), by means of a reference mark during an application-initiated movement (passive homing), or by means of direct position assignment.

A distinction is made between the following types of homing:

- Active homing

  Active homing initiates a homing movement and performs the necessary approach to the reference mark. When the reference mark is detected, the actual position is set to the configured value. It is possible to specify an offset from the home position.

  When active homing starts, current traversing movements are aborted.
  The offset is automatically traversed after the approach to home position.

- Passive homing

  The homing job does not perform its own homing motion. When the reference mark is detected during an application-initiated motion, the actual position is set to the configured value.

  Passive homing is also called homing on the fly.

- Direct homing

  The homing job directly sets the actual position to the configured value, or offsets it by this amount.

- Absolute value adjustment

  Absolute value adjustment adjusts the position of the technology object to the existing absolute actual value.

Homing mode

Depending on the type of reference mark and of the reference mark search, a distinction is made among the following homing modes (Page 36):

- Homing with zero mark via PROFIdrive message frame and proximity switch
- Homing with zero mark via PROFIdrive message frame and proximity switch
- Homing with digital input

3.10.2 Terms

Homing mark

A homing mark is an input signal, on whose occurrence a known mechanical position can be assigned to the actual values.

A homing mark can be:

- A zero mark

  The zero mark of an incremental encoder or an external zero mark is used as a homing mark.

  The zero mark is detected at the drive module or encoder module, and transmitted in the PROFIdrive frame. Perform the setting and evaluation as an encoder zero mark or external zero mark at the drive module and sensor module.

- An edge at the digital input

  The falling or rising edge at a digital input is used as a homing mark.

Proximity switch

If there are several zero marks in the traversing range, the proximity switch permits the selection of a specific zero mark before or after the proximity switch.

Homing mark position

This is the position assigned to the homing mark.

The homing mark position corresponds to the home position minus the home position offset.

Home position

At the end of the active homing motion, the axis arrives at the home position.

Home position offset

The difference between the homing mark position and the home position is the home position offset.

An offset between homing mark position and home position only has an effect during active homing. The offset is traversed after the synchronization of the axis via the Motion Control instruction "MC_Home". For axes with the modulo setting, the home position offset is always traversed using the direction setting for the shortest path.

Direction reversal at the hardware limit switch (reversing cam)

Hardware limit switches can be used as reversing cams in active homing. If the homing mark is not detected or was approached from the wrong side, then the motion continues after the reversing cam in the opposite direction.

3.10.3 Homing mode

Various homing modes are available for the positioning axis technology object and the external encoder technology object. The homing mode is set in the configuration.

Homing with zero mark via PROFIdrive message frame and proximity switch

The system checks for when the proximity switch is reached. After the proximity switch is reached and is left again in the assigned homing direction, zero mark detection is enabled via the PROFIdrive message frame.

When the zero mark is reached in the pre-selected direction, then the actual position of the technology object is set to the reference mark position.

Homing with zero mark via PROFIdrive message frame and proximity switch

The system enables zero mark detection, as soon as the actual value of the technology object moves in the assigned homing direction.

When the zero mark is reached in the specified homing direction, the actual position of the technology object is set to the reference mark position.

Homing with digital input

The system checks the state of the digital input, as soon as the actual value of the axis or encoder moves in the assigned homing direction.

When the reference mark is reached (setting of the digital input) in the specified homing direction, the actual position of the technology object is set to the reference mark position.

Note

The digital inputs must be placed into the process image partition "PIP OB Servo".

The filter time of the digital inputs must be set smaller than the duration of the input signal at the homing switch.

See also

Active homing for SINAMICS drives with external zero mark (Page 280)

3.10.4 Active homing with zero mark and proximity switch

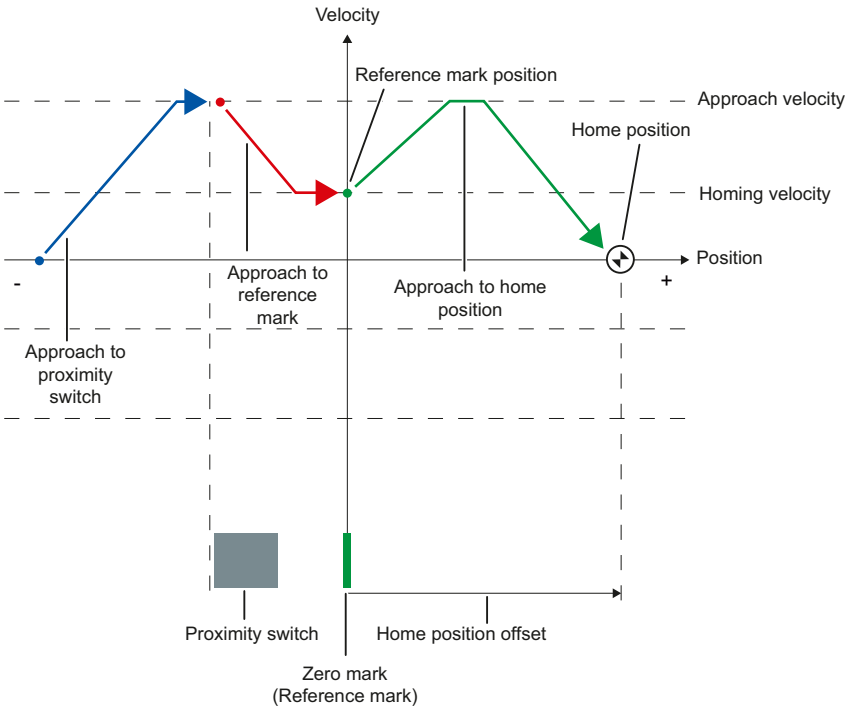
The following examples show homing motions in the positive and negative directions.

Example of homing in the positive direction

The approach to the reference mark and the home position occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with zero mark and proximity switch
- Approach in the positive direction
- Homing in the positive direction
- Positive home position offset

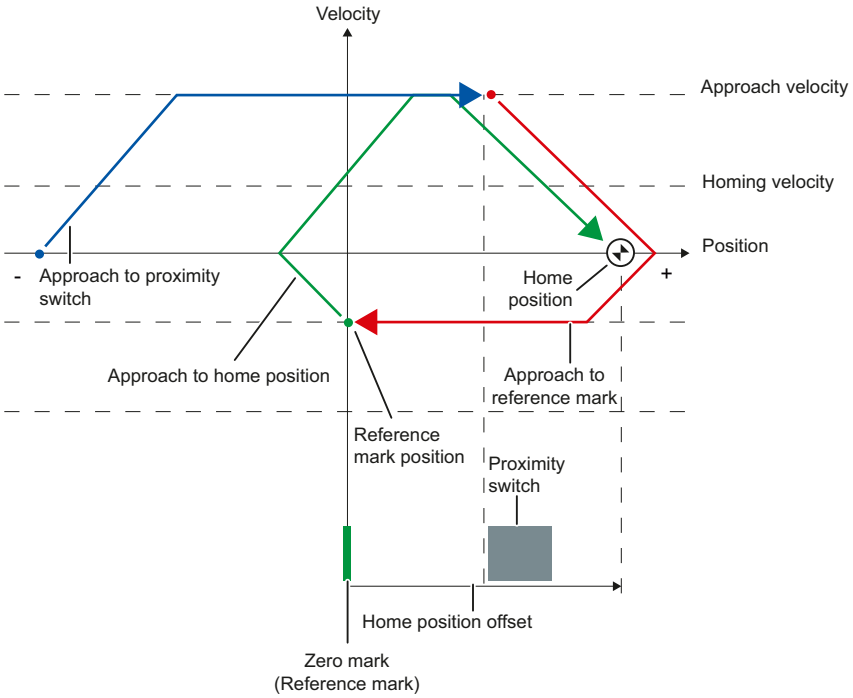


Example of homing in the negative direction

The move to the reference mark occurs in the negative direction by means of a direction reversal during the homing process. The move to the home position causes another direction reversal and occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with zero mark and proximity switch
- Approach in the positive direction
- Homing in the negative direction
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home"**
2. **Approach to the proximity switch**
3. **Detection of the proximity switch in the homing direction, while moving at homing velocity**
4. **Departure from the proximity switch, and approach to the reference mark**

   With the departure from the proximity switch, the detection of the reference mark is enabled.
5. **Detection of the reference mark**

   When the reference mark is detected, the position of the technology object is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 4

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" to "MC_Home" = 5

     Position = value in tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset
6. **Approach to the home position**

   – Parameter "Mode" to "MC_Home" = 4

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" to "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>.Homing.HomePosition tag.

   Note

   If the velocity on the span from the detection of the proximity switch to the zero mark cannot be reduced to the homing velocity, then homing occurs at the velocity that exists when the zero mark is traversed.

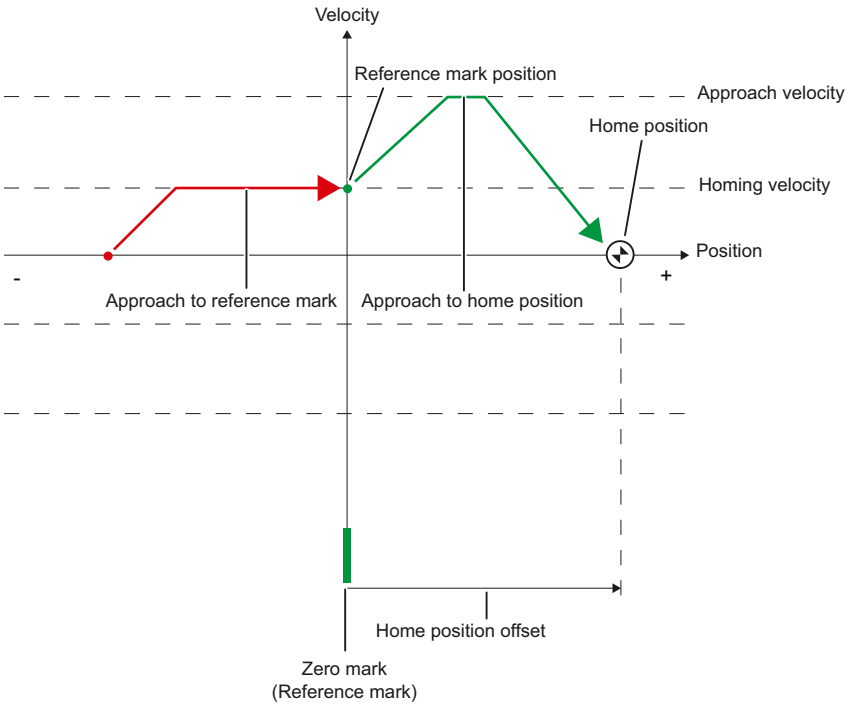
See also

Active homing for SINAMICS drives with external zero mark (Page 280)

3.10.5 Active homing with zero mark

The following figure shows an example of the homing motion with the following settings:

- Active homing with zero mark
- Homing in the positive direction
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home".**
2. **Move to the reference mark in the homing direction with the homing velocity**
3. **Detection of the reference mark**

   When the reference mark is detected, the position of the axis or encoder is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 4

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" to "MC_Home" = 5

     Position = value in tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

4. **Approach to the home position**

   – Parameter "Mode" to "MC_Home" = 4

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" to "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>.Homing.HomePosition tag.

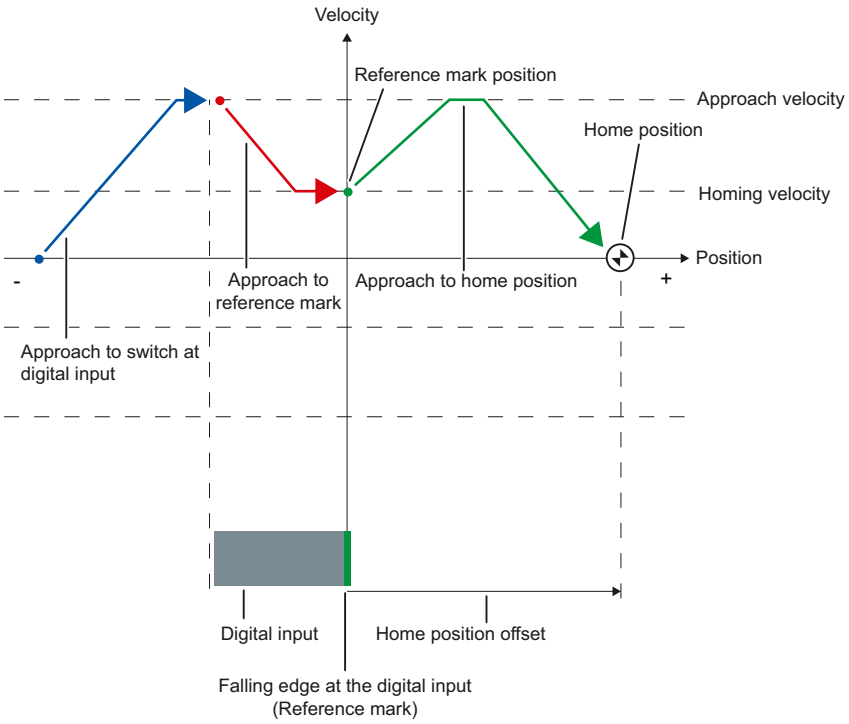
See also

Active homing for SINAMICS drives with external zero mark (Page 280)

3.10.6 Active homing with digital input

The following figure shows an example of the homing motion with the following settings:

- Active homing with digital input
- Approach in the positive direction
- Reference mark on the positive side of the digital input
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home"**
2. **Detection of the rising edge at the digital input, while moving at homing velocity**
3. **Approach to the reference mark**
4. **Detection of the reference mark**

   In the example, the falling edge of the switch at the digital input represents the reference mark.

   When the reference mark is detected, the position of the axis or encoder is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 4

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" to "MC_Home" = 5

     Position = value in tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

5. **Approach to the home position**

   – Parameter "Mode" to "MC_Home" = 4

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" to "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>.Homing.HomePosition tag.

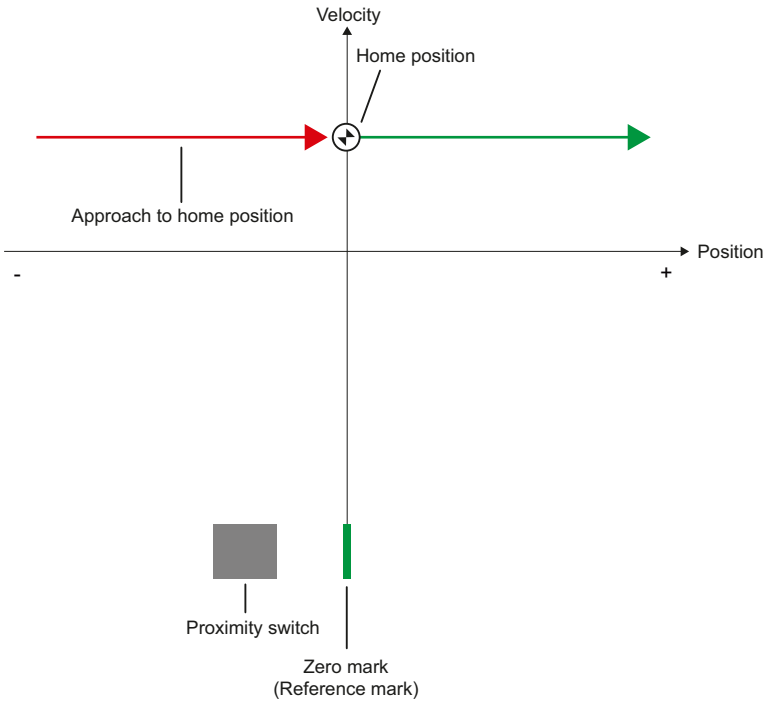
   Note

   If the velocity on the span from the detection of the rising edge to the falling edge cannot be reduced to the homing velocity, then homing occurs at the velocity that exists when the reference mark is traversed.

3.10.7 Passive homing with zero mark and proximity switch

The following figure shows an example of the homing motion with the following settings:

- Passive homing with zero mark and proximity switch
- Homing in the positive direction



Motion sequence

The motion occurs in the following sequence:

1. **Enablement of passive homing via the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job from the application**

   The detection of the proximity switch and of the reference mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the proximity switch**
4. **Departure from the proximity switch**

   The departure from the proximity switch enables the detection of the reference mark.
5. **Detection of the reference mark**

   When the reference mark is detected, the position of the axis or encoder is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 2

     Position = value in parameter "Position"

   – Parameter "Mode" to "MC_Home" = 3

     Position = value in tag <TO>.Homing.HomePosition

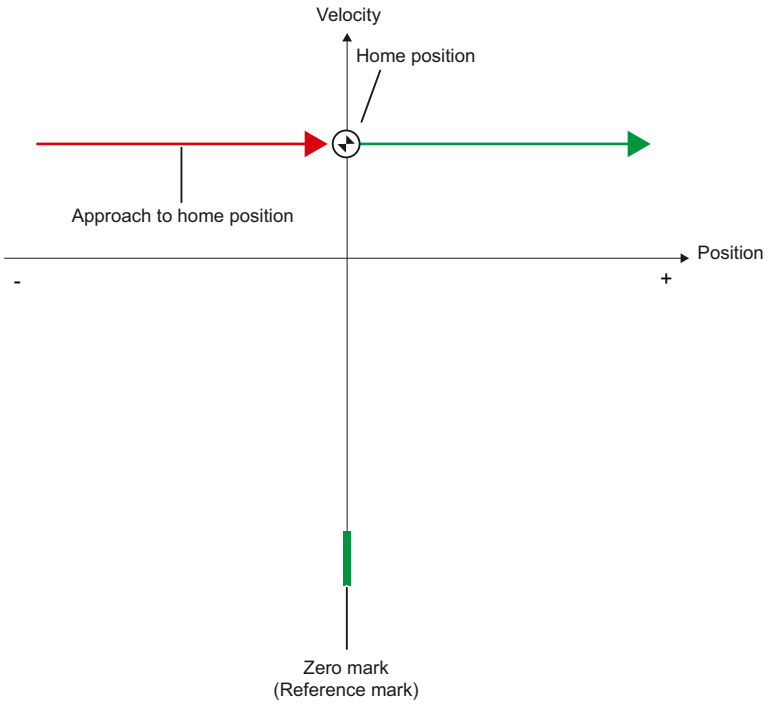
   Note

   If the direction of motion changes after departure from the proximity switch and before detection of the reference mark, then the proximity switch must be detected again. The Motion Control instruction "MC_Home" remains enabled.

3.10.8 Passive homing with zero mark

The following figure shows an example of the homing motion with the following settings:

- Passive homing with zero mark
- Homing in the positive direction



Motion sequence

The motion occurs in the following sequence:

1. **Enablement of passive homing via the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job from the application**

   The detection of the reference mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the reference mark**

   When the reference mark is detected, the position of the axis or encoder is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 2

     Position = value in parameter "Position"

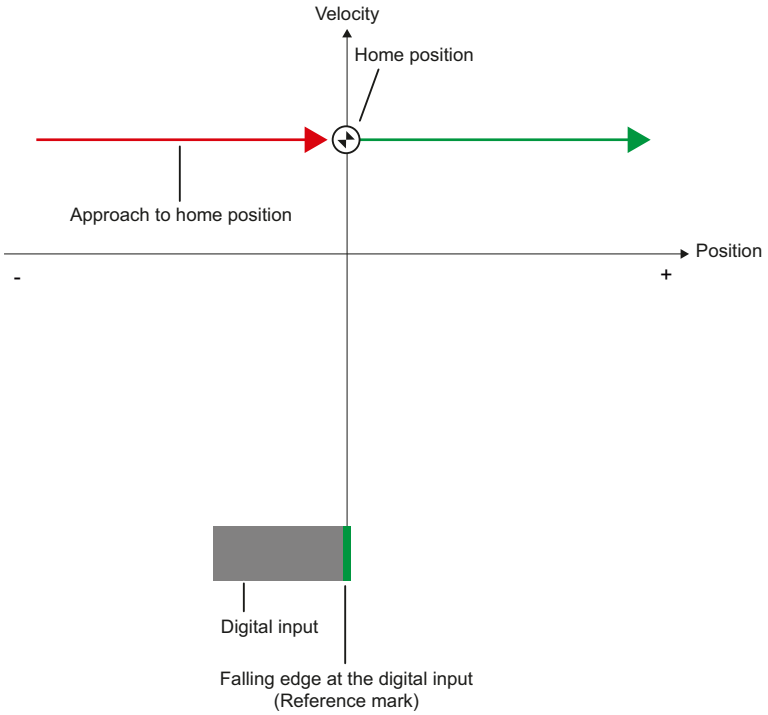
   – Parameter "Mode" to "MC_Home" = 3

     Position = value in tag <TO>.Homing.HomePosition

3.10.9 Passive homing with digital input

The following figure shows an example of the homing motion with the following settings:

- Passive homing with digital input
- Homing in the positive direction
- Reference mark on the positive side of the digital input



Motion sequence

The motion occurs in the following sequence:

1. **Enablement of passive homing via the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job from the application**

   The detection of the reference mark at the digital input is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the reference mark**

   In the example, the falling edge of the switch at the digital input represents the reference mark.

   When the reference mark is detected, the position of the axis or encoder is set depending on the configured mode.

   – Parameter "Mode" to "MC_Home" = 2

     Position = value in parameter "Position"

   – Parameter "Mode" to "MC_Home" = 3

     Position = value in tag <TO>.Homing.HomePosition

3.10.10 Direction reversal at the hardware limit switch (reversing cam)

During active homing, the hardware limit switch can optionally be used as a reversing cam. If the reference mark is not detected or the motion was not in the homing direction, then the motion continues after the reversing cam in the opposite direction with the approach velocity.

When the hardware limit switch is reached, the dynamic defaults become effective. Deceleration with the emergency stop deceleration does not occur.

NOTICE
Avoid moving to a mechanical endstop Ensure by one of the following measures, that in a direction reversal the machine does not move to a mechanical endstop. • Keep the approach velocity low. • Increase the configured acceleration / deceleration. • Increase the offset between the hardware limit switch and the mechanical endstop.

3.10.11 Direct homing

Depending on the configured mode, the position of the positioning axis technology object or external encoder can be absolutely or relatively set with "MC_Home".

Set position absolutely

Proceed as follows to set the position absolutely:

1. In the Motion Control instruction "MC_Home", enter the absolute position in the "Position" parameter.
2. Call the Motion Control instruction "MC_Home" with parameter "Mode" = 0.

The position is set to the value specified in the "Position" parameter.

Set position relatively

Proceed as follows to set the position relatively:

1. In the Motion Control instruction "MC_Home", enter the relative position in the "Position" parameter.
2. Call the Motion Control instruction "MC_Home" with parameter "Mode" = 1.

The position is set to the current position plus the value specified in the "Position" parameter.

3.10.12 Absolute value adjustment

In absolute value adjustment, Motion Control determines an absolute value offset, that is retentively stored in the CPU.

Depending on the configured mode, the position of the axis or the encoder is absolutely or relatively set in the "MC_Home" Motion Control instruction.

- Parameter "Mode" = 7 (absolute specification of position)

  Position = value in parameter "Position"

- Parameter "Mode" = 6 (relative specification of position)

  Position = current position + value in parameter "Position"

3.10.13 Resetting the "Homed" status

Incremental encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Errors in the sensor system / encoder failure
- Initiation of active homing with the Motion Control instruction "MC_Home" with "Mode" = 4, 5 (after successful completion of the homing process, the status "Homed" is set again.)
- Initiation of passive homing with the Motion Control instruction "MC_Home" with "Mode" = 2, 3 (after successful completion of the homing process, the status "Homed" is set again.)
- Replacement of the CPU
- Replacement of the SIMATIC Memory Card
- POWER OFF
- Memory reset
- Modification of the encoder configuration
- Restart of the technology object
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

Absolute value encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Errors in the sensor system / encoder failure
- Replacement of the CPU
- Modification of the encoder configuration
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

Resetting the memory of the CPU or upgrading a project does not require another absolute value adjustment.

3.10.14 Tags

The following technology object tags are relevant for homing:

Status indicators	
<TO>StatusWord.HomingCommand	Homing command active
<TO>StatusWord.HomingDone	Technology object is homed
<TO>ErrorWord.HomingFault	Error occurred during homing
Approach to the proximity switch	
<TO>.Homing.ApproachDirection	Start direction or approach direction for the approach to the proximity switch
<TO>.Homing.ApproachVelocity	Velocity for the approach to the proximity switch
Approach to the reference mark	
<TO>.Sensor[n].ActiveHoming.Direction	Homing direction
<TO>.Homing.ReferencingVelocity	Velocity for the approach to the reference mark
Approach to home position	
<TO>.Homing.ApproachVelocity	Velocity for the approach to the home position
Positions	
<TO>.Homing.AutoReversal	Reversal at the hardware limit switches
<TO>.Homing.HomePosition	Home position
<TO>.StatusSensor[n].AbsEncoderOffset	Calculated offset after the absolute value adjustment
Parameters for active homing	
<TO>.Sensor[n].ActiveHoming.Mode	Homing mode
<TO>.Sensor[n].ActiveHoming.SideInput	Side of the digital input
<TO>.Sensor[n].ActiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[n].ActiveHoming.DigitalInputAddress	I/O address of the digital input
<TO>.Sensor[n].ActiveHoming.DigitalInputBit Number	Bit number of the I/O address of the digital input
<TO>.Sensor[n].ActiveHoming.HomePosition Offset	Offset of the reference mark from the home position
Parameters for passive homing	
<TO>.Sensor[n].PassiveHoming.Mode	Homing mode
<TO>.Sensor[n].PassiveHoming.SideInput	Side of the digital input
<TO>.Sensor[n].PassiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[n].PassiveHoming.DigitalInput Address	Byte number of the I/O address of the digital input
<TO>.Sensor[n].PassiveHoming.DigitalInputBit Number	Bit number of the I/O address of the digital input

Note

Evaluation of the bits in StatusWord, ErrorWord and WarningWord

Read the information provided in section Evaluate StatusWord, ErrorWord and WarningWord (Page 143).

3.11 Control

3.11.1 Brief description

The position controller of the positioning axis is a closed-loop P controller with pre-control of velocity.

If the drive supports Dynamic Servo Control (DSC), then a closed-loop position controller in the drive can optionally be used.

Dynamic Servo Control (DSC)

In drives that support Dynamic Servo Control (DSC), you can optionally use the closed-loop position controller in the drive. The position controller in the drive is usually implemented with a rapid speed-control cycle. This improves the control performance for digitally coupled drives. The communication times between controller and drive are automatically taken into account.

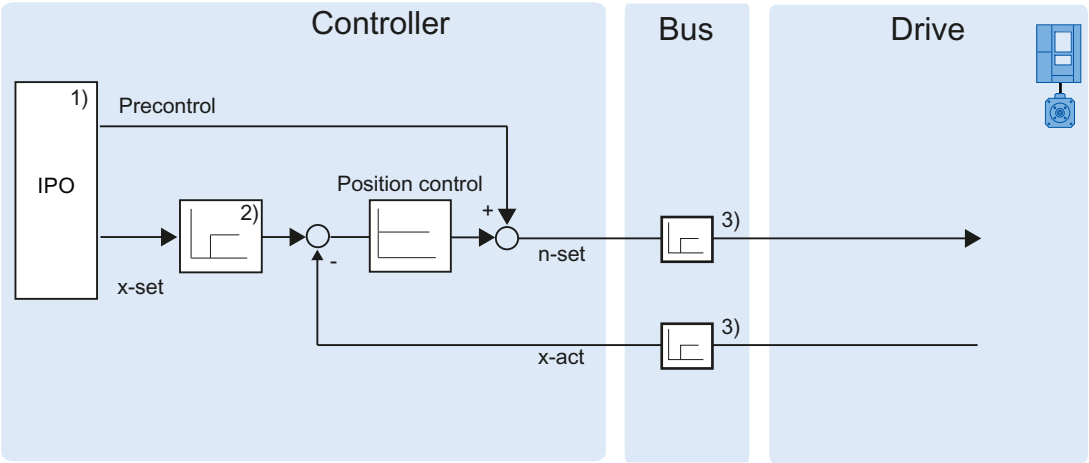
For DSC, the drive's encoder must be used and the drive must support standard frame 5.

See also

Frames (Page 26)

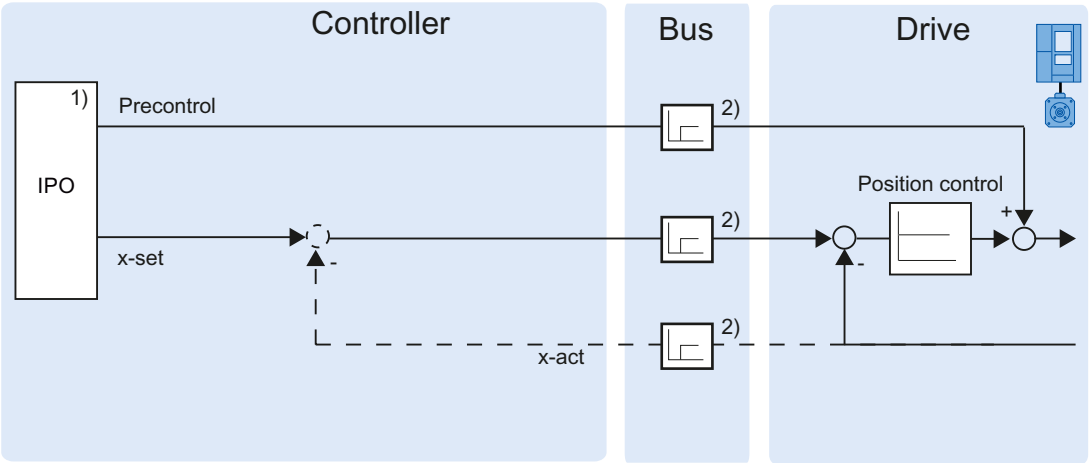
3.11.2 Control structure

The following figure shows the effective control structure without DSC:



1) Interpolator with Motion Control
2) Internal consideration of signal delays
3) Controller-drive communication

The following figure shows the effective control structure with DSC:



1) Interpolator with Motion Control
2) Controller-drive communication

3.11.3 Tags

The following technology object tags are relevant for control:

Parameter	
<TO>.PositionControl.Kv	Proportional gain in the position control
<TO>.PositionControl.EnableDSC	Enabling DSC

3.12 Position-related monitoring

3.12.1 Brief description

The following functions are available in the positioning axis technology object for monitoring positioning and motion:

- Positioning monitoring (Page 55)

  The actual position value must reach a positioning window within a specified time, and remain in this positioning window for a minimum dwell time.

- Following error monitoring (Page 56)

  The following error is monitored based on a velocity-dependent following error limit. The permissible maximum following error depends on the setpoint velocity.

If monitored conditions are violated, then technology alarms are output.
The technology object responds in accordance with the alarm response.

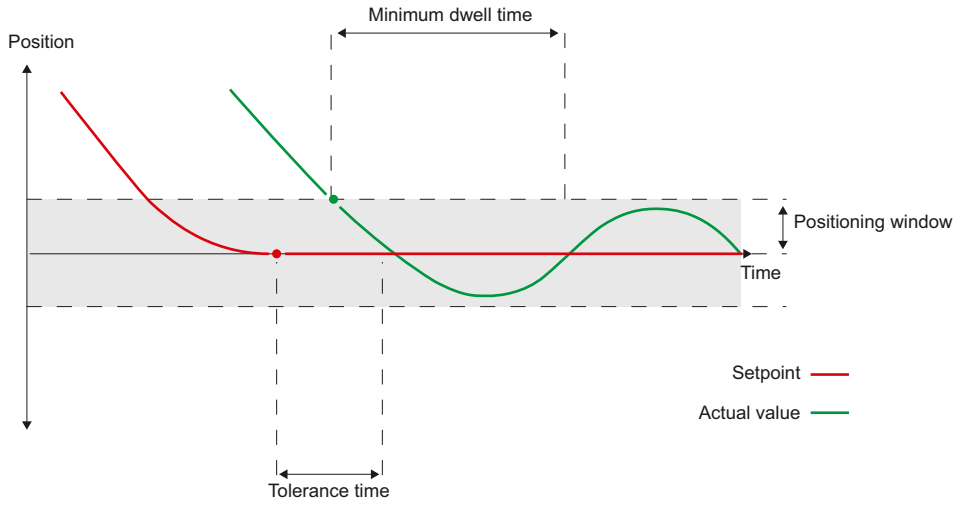
3.12.2 Positioning monitoring

Positioning monitoring monitors the behavior of the actual position at the end of the setpoint calculation.

As soon as the setpoint velocity reaches the value zero, the actual position value must be located within a tolerance time in the positioning window. The setpoint must not exit the positioning window during the minimum dwell time.

If the actual position value at the end of a positioning motion is reached within the tolerance time and remains in the positioning window for the minimum dwell time, then <TO>.StatusWord.Done is set in the technology data block. This completes a Motion Control job.

The following figure shows the chronological sequence and the positioning window:



Positioning monitoring does not make any distinction between how the setpoint interpolation was completed. The end of setpoint interpolation can for example be reached as follows:

- by the setpoint reaching the target position
- by position controlled stopping during the motion, via the Motion Control instruction "MC_Halt"

Violation of positioning monitoring

In the following cases, technology alarm 541 is output by the positioning monitoring, and the technology object is disabled (alarm response: Remove enable).

- The actual value does not reach the positioning window during the tolerance time.
- The actual value exits the positioning window during the minimum dwell time.

3.12.3 Following error monitoring

The following error in the positioning axis technology object is monitored based on a velocity-dependent following error limit. The permissible following error depends on the setpoint velocity.

A constant permissible following error can be specified for velocities less than an adjustable velocity low limit.

Above this lower velocity limit, the permissible following error increases in proportion to the setpoint velocity. The maximum permissible following error may be reached at the maximum velocity.

Calculation of the following error

The following error is the difference between the position setpoint and the actual position value. The transmission times of the setpoint to the drive, and of the actual position value to the controller, are taken into account in the calculation of the following error, i.e., subtracted out.

Warning limit

A warning limit can be specified for the following error. The warning limit is input as a percentage value and operates relative to the current permissible following error.
If the warning limit of the following error is reached, then technology alarm 522 is output. This is a warning and contains no alarm response.

Exceedance of the permissible following error

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm response: Remove enable).

3.12.4 Tags

The following technology object tags are relevant for positioning monitoring:

Status indicators	
<TO>.StatusWord.Standstill	Is set to the value TRUE, when the actual velocity value goes below the velocity threshold, and does not exit it within the minimum dwell time. The standstill signal is only present at the positioning axis.
<TO>.StatusWord.Done	**Positioning axis** Is set to the value TRUE, when the actual velocity value reaches the positioning window within the tolerance time, and remains for the minimum dwell time in the window **Speed-controlled axis** Is set to TRUE, when the motion is completed and thus the speed setpoint is equal to zero.
<TO>.ErrorWord.PositioningFault	A positioning error has occurred.
Positions and times	
<TO>.PositioningMonitoring.ToleranceTime	Maximum permissible time until positioning window is reached The time is started with the end of the setpoint interpolation.
<TO>.PositioningMonitoring.MinDwellTime	Minimum dwell time in the positioning window
<TO>.PositioningMonitoring.Window	Positioning window
Standstill signal	
<TO>.StandstillSignal.VelocityThreshold	Velocity threshold for the standstill signal
<TO>.StandstillSignal.MinDwellTime	Minimum dwell time below the velocity threshold

The following technology object tags are relevant for following error monitoring:

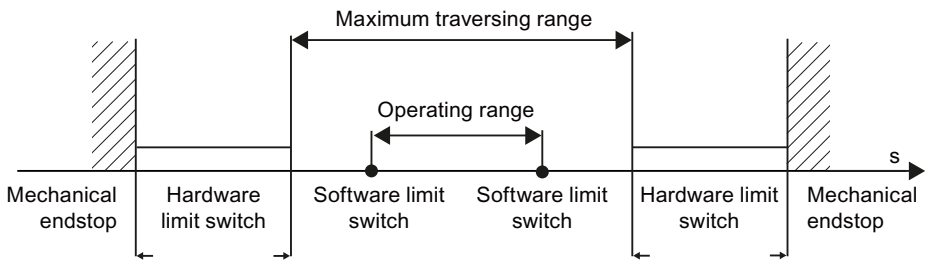
Status indicators	
<TO>.StatusPositioning.FollowingError	Current following error
<TO>.ErrorWord.FollowingErrorFault	Status indication, that the following error is too large
<TO>.WarningWord.FollowingErrorWarning	Status indication, that the following error warning limit has been reached
Control bits	
<TO>.FollowingError.EnableMonitoring	Enabling / disabling following error monitoring
Limit values	
<TO>.FollowingError.MinVelocity	Lower setpoint velocity for the characteristic curve of the maximum following error
<TO>.FollowingError.MinValue	Permissible following error below the <TO>.FollowingError.MinVelocity
<TO>.FollowingError.MaxValue	Maximum permissible following error at maximum axis velocity
<TO>.FollowingError.WarningLevel	Warning limit as a percentage value relative to the maximum permissible following error (velocity-dependent in accordance with the characteristic curve)

3.13 Traversing range limitation

3.13.1 Brief description

Hardware and software limit switches limit the permissible traversing range and operating range of the positioning axis. Before use, they must be enabled in the configuration or in the user program.

The following figure shows the relationship between operating range, maximum traversing range and the limit switches:



3.13.2 Hardware limit switches

Hardware limit switches are limit position switches that limit the maximum permissible traversing range of the axis.

The positions of the hardware limit switches should be selected so that sufficient braking distance exists for the axis when needed. The axis should come to a standstill before a mechanical endstop.

Approaching the hardware limit switches

In the monitoring of range limitation, no distinction is made, whether the switches are approached or overshot.

If a hardware limit switch is approached, technology alarm 531 is output, and the technology object is disabled (alarm response: remove enable).

Exception

If the hardware limit switches are used as reversing cams or reference cams, then the monitoring of the hardware limit switches has no effect.

Retracting

Proceed as follows to retract the axis free after approaching the hardware limit switch:

1. Acknowledge the technology alarm.
2. Move the axis in the free travel direction, until the hardware limit switch is exited.

   If you move opposite to the free travel direction before exiting the hardware limit switch, then the monitor with be triggered again.

The technology object's <TO>.ErrorWord.HWLimit tag shows the value TRUE, until the hardware limit switch is exited. As soon as the axis has traveled free, <TO>.ErrorWord.HWLimit takes the value FALSE.

3.13.3 Software limit switches

The operating range of the axis is limited with software limit switches. Relative to the traversing range, always position the software limit switches within the hardware limit switches. Since the positions of the software limit switches can be flexibly configured, the operating range of the axis can be individually adapted in accordance with the current velocity profile.

Software limit switches are only effective when there is a valid actual value after homing the technology object. The monitoring of the software limit switches is relative to the setpoint.

Modulo enabled

With modulo enabled, the modulo position is monitored.

The software limit switches are enabled or disabled using the tags in the technology data block. If the positions of both software limit switches are outside the modulo range, then the monitoring has no effect. It is not checked, whether the positions of the software limit switches are within the modulo range.

Approaching the software limit switches

At the beginning of a positioning motion, it is not checked, whether the software limit switches will be approached by approaching the specified target position.

If the software limit switches are approached, then technology alarm 533 is output, and the axis is stopped with the maximum dynamic values (alarm response: Stop with maximum dynamic values). The technology object remains enabled.

Overshooting the software limit switches

If a software limit switch is overshot, technology alarm 534 is output, and the technology object is disabled (alarm response: remove enable).

Retracting

Proceed as follows to retract the axis after violation of the software limit switch:

1. Acknowledge the technology alarm.
2. Move the axis in the free travel direction, until the software limit switch is exited.

   If you move opposite to the free travel direction before exiting the software limit switch, then the monitor with be triggered again.

3.13.4 Tags

The following technology object tags are relevant for software limit switches:

Status indicators	
<TO>.StatusWord.SWLimitMinActive	Negative software limit switch is enabled
<TO>.StatusWord.SWLimitMaxActive	Positive software limit switch is enabled
<TO>.ErrorWord.SWLimit	An alarm is pending, that a software limit switch was violated
Control bits	
<TO>.PositonLimits_SW.Active	Enables / disables the monitoring of the software limit switches
Position values	
<TO>.PositonLimits_SW.MinPosition	Position of the negative software limit switch
<TO>.PositonLimits_SW.MaxPosition	Position of the positive software limit switch

The following technology object tags are relevant for hardware limit switches:

Status indicators	
<TO>.StatusWord.HWLimitMinActive	Negative hardware limit switch is enabled
<TO>.StatusWord.HWLimitMaxActive	Positive hardware limit switch is enabled
<TO>.ErrorWord.HWLimit	An alarm is queued; a hardware limit switch was violated
Control bits	
<TO>.PositonLimits_HW.Active	Enables / disables the monitoring of the hardware limit switches
Parameter	
<TO>.PositonLimits_HW.MinSwitchLevel	Level selection for enablement of the lower hardware limit switch: FALSE: At low level, the signal is enabled TRUE: At high level, the signal is enabled
<TO>.PositonLimits_HW.MinSwitchAddress	I/O address of the hardware limit switch for the lower or minimum position
<TO>.PositonLimits_HW.MinSwitchBit Number	Bit number of the I/O address of the hardware limit switch for the lower or minimum position
<TO>.PositonLimits_HW.MaxSwitchLevel	Level selection for enablement of the upper hardware limit switch: FALSE: At low level, the signal is enabled TRUE: At high level, the signal is enabled
<TO>.PositonLimits_HW.MaxSwitchAddress	I/O address of the hardware limit switch for the upper or maximum position
<TO>.PositonLimits_HW.MaxSwitchBit Number	Bit number of the I/O address of the hardware limit switch for the upper or maximum position

3.14 Motion Control and limit values for dynamics

3.14.1 Brief description

Motion control of the axis occurs by means of velocity profiles (Page 63). The velocity profiles are calculated in accordance with the specifications for dynamics. A velocity profile defines the behavior of the axis during approach, braking and changes in velocity. During positioning a velocity profile is calculated, that moves the axis to the target point.

Maximum values for velocity, acceleration and jerk result from the properties of the drive and the mechanics. These maximum values can be configured in the limits for dynamics. The limits for dynamics are in effect as limits for every motion generated by means of the technology object.

The configurable emergency stop deceleration (Page 64) is triggered by the Motion Control instruction MC_Power or by a technology alarm.

The jerk limit reduces the mechanical load during an acceleration ramp or deceleration ramp. A "smoothed" velocity profile results.

3.14.2 Velocity profile

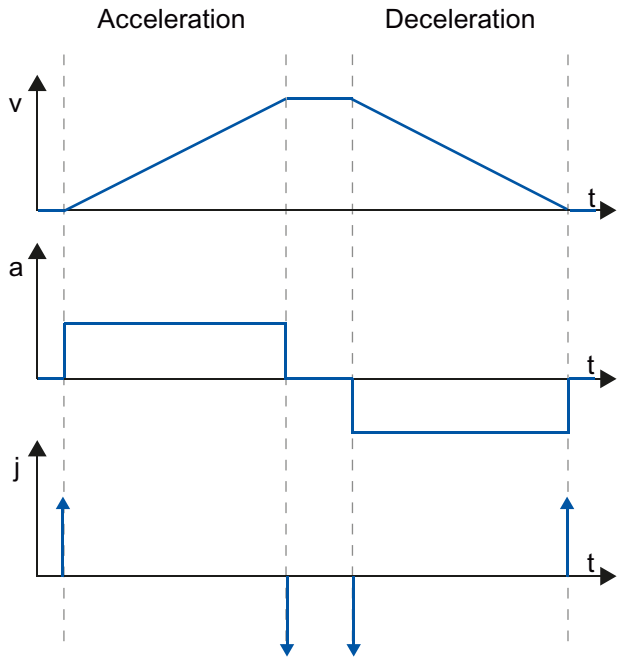
A velocity profile without jerk limit and a velocity profile with jerk limit are both supported for Motion Control of the axis.

The dynamic values for the motion are specified in the Motion Control job. Alternatively the dynamic default values can be used. The defaults and the limits for velocity, acceleration, deceleration and jerk are set in the configuration.

To influence velocity, a velocity override can override the current traversing velocity.

Velocity profile without jerk limit

The following figure shows velocity, acceleration and jerk:

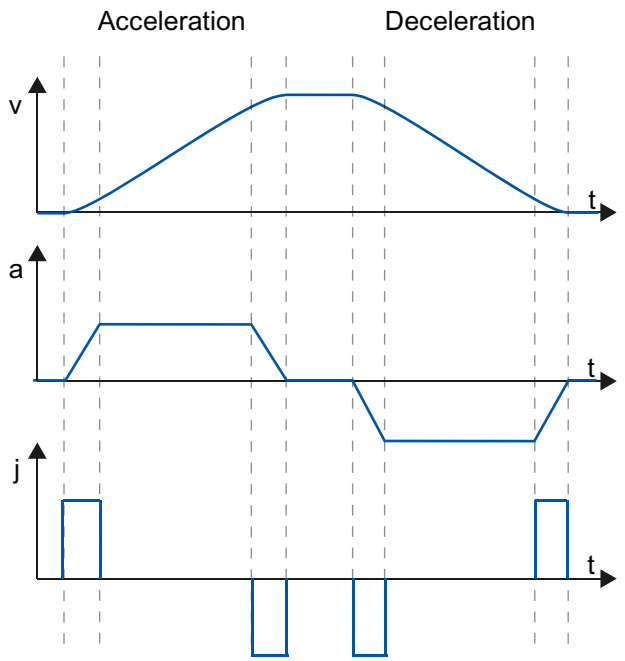


v - velocity
a - acceleration
j - jerk
t - time

A velocity without jerk limit is employed for motion with constant acceleration and deceleration.

Velocity profile with jerk limit

The following figure shows velocity, acceleration and jerk:



v - velocity
a - acceleration
j - jerk
t - time

A velocity profile with jerk limit is employed for a continuous acceleration and deceleration sequence. The jerk can be specified.

3.14.3 Emergency stop deceleration

When stopping with the emergency stop ramp, the axis is braked to a standstill without a jerk limit, using the configured emergency stop deceleration.

In the following cases the configured emergency stop deceleration is in effect:

- For an emergency stop ramp that has been enabled via the Motion Control instruction "MC_Power" with parameter "StopMode" = 0.
- For a technology alarm with the local alarm response "Stop with emergency stop ramp".

This emergency stop deceleration can be set greater than the maximum deceleration. If the emergency stop deceleration is set lower than this, it may occur that the axis does not stop until after the limit switch in the case of "Stop at software limit switch" and the occurrence of a technology alarm with the local alarm response "Stop with emergency stop ramp".

3.14.4 Tags

The following technology object tags are relevant for Motion Control:

Status	
<TO>.StatusWord	Status indicators for an active motion
<TO>.Position	Setpoint position
<TO>.Velocity	Setpoint velocity / setpoint speed
<TO>.ActualPosition	Actual position
<TO>.ActualVelocity	Actual velocity
<TO>.ActualSpeed	Actual speed of the motor (with analog setpoint = 0.0)
<TO>.Acceleration	Setpoint acceleration
<TO>.ActualAcceleration	Actual acceleration
Override	
<TO>.Override.Velocity	Velocity override
Dynamic limit values	
<TO>.DynamicLimits.MaxVelocity	Dynamic limit for maximum velocity
<TO>.DynamicLimits.MaxAcceleration	Dynamic limit for maximum acceleration
<TO>.DynamicLimits.MaxDeceleration	Dynamic limit for maximum deceleration
<TO>.DynamicLimits.MaxJerk	Dynamic limit for maximum jerk
Dynamic defaults	
<TO>.DynamicDefaults.Velocity	Default velocity
<TO>.DynamicDefaults.Acceleration	Default acceleration
<TO>.DynamicDefaults. Deceleration	Default deceleration
<TO>.DynamicDefaults.Jerk	Default jerk
<TO>.DynamicDefaults. EmergencyDeceleration	Emergency stop deceleration

3.15 Operational sequence

3.15.1 Organization Blocks for Motion Control

Description

When you create a technology object, organization blocks are automatically created for processing the technology objects. The Motion Control functionality of the technology objects creates its own execution level, and is cyclically called.

The following blocks are created:

- MC-Servo [OB91]

  Calculation of the Position Controller

- MC-Interpolator [OB92]

  Controller-side evaluation of the Motion Control instructions, generation of setpoints and monitoring functionality

The organization blocks are protected (know-how protection). The program code cannot be viewed or changed.

The frequency relationship of the two organization blocks to one another is always 1:1. MC-Servo [OB91] is always executed before MC-Interpolator [OB92].

You can configure the cycle clock source and the priority of the organization blocks in accordance with your requirements for control performance and system load.

Cycle clock sources

An equidistant cycle is required for Motion Control functionality.

You can configure the cycle clock source in the properties of the MC-Servo [OB91] under "General > Cycle Time":

- Synchronous with the bus

  The Motion Control functionality is called synchronously with a bus system.
  You can configure the cycle time in the properties for the selected interface.
  You can select the following interfaces:

  – Isochronous PROFIBUS DP

  – Isochronous PROFINET IO

- Cyclical

  The Motion Control functionality is called cyclically with the specified cycle time.

The cycle time must be sufficiently large to allow all technology objects to be processed in one clock cycle. If the clock cycle cannot be observed, then CPU timeouts occur (see also Operational Sequence and Timeouts (Page 68)).

Priority

You can configure the priority of the organization blocks as needed in their properties under "General > Properties > Priority":

- MC Servo [OB91]

  Priority 17 to 31 (default value 25)

- MC Interpolator [OB92]

  Priority 16 to 30 (default value 24)

The priority of MC Servo [OB91] must be at least one higher than the priority of the MC Interpolator [OB92].

3.15.2 Process image partition "OB Servo PIP"

The process image partition "OB Servo PIP" is made available in isochronous mode for Motion Control. All drives and encoders used by Motion Control are assigned to this process image partition.

Additionally, you should assign all I/O modules used by Motion Control to this process image partition (e.g. hardware limit switches). The assignment results in chronologically synchronous processing with the technology object.

The input process image partition is also updated in STOP mode.

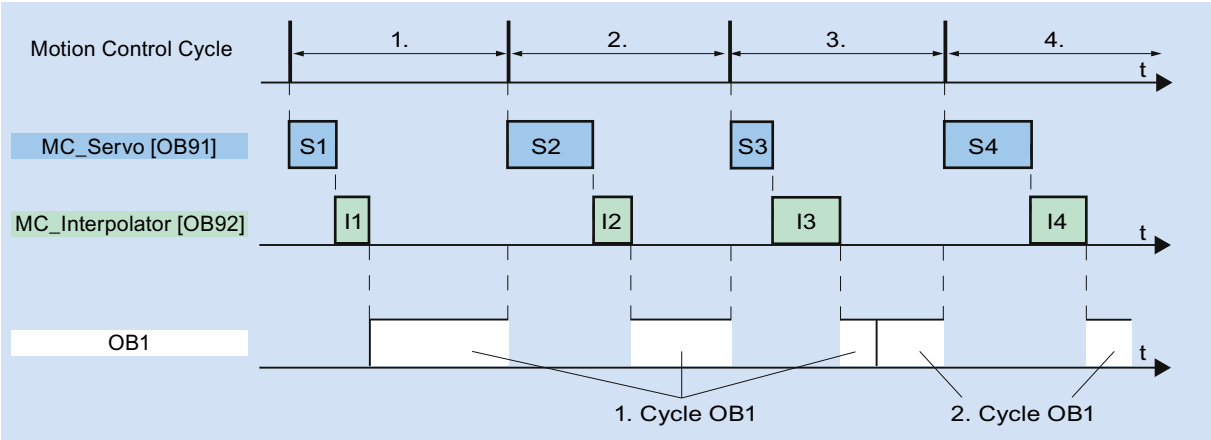
3.15.3 Operational Sequence and Timeouts

During the processing of Motion Control functionality, the organization blocks MC Servo [OB91] and MC Interpolator [OB92] are called and processed in each cycle. The remaining cycle time is available for the processing of your user program.

In each cycle (Motion Control Cycle):

- MC Servo [OB91] must be started and completely processed.
- the associated MC Interpolator [OB92] must at least be started.

The following figure shows an example of the error-free operational sequence for the processing of organization block OB1:

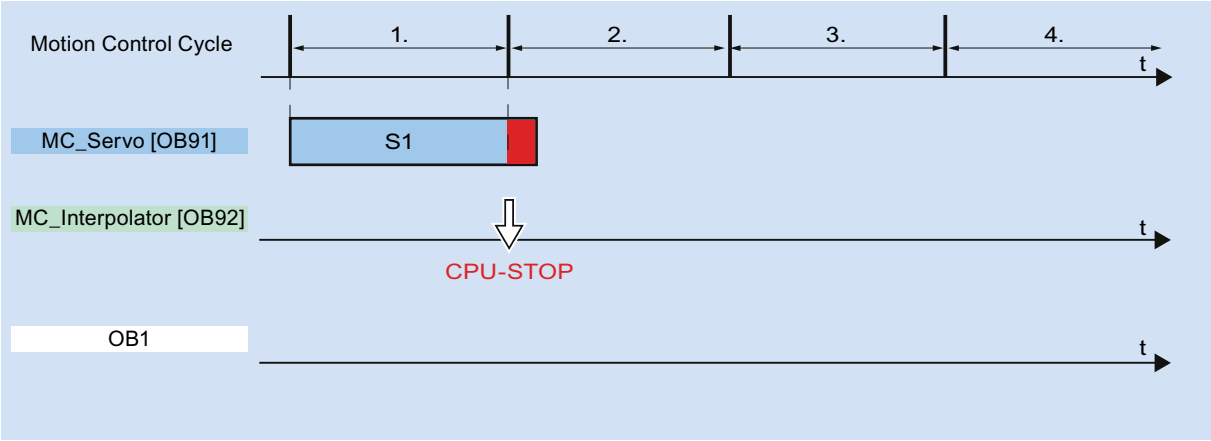


Timeouts

If the configured clock cycle for Motion Control functionality cannot be complied with, e.g. due to high CPU load or a cycle time that is too short, CPU timeouts can occur.

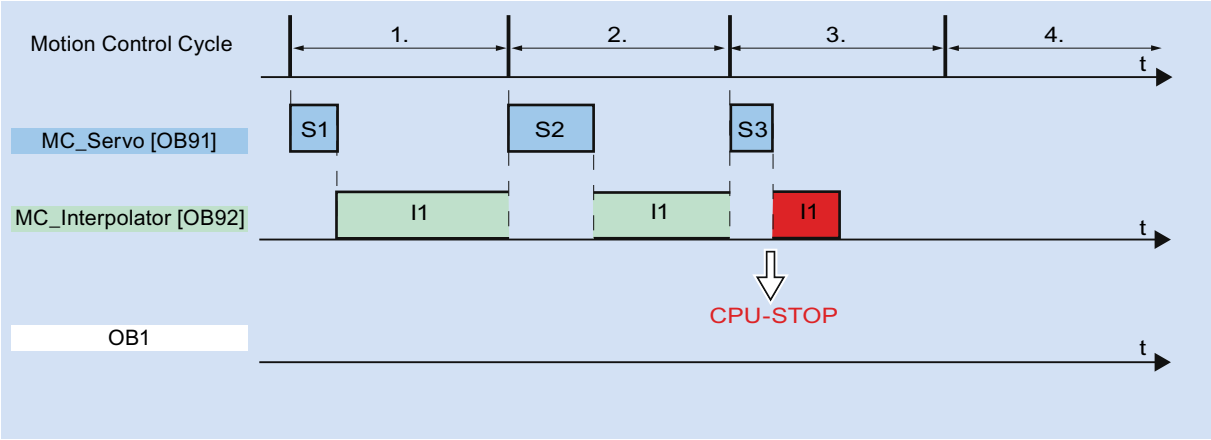
The MC Servo [OB91] does not tolerate any timeouts. A CPU timeout will cause the CPU to go into STOP mode.

The following figure shows the operational sequence for a timeout of the MC Servo [OB91]:



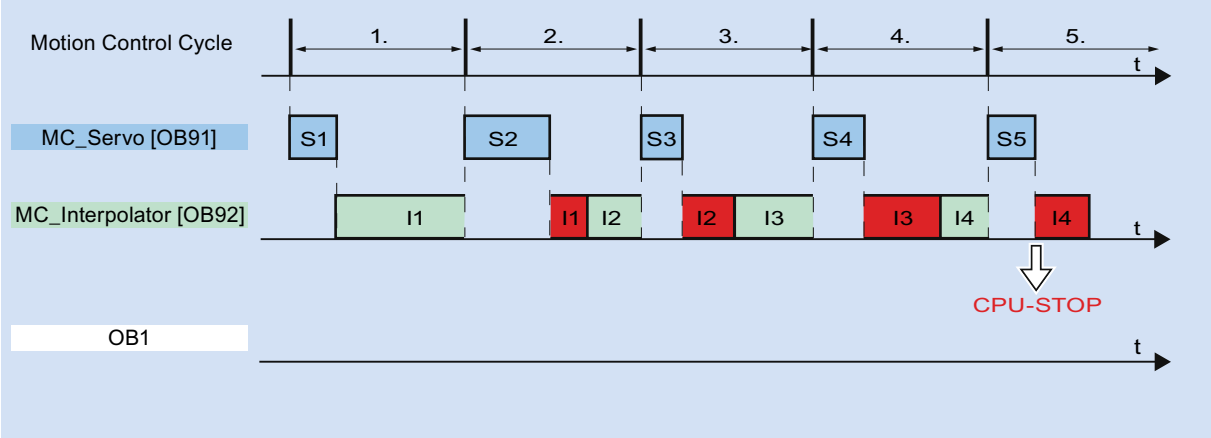
The processing of an MC Interpolator [OB92] can be interrupted by at most one call of the MC Servo [OB91]. If more interruptions occur, the CPU switches to STOP mode.

The following figure shows the operational sequence for an interruption of an MC Interpolator [OB92] over two time slices:



The MC Interpolator [OB92] tolerates a maximum of three successive CPU timeouts. If more timeouts occur, the CPU switches to STOP mode.

The following figure shows the operational sequence for four separate timeouts of the MC Interpolator [OB92] in a row:

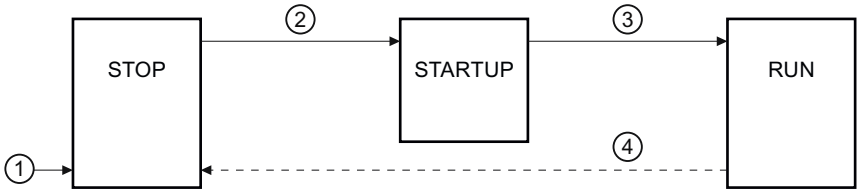


3.15.4 Operating modes

This section examines the behavior of Motion Control in each operating mode, and in the transitions between operating modes. A general description of the operating modes can be found in system manual S7-1500.

Operating modes and transitions

The CPU has three operating modes: STOP, STARTUP and RUN.
The following figure shows the operating modes and the operating mode transitions:



STOP mode

In STOP mode the user program is not processed and al process outputs are disabled. Thus no Motion Control jobs are executed.

The technology data blocks are updated.

STARTUP mode

Before the CPU starts processing of the cyclical user program, the startup OBs are processed one time.

In STARTUP mode, the process outputs are disabled. Motion Control jobs are rejected.

The technology data blocks are updated.

RUN mode

The user program is processed in RUN mode.

In RUN mode, the programmed Motion Control jobs are cyclically called and processed.

The technology data blocks are updated.

Operating mode transitions

The following table shows the behavior of Motion Control in the transitions between the operating modes:

No.	Operating mode transition	Behavior
①	POWER ON → STOP	The CPU performs a restart of the technology objects. The technology objects are reinitialized with the values from the load memory.
②	STOP → STARTUP	Not relevant to Motion Control.
③	STARTUP → RUN	The process outputs are enabled.
④	RUN → STOP	When the CPU changes to RUN mode after STOP mode, all technology objects are disabled in accordance with the alarm response "remove enablement". Running Motion Control jobs are terminated.

Guidelines 4

4.1 Guidelines on use of motion control

The guidelines described here present the basic procedure for using Motion Control with the CPU S7-1500. These guidelines serve as recommendations.

Requirements

- A project with a CPU S7-1500 has been created.

Procedure

Proceed as follows to use Motion Control with the CPU S7-1500:

1. Add technology object (Page 83)
2. Working with the configuration editor (Page 84)
3. Programming (Page 139)
4. Downloading to CPU (Page 165)
5. Functional test in the Commissioning window (Page 167)
6. Diagnostics (Page 185)

Configuring 5

5.1 Adding and configuring drives in the device configuration

5.1.1 Add and configure PROFINET IO drives

Adding and configuring a PROFINET IO drive is described below using a **SINAMICS S120 drive**. Adding and configuring other PROFINET IO drives may differ from the description in certain respects.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the Hardware Catalog, then it must be installed in the "Extras" menu as a device description file (GSD).

Adding a drive and message frame in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional Field Devices > PROFINET IO > Drives > Siemens AG > SINAMICS".
3. Select the desired drive with the desired version, then drag it to the network view.
4. Assign the drive to the PROFINET interface of the PLC.
5. Open the drive in the device view.
6. Drag a Drive Object (DO) and a standard message frame from the hardware catalog to the slot of the device overview of the drive.

Depending on the version of the SINAMICS S120 drive, select "DO with standard telegram X", or "DO Servo" and a "Standard telegram X" for the message frame.

For more information on suitable message frames, refer to section Frames (Page 26).

Repeat step 6, if you want to add another drive and another standard message frame.

Enable isochronous operation of the drive in the device configuration

PROFINET drives can always be operated in isochronous mode or non-isochronous mode. Isochronous mode, however, increases the quality of the position control of the drive.

Proceed as follows if you want to control the drive in isochronous mode:

1. Open the device view in the drive.
2. In the properties dialog, select the tab "PROFINET Interface [X1] > Advanced options > Isochronous mode".
3. Select the "Isochronous mode" check box in this tab.

The entry for the message frame also has to be selected for isochronous mode in the detailed view.

Interconnecting the port of the PLC with the port of the drive

1. Open the topology view in the device configuration.
2. Interconnect the port of the PLC with the port of the drive.

Configuring the PLC as the sync master and setting isochronous mode

1. Select the device view of the PLC.
2. In the properties dialog, select the tab "PROFINET Interface [X1] > Advanced options > Realtime settings > Synchronization".
3. Select "Sync master" from the "Synchronization role" drop-down list.
4. Click the "Domain settings" button.
5. Open the "Domain Management > Sync Domains" tab and set the desired "Send clock" (isochronous clock).

Select drive in the configuration of the technology object

1. Add a new axis technology object, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "PROFIdrive" from the "Drive type" drop-down list.
4. Select the Drive Object of the PROFINET drive from the "Drive" list.

In section Add technology object (Page 83), you can learn how to add a technology object.

Result

The technology object is connected to the drive and the "MC Servo" organization block can be checked/configured.

The message frame of the configured drive is assigned to the "PIP OB Servo" process image.

Checking/configuring the properties of the MC Servo

1. Open the "Program blocks" folder in the project tree.
2. Select the "MC Servo" organization block.
3. Select the "Properties" command in the shortcut menu.
4. Select the "Cycle times" tab.
5. The "Synchronize to bus" item must be selected in the "Data exchange" drop-down list.
6. The "Profinet IO_System" item must be selected in the "Assigned IO" drop-down list.
7. The cycle time of "MC Servo" must match the cycle time of the bus.

Result

The PROFINET IO drive is now configured so that it can be controlled in the PROFINET IO network in isochronous mode.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with a separate STARTER program.

Checking isochronous mode on the drive

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific error occurs when the project is compiled, the setting for isochronous mode on the drive must be checked.

1. Open the device view in the drive.
2. Select standard message item in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   - "Isochronous mode" is enabled.
   - "MC Servo" must be select the "Organization block".
   - "PIP OB Servo" must be select the "Process image".

See also

Frames (Page 26)

Add technology object (Page 83)

5.1.2 Add and configure PROFIBUS DP drives

Adding and configuring a PROFIBUS IO drive is described below using a **SINAMICS S120**. Adding and configuring other PROFIBUS drives may differ from the description in certain respects.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- You have a basic knowledge of how to configure PROFIBUS DP networks.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the Hardware Catalog, then it must be installed in the "Extras" menu as a device description file (GSD).

Adding a drive and message frame in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional Field Devices > PROFIBUS DP > Drives > Siemens AG > SINAMICS".
3. Select the folder of the desired drive with the desired version, then drag the drive object to the network view.
4. Assign the drive to the PROFIBUS interface of the PLC.
5. Open the drive in the device view.
6. Drag a standard message frame from the hardware catalog to the slot of the device overview of the drive.

For more information on suitable message frames, refer to section Frames (Page 26).

Use the "Axis disconnector" in the hardware catalog if you want to add another drive and another standard message frame in the device overview.

Enable isochronous operation of the drive in the device configuration

PROFIBUS drives can always be operated in cyclic mode or isochronous mode. Isochronous mode, however, increases the quality of the position control of the drive.

Proceed as follows if you want to control the drive in isochronous mode:

1. Open the device view in the drive.
2. In the properties dialog, select the tab "General > Isochronous Mode".
3. Select the "Synchronize DP slave to constant DP bus cycle time" check box .

Setting isochronous mode

1. Select the network view.
2. Select the DP master system.
3. In the properties dialog, select the tab "General > Constant bus cycle time".
4. Select the desired "Constant DP bus cycle times".

Select drive in the configuration of the technology object

1. Add a new axis technology object, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "PROFIdrive" from the "Drive type" drop-down list.
4. Select the standard message frame of the PROFIBUS drive from the "Drive" list.

You can learn how to add a technology object in section Add technology object (Page 83).

Result

The technology object is connected to the drive and the "MC Servo" organization block can be checked/configured.

The message frame of the configured drive is assigned to the "PIP OB Servo" process image.

Checking/configuring the properties of the MC Servo

1. Open the "Program blocks" folder in the project tree.
2. Select the "MC Servo" organization block.
3. Select the "Properties" command in the shortcut menu.
4. Select the "Cycle times" tab.
5. The "Synchronize to bus" item must be selected in the "Data exchange" drop-down list.
6. The "DP master system" entry must be selected in the "Assigned IO" drop-down list.
7. The cycle time of "MC Servo" must match the cycle time of the bus.

Result

The PROFIBUS DP drive is now configured so that it can be controlled in the PROFIBUS network in isochronous mode.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with a separate STARTER program.

Checking isochronous mode on the drive

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific error occurs when the project is compiled, isochronous mode can be checked on the drive.

1. Open the device view in the drive.
2. Select standard message item in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   – "MC Servo" must be select the "Organization block".
   – "PIP OB Servo" must be select the "Process image".

See also

Add technology object (Page 83)

Frames (Page 26)

5.1.3 Adding and configuring drives with analog connections

The following describes how to add and configure a drive with an analog drive connection. A technology module in the rack of the PLC is used as an example of the connection of an incremental encoder.

Requirements

The SIMATIC S7-1500 device is created in the project.

Adding and configuring an analog output module in the device configuration

1. Open the device configuration of the PLC.
2. Select an analog output module from the hardware catalog and drag the module to the rack of the PLC.
3. Select the analog output module in the device view.
4. Open the "General" tab in the properties dialog and select there "Name of the Analog Output Module > I/O Addresses".
5. Enter the desired start address.
6. In the properties dialog, select the tab "General > IO tags".
7. Enter the tag name for the desired analog output.

Adding and configuring a technology module

1. Switch to the device view of the PLC.
2. In the hardware catalog, open the folder "TM > Count > TM Count 2X24V".
3. Drag the counter module to a free slot in the rack.
4. Select the technology module in the device view.
5. In the properties dialog, open the "General" tab and select there "Count 2x24V > Basic Parameters > Channel X > Operating Mode" of the channel to be used.
6. Select "Position detection for motion control" option for "Selection of the operating mode for the channel".
7. Under "Module parameters", adapt the parameters of the incremental encoder (steps per revolution = increments per revolution).
8. Under "Reaction to CPU STOP", select the item "Continue working".

Selecting the drive and encoder in the configuration of the technology object

1. Add a new "Position axis" technology object, or open the configuration of an existing position axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "Analog drive connection" from the "Drive type" drop-down list.
4. Select the previously defined tag name of the analog output from the "Output" list.
5. Open the configuration "Hardware interface > Encoder".
6. Under "Select encoder coupling" select "Encoder on technology module (TM)".
7. Select the channel of the incremental encoder from the "Technology module" list under "local modules".

You can learn how to add a technology object in section Add technology object (Page 83).

Result

The analog drive connection and the encoder connection are configured.

The analog addresses and the addresses of the TM module are assigned to the process image "PIP OB Servo".

Checking the encoder connection / drive connection

The encoder data are applied to the position control cycle clock.
If in doubt, check the following settings:

1. Switch to the device view of the PLC.
2. Select the module technology.
3. Open the properties dialog "Basic Parameters > I/O Addresses".
4. The following settings apply for the input and output addresses:
   – "MC Servo" must be select the "Organization block".
   – "PIP OB Servo" must be select the "Process image".
5. Select the analog module.
6. Open the properties dialog "Name of the Analog Module > I/O Addresses".
7. The settings from Step 4 apply for the input and output addresses

See also

Add technology object (Page 83)

5.2 Add technology object

To add a technology object in the project navigator, proceed as follows:

Requirements

A project with a CPU S7-1500 has been created.

Procedure

1. Open the CPU's folder in the project navigator.
2. Open the "Technology Objects" folder.
3. Double-click "Add new object".

   The "Add new object" dialog box opens.
4. Select the "Motion Control" technology.
5. Open the folder "Motion Control" > "SIMATIC S7-1500".
6. If you want to add an axis from an older version, then click on the Version entry and select an alternative version of the technology.
7. Select the "TO_SpeedAxis" object for a speed-controlled axis, "TO_PositioningAxis" for a positioning axis, or "TO_ExternalEncoder" for an external encoder.
8. In the "Name" field, adapt the name of the axis to your requirements.
9. Select the "Manual" option if you want to change the suggested data block number.
10. Click on "Further Information" if you want to add your own information to the technology object.
11. Click on the "OK" button if you want to add the technology object.

    Click on the "Cancel" button if you want to discard the entries.

    Activate the "Add new and open" check box if you want to open the configuration after adding the technology object.

Result

The new technology object was created and saved in the project navigator in the folder "Technology objects".

If the organization blocks "MC Servo" and "MC Interpolator" had not yet been added, they have now been added.

5.3 Working with the configuration editor

You configure the properties of a technology object in the configuration window.
To open the configuration window of the technology object in the project view, follow these steps:

1. Open the device "Technology objects" group in the project navigator.
2. Select the technology object and double-click on "Configuration".

The configuration is divided into categories which depend on the object type, for example: Basic parameters, hardware interface, extended parameters.

Configuration editor icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values you can use the technology object without additional changes.
	The configuration contains values set by the user and is complete. All input fields of the configuration contain valid values and at least one preset value has changed.
	The configuration is incomplete or incorrect At least one input field or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the field shows you the roll-out error message that indicates the cause of error.

5.4 Configuring the Positioning Axis technology object

5.4.1 Configuration - Basic Parameters

Axis name

Define the name of the positioning axis in this field. The technology object is listed in the project navigation under this name. The tags of the positioning axis can be used in the user program under this name.

Axis type

In this selection, configure whether the axis should perform linear or rotary motions.

User unit

In the drop-down list, select the desired measurement system for the position and velocity of the axis.

Modulo

Select the check box "Enable modulo", if you want to employ a recurring unit of measure for the axis (e.g. 0-360° for an axis of the "rotary" axis type).

- Start value

  In this field, define the position at which the modulo range should begin (e.g. 360° for an axis of the "rotary" axis type).

- Length

  In this field, define the length of the modulo range (e.g. 360° for an axis of the "rotary" axis type).

5.4.2 Hardware interface

5.4.2.1 Configuration - Drive

In the "Drive" configuration window, configure which drive type and which drive you want to use.

Drive type

In the drop-down list, select whether you want to deploy a PROFIdrive drive or a drive with an analog drive connection.

PROFIdrive drives are connected to the controller by means of a digital communication system (PROFINET or PROFIBUS). The communication occurs via PROFIdrive frames.

Drives with an analog drive connection receive the setpoint speed via an analog output signal (e.g. from -10 V to +10 V) from the PLC.

Drive (drive type: PROFIdrive)

In the "Drive" field, select an already configured PROFIdrive drive / slot. If a PROFIdrive drive was selected, then it can be configured using the "Device configuration" button.

Switch to the device configuration, and add a PROFIdrive drive in the network view, in the event that no PROFIdrive drive can be selected.

Drive (drive type: Analog drive connection)

In the "Output" field, select the PLC tag of the analog output over which the drive is to be controlled. If an output was selected, then it can be configured using the "Device configuration" button.

In order to be able to select an output, an analog output module must have been added in the device configuration, and the PLC tag name for the analog output must be defined.

Activate enable output (drive type: Analog drive connection)

In the "Enable output" field, select the PLC tag of the digital output for the enablement of the drive. With the enable output, the speed controller in the drive is enabled, or disabled.

In order to be able to select an enable output, a digital output module must have been added in the device configuration, and the PLC tag name for the digital output must be defined.

Note

If you do not use an enable output, the drive cannot be immediately disabled on the part of the system due to error responses or monitoring functions. A controlled stop of the drive is not guaranteed.

Enable ready input (drive type: Analog drive connection)

In the "Ready input" field, select the PLC tag of the digital input with which the drive is to report its operational readiness to the technology object. The power unit is switched on and the analog setpoint speed input is enabled.

In order to be able to select a ready input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Note

The enable output and the ready input can be separately enabled.

The following conditions apply to the enabled ready input:

- The axis is not enabled (MC_Power Status=TRUE), until a signal is pending at the ready input.
- If the signal at the ready input goes away for an enabled axis, then the axis is disabled with an error.
- If the axis is disabled with the instruction MC_Power (Enable= FALSE), then the axis is disabled even with a pending signal at the ready input.

5.4.2.2 Configuration - Encoder

For position control, positioning axes require an actual position value in the form of an encoder position. The encoder position is transmitted to the controller by means of a PROFIdrive message frame. In the "Encoder" configuration window, configure the encoder coupling with which the encoder is to be connected.

Select encoder coupling:

In this area, select according to the graphical representation, how the encoder is to be connected.

- Connection to drive (not with analog drive connection)

  Select this option, if the encoder is connected to the drive. The configuration of the encoder occurs via the configuration of the PROFIdrive drive. The drive evaluates the encoder signals, and sends them in the PROFIdrive message frame to the controller.

- Connection via technology module (TM)

  Select this option, if the encoder is connected to a technology module (TM).

  – Technology module:

    In the "Technology module" field, select a technology module that has already been configured, and the channel to be used. If a technology module was selected, then it can be configured using the "Device configuration" button.

    Switch to the device configuration, and add a technology module, in the event that no technology module can be selected. The technology module can be driven centrally on a S7-1500 PLC, or decentrally on a distributed I/O. To connect an incremental encoder use the technology module Count2x24V, and to connect an absolute value encoder use the technology module TM PosInput2.

- Connection via PROFINET/PROFIBUS (PROFIdrive)

  Select this option, if you are deploying a PROFIdrive compatible encoder.

  – Encoder selection:

    In the "Encoder selection" field, select an already configured encoder on PROFINET/PROFIBUS. If an encoder was selected, then it can be configured using the "Device configuration" button.

    Switch to the device configuration in the network view, and add an encoder, in the event that no encoder can be selected.

5.4.2.3 Configuration - Data exchange

Configuration - Data exchange

In the "Data exchange" configuration window, you can configure the data exchange of the drive and the encoder. The configuration varies according to the drive type and encoder coupling:

Analog driver connection - Encoder to technology module (TM) (Page 89)

Analog driver connection - PROFIdrive encoder on PROFINET/PROFIBUS (Page 92)

PROFIdrive Drive - Encoder to Drive (Page 94)

PROFIdrive drive - Encoder on the technology module (TM) (Page 96)

PROFIdrive drive - PROFIdrive encoder on PROFINET/PROFIBUS (Page 98)

Analog driver connection - Encoder to technology module (TM)

Data exchange drive

In this area, you can configure the data exchange for the drive.

- Message frame:

  Since the analog drive is controlled via an analog signal, the selection of the message frame type is omitted.

- Reference speed:

  The reference speed of the drive is the speed, with which the drive spins when there is an output of 100% at the analog output. The reference speed must be configured in the drive, and transferred into the configuration of the technology object.

  The analog value that is output at 100% depends on the type of the analog output. As an example, with an analog output with +/- 10 V, the value 10 V is output at 100%.

  Analog outputs can be overloaded by about 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

- Maximum speed

  In this field, specify the maximum speed of the drive.

- Inverting the direction

  Enable the check box if the rotation direction of the drive should be inverted.

Data exchange encoder

In this area, you can configure how the encoder data are to be evaluated.
The data must match the data in the device configuration.

- **Message frame:**

  The encoder data are transmitted with the drive message frame.
  Therefore no message frame selection is available.

- **Encoder type:**

  Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

Analog driver connection - PROFIdrive encoder on PROFINET/PROFIBUS

Data exchange drive

In this area, you can configure the data exchange for the drive.

- Message frame:

  Since the analog drive is controlled via an analog signal, the selection of the message frame type is omitted.

- Reference speed:

  The reference speed of the drive is the speed, with which the drive spins when there is an output of 100% at the analog output. The reference speed must be configured in the drive, and transferred into the configuration of the technology object.

  The analog value that is output at 100% depends on the type of the analog output. As an example, with an analog output with +/- 10 V, the value 10 V is output at 100%.

  Analog outputs can be overloaded by about 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

- Maximum speed

  In this field, specify the maximum speed of the drive.

- Inverting the direction

  Enable the check box if the rotation direction of the drive should be inverted.

Data exchange encoder

In this area, you can configure the encoder message frame and the criteria for how the encoder data are to be evaluated. The data must match the data in the device configuration.

- Message frame:

  In the drop-down list, select the message frame of the encoder.
  The data must match the configuration in the device configuration.

- Encoder type:

  Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (Gn_XIST2)	In this field, configure the number of bits for fine resolution within the absolute actual value (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (Gn_XIST2)	In this field, configure the number of bits for fine resolution within the absolute actual value (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

PROFIdrive Drive - Encoder to Drive

Data exchange drive

In this area, you can configure the data exchange for the drive.

- **Message frame:**

  In the drop-down list, select the message frame to the drive.
  The data must match the configuration in the device configuration.

- **Reference speed:**

  In this field, configure the reference speed of the drive in accordance with the manufacturer's specifications. The specification of the drive's speed occurs as a percentage of the reference speed in the range from -200% to 200%.

- **Maximum speed**

  In this field, specify the maximum speed of the drive.

- **Inverting the direction**

  Enable the check box if the rotation direction of the drive should be inverted.

Data exchange encoder

In this area, you can configure how the encoder data are to be evaluated.
The data must match the data in the device configuration.

- **Message frame:**

  The encoder data are transmitted with the drive message frame.
  Therefore no message frame selection is available.

- **Encoder type:**

  Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.

Encoder type	Rotary absolute
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

PROFIdrive drive - Encoder on the technology module (TM)

Data exchange drive

In this area, you can configure the data exchange for the drive.

- **Message frame:**

  In the drop-down list, select the message frame to the drive.
  The data must match the configuration in the device configuration.

- **Reference speed:**

  In this field, configure the reference speed of the drive in accordance with the manufacturer's specifications. The specification of the drive's speed occurs as a percentage of the reference speed in the range from -200% to 200%.

- **Maximum speed**

  In this field, specify the maximum speed of the drive.

- **Inverting the direction**

  Enable the check box if the rotation direction of the drive should be inverted.

Data exchange encoder

In this area, you can configure how the encoder data are to be evaluated.
The data must match the data in the device configuration.

- **Message frame:**

  The encoder data are transmitted with the drive message frame.
  Therefore no message frame selection is available.

- **Encoder type:**

  Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.

Encoder type	Rotary absolute
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

PROFIdrive drive - PROFIdrive encoder on PROFINET/PROFIBUS

Data exchange drive

In this area, you can configure the data exchange for the drive.

- **Message frame:**

  In the drop-down list, select the message frame to the drive.
  The data must match the configuration in the device configuration.

- **Reference speed:**

  In this field, configure the reference speed of the drive in accordance with the manufacturer's specifications. The specification of the drive's speed occurs as a percentage of the reference speed in the range from -200% to 200%.

- **Maximum speed**

  In this field, specify the maximum speed of the drive.

- **Inverting the direction**

  Enable the check box if the rotation direction of the drive should be inverted.

Data exchange encoder

In this area, you can configure the encoder message frame and the criteria for how the encoder data are to be evaluated. The data must match the data in the device configuration.

- **Message frame:**

  In the drop-down list, select the message frame of the encoder.
  The data must match the configuration in the device configuration.

- **Encoder type:**

  Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.

Encoder type	Rotary absolute
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

5.4.3 Extended Parameters

5.4.3.1 Configuration - Mechanics

Configuration - Mechanics

In the "Mechanics" configuration window, you can configure the mounting type of the encoder, and the adaptation of the encoder value to the mechanical conditions.

Type of encoder mounting

In the drop-down list, select how the encoder is mounted on the mechanism.
The configuration varies depending on the axis type and the type of encoder mounting.

Axis type: Linear

Linear - On the motor shaft (Page 100)

Linear - On the motor side (Page 101)

Linear - External Measuring System (Page 101)

Axis type: Rotary

Rotary - On the motor shaft (Page 102)

Rotary - On the load side (Page 102)

Rotary - External Measuring System (Page 103)

Linear - On the motor shaft

The encoder is firmly mechanically connected with the motor shaft.
Motor and encoder form a unit.

Load gear

- **Consider load gear / leadscrew pitch**

  Activate the check box, if you want to perform the configuration based on the gear ratio and the leadscrew pitch.

  Deactivate the check box, if you want to perform the configuration based on the motor revolution and the resulting distance.

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

Position parameter

- **Leadscrew pitch ("Consider load gear / leadscrew pitch" enabled)**

  In this field, configure the distance by which the load is moved when the leadscrew makes one revolution.

- **Load motion per motor revolution**

  In this field, configure the load distance for one motor revolution ("Consider load gear / leadscrew pitch" disabled):

Linear - On the motor side

The encoder is mechanically connected with the load side of the gear.

Load gear

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Position parameter

- **Leadscrew pitch**

  In this field, configure the distance by which the load is moved when the leadscrew makes one revolution.

Linear - External Measuring System

An external measuring system provides the position values of the linear load motion.

Load gear

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Position parameter

- **Load motion per motor revolution**

  In this field, configure the distance by which the load is moved when the motor makes one revolution.

- **Distance per encoder revolution**

  In this field, configure the distance recorded by the external measuring system per encoder revolution.

Rotary - On the motor shaft

The encoder is firmly mechanically connected with the motor shaft.
Motor and encoder form a unit.

Load gear

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Rotary - On the load side

The encoder is mechanically connected with the load side of the gear.

Load gear

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Rotary - External Measuring System

An external measuring system provides the position values of the rotary load motion.

Load gear

- **Number of motor revolutions / number of load revolutions**

  The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Position parameter

- **External measuring system**

  In this field, configure the value indicated by the external measuring system per load revolution.

5.4.3.2 Configuration - Position monitoring

Configure the hardware and software limit switches of the axis in the "Position monitoring" configuration window.

Enable hardware limit switches

The check box activates the function of the negative and positive hardware limit switches. The negative hardware limit switch is located on the side in the negative direction of travel, and the positive hardware limit switch on the side in the positive direction of travel.

With enabled hardware limit switches, the drive is disabled when the hardware limit switch is approached or overshot. The drive brakes with the braking ramp configured in the drive.

Exception: If a hardware limit switch is overshot during an active home position approach with activated direction reversal at the hardware limit switch, then the axis stops with the configured maximum deceleration, and continues the home position approach in the opposite direction.

Note

Only use hardware limit switches that remain permanently switched after the approach. This switch state may only be canceled after the return into the permitted traversing range.

The digital inputs of the hardware limit switch are evaluated by default in cyclical data exchange. In the settings for the input module under "I/O addresses", select the entry "MC-Servo" for "Organization block" and the entry "PIP OB servo" for "Process image" if the hardware limit switches are to be evaluated in the position control cycle of the drive.

Negative / positive HW limit switch input

In these fields, select the PLC tags of the digital input for the negative and positive HW limit switches.

In order to be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

CAUTION

During installation of hardware limit switches, attention must be paid to the filter times of the digital inputs

Based on the time for a servo clock cycle and the filter time of the digital inputs, the resulting delay times must be taken into account.

The filter time is configurable in individual digital input modules in the device configuration.

The digital inputs are set to a filter time of 6.4 ms by default. If these are used as hardware limit switches, undesired decelerations may occur. If this occurs, reduce the filter time for the relevant digital inputs.

The filter time can be set under "Input filter" in the device configuration of the digital inputs.

Signal level selection

Select the triggering signal level ("Lower level" / "Upper level") of the hardware limit switch. At "Lower level", the input signal is FALSE after the axis has reached or passed the hardware limit switch. At "Upper level", the input signal is TRUE after the axis has reached or passed the hardware limit switch.

Enable software limit switches

This check box activates the upper and lower software limit switches. An active motion is stopped after the axis has reached a position of the software limit switch. The technological object reports a fault. After acknowledging the error, the axis can again be moved in the direction of its working range.

Note

Enabled software limit switches only affect a homed axis.

Lower / upper SW limit switch input

Configure the operating range of the axis using the positions of the lower and upper software limit switches.

5.4.3.3 Configuration - Dynamic limits

In the "Dynamic limits" configuration window, configure the maximum values for velocity, acceleration, deceleration and jerk of the axis.

Maximum velocity

In this field, define the maximum permitted velocity of the axis.

Maximum acceleration / maximum deceleration - ramp-up time / ramp-down time

Set the desired acceleration in the "Ramp-up time" or "Acceleration" fields.
The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The relationship between ramp-up time and acceleration, and ramp-down time and deceleration can be seen in the following equations:

$$\text{Ramp-up time} = \frac{\text{Maximum velocity}}{\text{Acceleration}}$$

$$\text{Ramp-down time} = \frac{\text{Maximum velocity}}{\text{Deceleration}}$$

Note

A change in the maximum velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

The "maximum deceleration" for active homing with change of direction at the hardware limit switch must be set sufficiently large, to brake the axis before reaching the mechanical endstop.

Minimum smoothing time / maximum jerk

You can enter the jerk limit parameter in the "Minimum smoothing time" field, or alternatively in the "Maximum jerk" field:

- Set the desired jerk for the acceleration ramp and the deceleration ramp in the "Maximum jerk" field. The value 0 means that the jerk is unlimited.
- Set the desired smoothing time for the acceleration ramp in the "Minimum smoothing time" field.

Note

The configured smoothing time, which is displayed in the configuration, applies only to the acceleration ramp.

In the event that the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated according to the jerk of the acceleration ramp, and used.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**
  A smaller smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration < Deceleration**
  A larger smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration = Deceleration**
  The smoothing times of the acceleration ramp and the deceleration ramp are the same.

In the event of an error, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Rounding off time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Step}}$$

$$\text{Rounding off time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Step}}$$

Motion jobs initiated in the user program are executed with the selected jerk.

5.4.3.4 Configuration - Dynamic Defaults

In the "Dynamic defaults" configuration window, configure the default values for velocity, acceleration, deceleration and jerk of the axis.

The default values have an effect, when values < 0 are specified in Motion Control instructions for the "Velocity", "Acceleration", "Deceleration" or "Jerk" parameters. The default values can be applied separately for each of the parameters just listed.

The default values for acceleration and deceleration additionally have an effect on the traversing motions of active homing.

Velocity

In this field, define the default value for the velocity of the axis.

Acceleration / deceleration - ramp-up time / ramp-down time

Set the desired default value for acceleration in the "Ramp-up time" or "Acceleration" fields. The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The relationship between ramp-up time and acceleration, and ramp-down time and deceleration can be seen in the following equations:

$$\textit{Ramp-up time} = \frac{\textit{Velocity}}{\textit{Acceleration}}$$

$$\textit{Ramp-down time} = \frac{\textit{Velocity}}{\textit{Deceleration}}$$

Note

A change in the velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Smoothing time / jerk

You can enter the jerk limit parameter in the "Smoothing time" field, or alternatively in the "Jerk" field:

- Set the desired jerk for the acceleration ramp and the deceleration ramp in the "Jerk" field. The value 0 means that the jerk is disabled.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The configured smoothing time, which is displayed in the configuration, applies only to the acceleration ramp.

In the event that the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated according to the jerk of the acceleration ramp, and used.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**
  A smaller smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration < Deceleration**
  A larger smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration = Deceleration**
  The smoothing times of the acceleration ramp and the deceleration ramp are the same.

In the event of an error, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Rounding off time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Step}}$$

$$\text{Rounding off time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Step}}$$

Motion jobs initiated in the user program are executed with the selected jerk.

5.4.3.5 Configuration - Emergency stop

In the "Emergency stop" configuration window, you can configure the emergency stop deceleration of the axis. In the event of an error, and when disabling the axis, the axis is brought to a standstill with this deceleration using the Motion Control instruction "MC_Power" (input parameter StopMode = 0).

Emergency stop deceleration

Configure the deceleration value for emergency stop in the "Emergency stop deceleration" field or the "Emergency stop ramp-down time" field.

The relationship between emergency stop ramp-down time and emergency stop deceleration can be seen in the following equation:

$$\textit{Emergency stop ramp-down time} = \frac{\textit{Maximum velocity}}{\textit{Emergency stop deceleration}}$$

The configuration of the emergency stop deceleration is related to the configured maximum velocity of the axis. If the maximum velocity of the axis changes, then the value of the emergency stop deceleration also changes (the emergency stop ramp-down time remains unchanged).

5.4.3.6 Homing

Homing means matching the position value of a technology object to the real, physical location of the drive. Absolute positions on the axis can only be approached with a homed axis.

In S7-1500 Motion Control, axis homing is implemented with the Motion Control instruction, "MC_Home". A distinction is made between the following operation modes of the Motion Control instruction:

Operation modes of the Motion Control instruction "MC_Home"

- Active homing

  In active homing mode, the Motion Control instruction "MC_Home" performs the configured home position approach. Active traversing motions are aborted. When the reference mark is detected, the position of the axis is set according to the configuration.

- Passive homing

  During passive homing, the motion control instruction "MC_Home" does not carry out any homing motion. The traversing motion required for this step must be implemented by the user via other motion control instructions. Active traversing motions are not aborted upon start of passive homing. When the reference mark is detected, the axis is set according to the configuration.

- Direct homing absolute

  The axis position is set regardless of the homing switch. Active traversing motions are not aborted. The value of input parameter "Position" of motion control instruction "MC_Home" is set immediately as the reference point of the axis.

- Direct homing relative

  The axis position is set regardless of the homing switch. Active traversing motions are not aborted. The following statement applies to the axis position after homing:

  New axis position = current axis position + value of parameter "Position" of instruction "MC_Home".

Active homing

Configuration - Active homing

Configure the parameters for active homing in the "Active Homing" configuration window. "Active Homing" is performed using the Motion Control instruction "MC_Home" Mode = 4 and 5.

Select the Homing Mode

Select from among the following homing modes:

Zero mark via PROFIdrive frame and proximity switch (Page 111)

Zero mark via PROFIdrive frame (Page 112)

Reference mark via digital input (Page 113)

Zero mark via PROFIdrive frame and proximity switch

Enable direction reversal at the hardware limit switch

Activate this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and then reversed.
The proximity switch is then sought in the reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Approach direction

Select the approach direction for seeking the proximity switch.

"Positive" is the approach direction in the direction of positive position values; "negative" in the direction of negative position values.

Homing direction

Select the direction in which the zero mark should be approached for homing.

Approach velocity

In this field, specify the velocity at which the proximity switch is sought during the home position approach. A possibly configured home position offset is traversed with the same velocity.

Homing velocity

In this field, specify the velocity at which the axis approaches the zero mark for homing. For zero mark detection, the proximity switch must be exited.

Home position offset

In the case of a differing zero mark position and home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

Zero mark via PROFIdrive frame

Enable direction reversal at the hardware limit switch

Activate this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and then reversed. The zero mark is then sought in the reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Homing direction

Select the direction in which the next zero mark should be approached for homing.

"Positive" is the homing direction in the direction of positive position values; "negative" in the direction of negative position values.

Approach velocity

In the "Zero mark via PROFIdrive frame" homing mode, the approach velocity for traversing the home position offset is used.

Homing velocity

In this field, specify the velocity at which the axis approaches the zero mark for homing.

Home position offset

In the case of a differing zero mark position and home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

Reference mark via digital input

If a digital input is used as a reference mark, then the accuracy of the homing process is not as high as with hardware-supported homing using zero marks.

You can improve the accuracy by using a low homing velocity and a timer-supported input module.

Pay attention to the setting of short filter times at the digital input as well.

Digital input

In this field, select the PLC tag of the digital input, which should act as a reference mark (reference cam).

In order to be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Enable direction reversal at the hardware limit switch

Activate this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and then reversed.
The home position switch is then sensed in reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Approach direction

Select the approach direction for seeking the reference mark.

"Positive" is the approach direction in the direction of positive position values; "negative" in the direction of negative position values.

Homing direction

Select the direction in which the reference mark should be approached for homing.

Reference mark

Select which switch position of the "digital input" is to be used as reference mark.

When a "digital input" is overshot, two switch edges are generated, which are spatially separated. The selection of the positive or negative side ensures that the reference mark is always evaluated based on the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Approach velocity

In this field, specify the velocity at which the "digital input" should be sought during the home position approach. A possibly configured home position offset is traversed with the same velocity.

Homing velocity

In this field, specify the velocity at which the axis approaches the home position for homing.

Home position offset

In the case of a differing switch position and home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

Passive homing

Configuration - Passive homing

Configure the parameters for passive homing in the "Passive Homing" (homing on the fly) configuration window. The homing function "Passive Homing" is performed using the Motion Control instruction "MC_Home" Mode = 2 and 3.

Select the Homing Mode

Select from among the following homing modes:

Zero mark via PROFIdrive frame and proximity switch (Page 115)

Zero mark via PROFIdrive frame (Page 116)

Reference mark via digital input (Page 116)

Zero mark via PROFIdrive frame and proximity switch

Homing direction

Select the direction in which the zero mark should be approached for homing.
The next zero mark after exiting the proximity switch is used.

The following options are available:

- Positive

  Axis moves in the direction of higher position values.

- Negative

  Axis moves in the direction of lower position values.

- Current

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

Zero mark via PROFIdrive frame

Homing direction

Select the direction in which the next zero mark should be approached for homing.
The following options are available:

- Positive

  Axis moves in the direction of higher position values.

- Negative

  Axis moves in the direction of lower position values.

- Current

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

Reference mark via digital input

Digital input

In this dialog field, select a digital input, which should act as a reference mark (reference cam).

Homing direction

Select the direction in which the reference mark should be approached for homing.

The following options are available:

- Positive

  Axis moves in the direction of higher position values.

- Negative

  Axis moves in the direction of lower position values.

- Current

  The currently effective approach direction is used for homing.

Reference mark

Select which switch position of the "digital input" is to be used as reference mark.

When a "digital input" is overshot, two switch edges are generated, which are spatially separated. The selection of the positive or negative side ensures that the reference mark is always evaluated based on the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

5.4.3.7 Position monitoring

Configuration - Positioning monitoring

In the "Positioning Monitoring" configuration window, configure the criteria for monitoring the target position.

Positioning window:

In this field, configure the size of the positioning window. If the axis is located within this window, then the position is considered to be "reached".

Positioning tolerance time:

In this field, configure the tolerance time, in which the position value must reach the positioning window.

Minimum dwell time in the positioning window:

In this field, configure the minimum dwell time. The current position value must be located in the positioning window for at least the "minimum dwell time".

If one of the criteria is violated, then the axis is stopped and a positioning alarm is displayed.

Configuration - Following error

In the "Following Error" configuration window, configure the permissible deviation of the actual position of the axis from the setpoint position. The following error can be dynamically adapted to the current velocity of the axis.

Enable following error monitoring

Activate this check box, if you want to enable following error monitoring. When following error monitoring is enabled, the axis will be stopped in the error range (orange); in the warning range an alarm will be displayed.

When following error monitoring is disabled, the configured limits have no effect.

Maximum following error:

In this field, configure the following error that is permissible at maximum velocity.

Warning level:

In this field, configure a percentage of the current following error limit, above which a following error warning should be output.

Example: The current maximum following error is 100 mm; the warning level is configured at 90%. If the current following error exceeds a value of 90 mm, then a following error warning will be output.

Following error:

In this field, configure the permissible following error for low velocities (without dynamic adaptation).

Beginning of dynamic adaptation:

In this field, configure the velocity above which the following error should be dynamically adapted. Above this velocity the following error will be adapted up to the maximum following error at the maximum velocity.

Configuration - Standstill signal

In the "Standstill Signal" configuration window, configure the criteria for standstill detection.

Standstill window:

In this field, configure the size of the standstill window. For standstill to be indicated, the velocity of the axis must be within this window.

Minimum dwell time in the standstill window:

In this field, configure the minimum dwell time in the standstill window.
The velocity of the axis must also be in the standstill window for the specified duration.

If both criteria are met, then the standstill of the axis is indicated.

5.4.3.8 Configuration - Control loop

In the "Control Loop" configuration window, configure the gain Kv of the position control loop.

The Kv factor affects the following parameters:

- Positioning accuracy and stop control
- Uniformity of motion
- Positioning time

The better the mechanical conditions of the axis are (high stiffness), the higher the Kv factor can be configured. This reduces the following error, and a higher dynamic response is achieved.

For basic information, refer to the section " Function and structure of the optimization (Page 176) ".

Gain

In the input field, enter the gain Kv of the control loop.

Dynamic Servo Control (DSC):

For position-controlled axes (positioning axes), the position control can occur either in the CPU or in the drive, provided the drive supports the Dynamic Servo Control (DSC) control process. Select your preferred control process:

- **Position and speed control in the drive (DSC enabled)**
- **Position and speed control in the PLC**

Note

Dynamic Servo Control (DSC) is only possible with standard frame 5.

5.5 Configuring the Speed-Control Axis technology object

5.5.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Axis name

Define the name of the speed-controlled axis in this field. The technology object is listed in the project navigation under this name. The tags of the speed-controlled axis can be used in the user program under this name.

User unit

Select the measuring system for speed from the drop-down list box.

5.5.2 Hardware interface

5.5.2.1 Configuration - Drive

In the "Drive" configuration window, configure which drive type and which drive you want to use.

Drive type

In the drop-down list, select whether you want to deploy a PROFIdrive drive or a drive with an analog drive connection.

PROFIdrive drives are connected to the controller by means of a digital communication system (PROFINET or PROFIBUS). The communication occurs via PROFIdrive message frames.

Drives with an analog drive connection receive the setpoint speed via an analog output signal (e.g. from -10 V to +10 V) from the PLC.

Drive (drive type: PROFIdrive)

In the "Drive" field, select an already configured PROFIdrive drive / slot. If a PROFIdrive drive was selected, then it can be configured using the "Device configuration" button.

Switch to the device configuration, and add a PROFIdrive drive in the network view, in the event that no PROFIdrive drive can be selected.

Output (drive type: Analog drive connection)

In the "Output" field, select the PLC tag of the analog output over which the drive is to be controlled. If an output was selected, then it can be configured using the "Device configuration" button.

In order to be able to select an output, an analog output module must have been added in the device configuration, and the PLC tag name for the analog output must be defined.

Activate enable output (drive type: Analog drive connection)

In the "Enable output" field, select the PLC tag of the digital output for the enablement of the drive. With the enable output, the speed controller in the drive is enabled, or disabled.

In order to be able to select an enable output, a digital output module must have been added in the device configuration, and the PLC tag name for the digital output must be defined.

Note

If you do not use an enable output, the drive cannot be immediately disabled on the part of the system due to error responses or monitoring functions. A controlled stop of the drive is not guaranteed.

Enable ready input (drive type: Analog drive connection)

In the "Ready input" field, select the PLC tag of the digital input with which the drive is to report its operational readiness to the technology object. The power unit is switched on and the analog setpoint speed input is enabled.

In order to be able to select a ready input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Note

The enable output and the ready input can be separately enabled.

The following conditions apply to the enabled ready input:

- The axis is not enabled (MC_Power Status=TRUE), until a signal is pending at the ready input.
- If the signal at the ready input goes away for an enabled axis, then the axis is disabled with an error.
- If the axis is disabled with the instruction MC_Power (Enable= FALSE), then the axis is disabled even with a pending signal at the ready input.

See also

Configuration - Data Transmission (Page 122)

5.5.2.2 Configuration - Data Transmission

Data transmission to the drive

In this area, you can configure the data transmission to the drive.

Message frame type (drive type PROFIdrive)

In the drop-down list, select the message frame to the drive.
The data must match the configuration in the device configuration.

Reference speed (drive type PROFIdrive)

In this field, configure the reference speed of the drive in accordance with the manufacturer's specifications. The specification of the drive's speed occurs as a percentage of the reference speed in the range from -200% to 200%.

Reference speed (drive type analog drive connection)

The reference speed of the drive is the speed, with which the drive spins when there is an output of 100% at the analog output. The reference speed must be configured in the drive, and transferred into the configuration of the technology object.

The analog value that is output at 100% depends on the type of the analog output.
As an example, with an analog output with +/- 10 V, the value 10 V is output at 100%.

Analog outputs can be overloaded by about 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

Maximum speed

In this field, specify the maximum speed of the drive.

Inverting the direction

Enable the check box if the rotation direction of the drive should be inverted.

5.5.3 Extended Parameters

5.5.3.1 Configuration - Mechanics

Configure the connection of the load to the drive in the "Mechanics" configuration window.

Use gearbox parameters for calculation

Activate this check box, if you want to take account of a load gear when calculating the load speed.

Number of motor revolutions / number of load revolutions

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

5.5.3.2 Configuration - Dynamic limits

In the "Dynamic limits" configuration window, configure the maximum values for speed, acceleration, deceleration and jerk of the axis.

Maximum speed

In this field, define the maximum permitted speed of the axis.

Maximum acceleration / maximum deceleration - ramp-up time / ramp-down time

Set the desired acceleration in the "Ramp-up time" or "Acceleration" fields.
The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The relationship between ramp-up time and acceleration, and ramp-down time and deceleration can be seen in the following equations:

$$\textit{Ramp-up time} = \frac{\textit{Maximum velocity}}{\textit{Acceleration}}$$

$$\textit{Ramp-down time} = \frac{\textit{Maximum speed}}{\textit{Deceleration}}$$

Note

A change in the maximum speed influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Minimum smoothing time / maximum jerk

You can enter the jerk limit parameter in the "Minimum smoothing time" field, or alternatively in the "Maximum jerk" field:

- Set the desired jerk for the acceleration ramp and the deceleration ramp in the "Maximum jerk" field. The value 0 means that the jerk is unlimited.
- Set the desired smoothing time for the acceleration ramp in the "Minimum smoothing time" field.

Note

The configured smoothing time, which is displayed in the configuration, applies only to the acceleration ramp.

In the event that the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated according to the jerk of the acceleration ramp, and used.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**
  A smaller smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration < Deceleration**
  A larger smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration = Deceleration**
  The smoothing times of the acceleration ramp and the deceleration ramp are the same.

In the event of an error, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Rounding off time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Step}}$$

$$\text{Rounding off time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Step}}$$

Motion jobs initiated in the user program are executed with the selected jerk.

5.5.3.3 Configuration - Dynamic Defaults

In the "Dynamic defaults" configuration window, configure the default values for speed, acceleration, deceleration and jerk of the axis.

The default values have an effect, when values < 0 are specified in Motion Control instructions for the "Velocity", "Acceleration", "Deceleration" or "Jerk" parameters. The default values can be applied separately for each of the parameters just listed.

Velocity

In this field, define the default value for the speed of the axis.

Acceleration / deceleration - ramp-up time / ramp-down time

Set the desired default value for acceleration in the "Ramp-up time" or "Acceleration" fields. The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The relationship between ramp-up time and acceleration, and ramp-down time and deceleration can be seen in the following equations:

$$\text{Ramp-up time} = \frac{\text{Speed}}{\text{Acceleration}}$$

$$\text{Ramp-down time} = \frac{\text{Speed}}{\text{Deceleration}}$$

Note

A change in the velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Smoothing time / jerk

You can enter the jerk limit parameter in the "Smoothing time" field, or alternatively in the "Jerk" field:

- Set the desired jerk for the acceleration ramp and the deceleration ramp in the "Jerk" field. The value 0 means that the jerk is disabled.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The configured smoothing time, which is displayed in the configuration, applies only to the acceleration ramp.

In the event that the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated according to the jerk of the acceleration ramp, and used.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**
  A smaller smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration < Deceleration**
  A larger smoothing time is employed for the deceleration ramp, than for the acceleration ramp.
- **Acceleration = Deceleration**
  The smoothing times of the acceleration ramp and the deceleration ramp are the same.

In the event of an error, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Rounding off time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Step}}$$

$$\text{Rounding off time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Step}}$$

Motion jobs initiated in the user program are executed with the selected jerk.

5.5.3.4 Configuration - Emergency stop ramp

In the "Emergency stop ramp" configuration window, you can configure the emergency stop deceleration of the axis. In the event of an error, and when disabling the axis, the axis is brought to a standstill with this deceleration using the Motion Control instruction "MC_Power" (input parameter StopMode = 0).

Emergency stop deceleration

Configure the deceleration value for emergency stop in the "Emergency stop deceleration" field or the "Emergency stop ramp-down time" field.

The relationship between emergency stop ramp-down time and emergency stop deceleration can be seen in the following equation:

$$\textit{Emergency stop ramp-down time} = \frac{\textit{Maximum speed}}{\textit{Emergency stop deceleration}}$$

The configuration of the emergency stop deceleration is related to the configured maximum speed of the axis. If the maximum speed of the axis changes, then the value of the emergency stop deceleration also changes (the emergency stop ramp-down time remains unchanged).

5.6 Configuring the External Encoder technology object

5.6.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name of the external encoder

Define the name of the external encoder in this field. The technology object is listed in the project navigation under this name. The tags of the external encoder can be used in the user program under this name.

Type of the external encoder

In this selection, configure whether the external encoder records linear or rotary motions.

User unit

In the drop-down list, select the desired measurement system for the position and velocity of the external encoder.

Modulo

Select the check box "Activate modulo", if you want to employ a recurring unit of measure for the external encoder (e.g. 0-360° for an external encoder of the "rotary" type).

- Start value

  In this field, define at which position the modulo range should begin (e.g. 360° for an external encoder of the "rotary" type).

- Length

  In this field, define the length of the modulo range (e.g. 360° for an external encoder of the "rotary" type).

5.6.2 Hardware interface

5.6.2.1 Configuration - Encoder

The external encoder records the position of an externally controlled drive. The encoder required for this purpose communicates the encoder position to the controller by means of a PROFIdrive frame. In the "Encoder" configuration window, configure the encoder coupling with which the encoder is to be connected.

Select encoder coupling:

In this area, select according to the graphical representation, how the encoder is to be connected.

- Connection via technology module (TM)

  Select this option, if the encoder is connected to a technology module (TM).

  – Technology module:

    In the "Technology module" field, select a technology module that has already been configured, and the channel to be used. If a technology module was selected, then it can be configured using the "Device configuration" button.

    Switch to the device configuration, and add a technology module, in the event that no technology module can be selected. The technology module can be driven centrally on a S7-1500 PLC, or decentrally on a distributed I/O. To connect an incremental encoder use the technology module Count2x24V, and to connect an absolute value encoder use the technology module TM PosInput2.

- Connection via PROFINET/PROFIBUS (PROFIdrive)

  Select this option, if you are deploying a PROFIdrive compatible encoder.

  – Encoder selection:

    In the "Encoder selection" field, select an already configured encoder on PROFINET/PROFIBUS. If an encoder was selected, then it can be configured using the "Device configuration" button.

    Switch to the device configuration in the network view, and add an encoder, in the event that no encoder can be selected.

5.6.2.2 Configuration - Data Transmission

Configuration - Data Transmission

In the "Data transmission" configuration window, configure the data transmission to the encoder. The configuration varies according to the encoder coupling:

Encoder to technology module (Page 130)

Encoder to PROFINET/PROFIBUS (Page 132)

Encoder to technology module

Encoder message frame

In this area, you can configure the encoder message frame and the criteria for how the encoder data are to be evaluated. The data must match the data in the device configuration.

Message frame

In the drop-down list for the technology module, select the message frame that you have configured in the technology module.

Encoder type

In this area, you can configure how the encoder data are to be evaluated.
The data must match the data in the device configuration.

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (Gn_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (Gn_XIST1).
Bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2)	In this field, configure the number of reserved bits for the multiplication factor of the absolute value of the fine resolution (Gn_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

See also

Configuration - Data Transmission (Page 130)

Encoder to PROFINET/PROFIBUS (Page 132)

Encoder to PROFINET/PROFIBUS

Encoder message frame

In this area, you can configure the encoder message frame and the criteria for how the encoder data are to be evaluated. The data must match the data in the device configuration.

Data transmission

In the drop-down list, select the message frame of the encoder.
The data must match the configuration in the device configuration.

Encoder type

Depending on the encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Bits for fine resolution in the incremental actual value (GN_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (GN_XIST1).

Encoder type	Rotary absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (GN_XIST1)	In this field, configure the number of reserved bits for fine resolution within the incremental actual value (GN_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (GN_XIST2).

Encoder type	Rotary cyclic absolute
Steps per revolution:	In this field, configure the number of steps that the encoder resolves per revolution.
Number of revolutions:	In this field, configure the number of revolutions that the absolute value encoder can detect.
Bits for fine resolution in the incremental actual value (GN_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (GN_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (GN_XIST2).

Encoder type	Linear incremental
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (GN_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (GN_XIST1).

Encoder type	Linear absolute
Distance between two increments:	In this field, you can configure the distance between two steps of the encoder.
Bits for fine resolution in the incremental actual value (GN_XIST1)	In this field, configure the number of bits for fine resolution within the incremental actual value (GN_XIST1).
Bits for fine resolution in the absolute actual value (GN_XIST2)	In this field, configure the number of reserved bits for fine resolution within the absolute actual value (GN_XIST2).

Inverting the direction

Select this check box if you would like to invert the actual value of the encoder.

See also

Configuration - Data Transmission (Page 130)

Encoder to technology module (Page 130)

5.6.3 Extended Parameters

5.6.3.1 Configuration - Mechanics

Configuration - Mechanics

Configure the encoder parameters for the position of the externally controlled drive in the "Mechanics" configuration window.

The configuration varies according to the type of encoder:

Linear (Page 134)

Rotary (Page 134)

Linear

Distance between two increments

In this field you can configure the distance between two steps of the incremental encoder or absolute value encoder.

See also

Configuration - Mechanics (Page 134)

Rotary (Page 134)

Rotary

Use gearbox parameters for calculation

Activate this check box, if you want to take account of a load gear when calculating the actual position. Deactivate this check box, if you want to configure the distance per encoder revolution.

Measuring gearbox

- **Number of encoder revolutions / number of load revolutions**

  The gear ratio of the measuring gearbox is specified as the ratio between encoder revolutions and load revolutions. Specify here an integral number of load revolutions and the resulting number of encoder revolutions.

  Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Position parameter

- **Distance per encoder revolution**

  In this field, configure the value indicated by the external measuring system per encoder revolution.

See also

Configuration - Mechanics (Page 134)

Linear (Page 134)

5.6.3.2 Homing

Configuration - Homing

Configure the parameters for homing the external encoder in the "Homing" configuration window. Homing is performed using the Motion Control instruction "MC_Home" Mode = 2 and 3.

Select the Homing Mode

Select from among the following homing modes:

Zero mark via PROFIdrive frame and proximity switch (Page 135)

Zero mark via PROFIdrive frame (Page 136)

Reference mark via digital input (Page 137)

Zero mark via PROFIdrive frame and proximity switch

Homing direction

Select the direction in which the zero mark should be approached for homing. The next zero mark after exiting the proximity switch is used.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

See also

Configuration - Homing (Page 135)

Zero mark via PROFIdrive frame (Page 136)

Reference mark via digital input (Page 137)

Zero mark via PROFIdrive frame

Homing direction

Select the direction in which the next zero mark should be approached for homing.
The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

See also

Configuration - Homing (Page 135)

Zero mark via PROFIdrive frame and proximity switch (Page 135)

Reference mark via digital input (Page 137)

Reference mark via digital input

Digital input

In this dialog field, select a digital input, which should act as a reference mark (reference cam).

Homing direction

Select the direction in which the reference mark should be approached for homing.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Reference mark

Select which switch position of the "digital input" is to be used as reference mark.

When a "digital input" is overshot, two switch edges are generated, which are spatially separated. The selection of the positive or negative side ensures that the reference mark is always evaluated based on the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 3.

See also

Configuration - Homing (Page 135)

Zero mark via PROFIdrive frame (Page 136)

Zero mark via PROFIdrive frame and proximity switch (Page 135)

5.6.3.3 Configuration - Standstill signal

In the "Standstill Signal" configuration window, configure the criteria for standstill detection.

Standstill window:

In this field, configure the size of the standstill window. For standstill to be indicated, the velocity of the external encoder must be within this window.

Minimum dwell time in the standstill window:

In this field, configure the minimum dwell time in the standstill window. The velocity of the external encoder must also be in the standstill window for the specified duration.

If both criteria are met, then the standstill of the external encoder is indicated.

Programming 6

6.1 Introduction

The "Programming" section contains general information on supplying and evaluating the Motion Control instructions and on technology data blocks.

An overview of the Motion Control instructions can be found in the Functions (Page 19) section.

You can transmit jobs to the technology object by means of Motion Control instructions in the user program. You define the job using the input parameters of the Motion Control instructions. The current job status is indicated in the output parameters.

The technology data block is available to you as an additional interface to the technology object. Via your user program, you can access the technology data block's data.

6.2 Technology data block

6.2.1 Introduction

The technology data block represents the technology object and contains all configuration data, setpoint and actual values, and status information of the technology object.
The technology data block is automatically created when the technology object is created.
In your user program you can access the technology data block's data.

A listing and description of the tags can be found in the appendix,
Technology Object Data Block Tags (Page 243).

6.2.2 Evaluating the technology data block

Description

Access to data in the technology data block occurs in accordance with the access to standard data blocks.

Reading values from the technology data block

In your user program you can read actual values (e.g. current position) and status information, or detect error messages in the technology object. When you program a query in your user program (e.g. current velocity), the value is directly read from the technology object.

Reading values from the technology data block takes longer than for other data blocks. If you use these tags several times in a single cycle of your user program, it is recommended to copy the tag values to local tags, and use the local tags in your program.

Writing values to the technology data block

By means of the configuration of the technology object in the TIA Portal, the corresponding data are written to the technology data block. After they have been loaded into the CPU, these data are stored in the CPU on the SIMATIC Memory Card (load memory).

- **Required changes in the technology data block**

  In the following cases, it may be necessary for the user program to write values to the technology data block:

  – Adaptation of the configuration of the technology object (e.g. dynamic limits, software limit switches)

  – Use of overrides

  – Adaptation of position control (e.g. "Kv" parameter)

- **Efficacy of changes in the technology data block**

  Changes to values in the technology data block by the user program can take effect at various points in time. The applicable property of the individual tags can be discerned from their description in the appendix, Technology Object Data Block Tags (Page 243).

  – **Effective immediately:**

    LREAL data type

    (e.g. <TO>.Override.Velocity)

    Value changes take effect immediately when writing these tags. The technology object performs a range check on the written value, and immediately starts using the new value. If range limits are violated when writing, the technology object automatically corrects the values. If the value is below the range, then the value is set to the lower limit of the range; if the range is exceeded, then the value is set to the upper limit of the range. You write changes using direct assignments. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.

    DINT/BOOL data types

    (e.g. <TO>.Senso[n].ActiveHoming.Direction)

    Changes are only permitted in the defined value range. Value changes outside the value range are not applied. If you enter invalid values, the programming error OB (OB 121) is started. You write changes using direct assignments. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.

  – **Effective after restart:**

    (e.g. <TO>.Homing.AutoReversal)

    Since restart-relevant tags have dependencies on other tags, value changes cannot be applied at any arbitrary time. The changes are only used after reinitialization (restart) of the technology object. During a restart the technology object is reinitialized with the data in load memory. You therefore write changes to the starting value in load memory, using the extended instruction "WRIT_DBL" (write to data block in load memory).

    You trigger the restart in your user program using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE. Additional information on a restart can be found in the Restarting Technology Objects (Page 163) section.

Note

Save changes with "WRIT_DBL"

Changes to immediately effective tags are lost on POWER OFF of the CPU, or restart of the technology object.

If changes in the technology data block should also be retained after POWER OFF of the CPU, or restart of the technology object, you must write the changes to the starting value in load memory using the extended instruction "WRIT_DBL".

Note

Using the "READ_DBL" and "WRIT_DBL" data block functions

The "READ_DBL" and "WRIT_DBL" data block functions can only be used on a single tag in conjunction with the tags of the technology. The "READ_DBL" and "WRIT_DBL" data block functions cannot be applied to data structures of the technology object.

Evaluation of data in the isochronous alarm OB

If you want to write the technology data block's data isochronously from a Motion Control clock cycle, there is the option of evaluating these data in the isochronous alarm OB.

For this purpose, assign the same clock cycle source (Page 66) to the isochronous alarm OB, as to the MC_Servo [OB91]. By this means, the isochronous alarm OB is called in each Motion Control clock cycle.

In the isochronous alarm OB, read the necessary data into global tags. Use these global tags for further programming.

6.2.3 Evaluate StatusWord, ErrorWord and WarningWord

Specific status and error information derived from the "StatusWord", "ErrorWord" and "WarningWord" data words can be evaluated symbolically as follows. For consistent evaluation, you should avoid using bit addresses to access these data words in the technology data block. Access to an individual bit in the technology data block only lasts as long as the access to the entire data word.

Copy the required data word as needed into a data structure, and query the individual bits from the data structure.

A description of the data words and the allocation of the individual bits can be found in the appendix, Technology Object Data Block Tags:

- StatusWord (Page 261)
- ErrorWord (Page 263)
- WarningWord (Page 265)

Requirements

The technology object has been created.

Procedure

To evaluate the individual bits in the data word "StatusWord", proceed as follows:

1. Crate a global data structure. Name the data structure, e.g. as "Status".
2. Create a double word (DWORD) in the data structure "Status". Name the data structure, e.g. as "Temp".
3. Create 32 boolean tags in the "Status" data structure. You can obtain a clearer overview by naming the boolean tags as defined for the bits in the technology DB (e.g. name the fifth boolean tag "HomingDone").
4. Copy the tag <TO>.StatusWord as needed from the technology data block to the double word "Temp" in your data structure.
5. Copy the bits of dword "Temp" to the corresponding boolean tags by means of bit access.
6. Use the boolean tags to query the status bits.

Evaluate the "ErrorWord" and "WarningWord" data words as specified in steps 1 to 6.

Example

The following example shows how you can read and save the fifth bit "HomingDone" of the data word "StatusWord":

```
SCL
Status.Temp := <TO>.StatusWord;                          Copy status
                                                         word
Status.HomingDone := Status.Temp.X5;                     Copy individual
                                                         bits per bit
                                                         access
```

```
STL
L <TO>.StatusWord                                        Copy status
                                                         word
T Status.Temp
U Status.Temp.X5                                         Copy individual
                                                         bits per bit
                                                         access
= Status.HomingDone
```

6.2.4 Change restart-relevant data

In order to change restart-relevant data in the technology data block, write to the starting values of the tags in load memory using the extended instruction "WRIT_DBL". In order for the changes to be applied, a restart of the technology object must be performed.

Whether value changes to a tag are restart-relevant, can be discerned from the description of the Tags of the Technology Data Block (Page 243)

Requirements

The technology object has been created.

Procedure

To change restart-relevant data, proceed as follows:

1. Create a data block and fill it with the restart-relevant values, that you want to change in the technology data block. In doing so, the data types must match the tags to be changed.
2. Write the values from your data block to the starting values of the tags of the technology data block in load memory, using the extended instruction "WRIT_DBL".

   If restart-relevant data were changed, this will be indicated in the <TO>.StatusWord.OnlineStartValuesChanged tag of the technology object.
3. Perform a restart of the technology object using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE.

After the restart of the technology object, the new value is transferred into the technology data block in work memory, and is effective.

6.3 Motion Control instructions

6.3.1 Motion Control instruction parameters

Description

When creating your user program, take account of the following explanations of the Motion Control instruction parameters.

Reference to the technology object

The specification of the technology object to the Motion Control instruction occurs as follows:

- **"Axis" parameter**

  In the "Axis" input parameter of a Motion Control instruction, a reference to the technology object is specified, which the corresponding job should use.

Job start and receipt of the input parameters of a Motion Control instruction

When jobs are started, and when changed parameter values are received, a distinction is made between the following Motion Control instructions:

- **Motion Control instructions with "Execute" parameter**

  With a rising edge at the "Execute" parameter, the job is started and the values pending in the input parameters are applied.

  Subsequently changed parameter values are not applied until the next job start.

  Resetting the "Execute" parameter does not end the job, but does have an effect on the indication duration of the job status. As long as "Execute" is set to TRUE, the output parameters will be updated. If "Execute" is reset before the completion of a job, the parameters "Done", "Error" and "CommandAborted" are correspondingly set for only one call cycle.

- **Motion Control instructions with "Enable" parameter**

  The job is started by setting the "Enable" parameter.

  As long as "Enable" = TRUE. the job remains enabled and changed parameter values are immediately applied.

  The job is ended by resetting the "Enable" parameter.

  The input parameters "JogForward" and "JogBackward" of the "MC_MoveJog" Motion Control instruction correspond in their behavior to the "Enable" parameter.

Job status

The following output parameters indicate the status of the job processing:

- **Motion Control instructions with "Done" parameter**

  The normal completion of a job is indicated with parameter "Done" = TRUE.

- **Motion Control instructions without "Done" parameter**

  The achievement of the job target is indicated by means of other parameters (e.g. "Status", "InVelocity"). For more information, refer to the section " Tracking running jobs (Page 152).

- **"Busy" parameter**

  As long as a job is being processed, the parameter "Busy" shows the value TRUE. If a job was ended or aborted, "Busy" shows the value FALSE.

- **"CommandAborted" parameter**

  If a job was aborted by another job, CommandAborted shows the value "TRUE".

- **"Error" parameter**

  If an error occurs in the Motion Control instruction, the "Error" parameter shows the value TRUE. The ErrorID parameter shows the cause of the error.

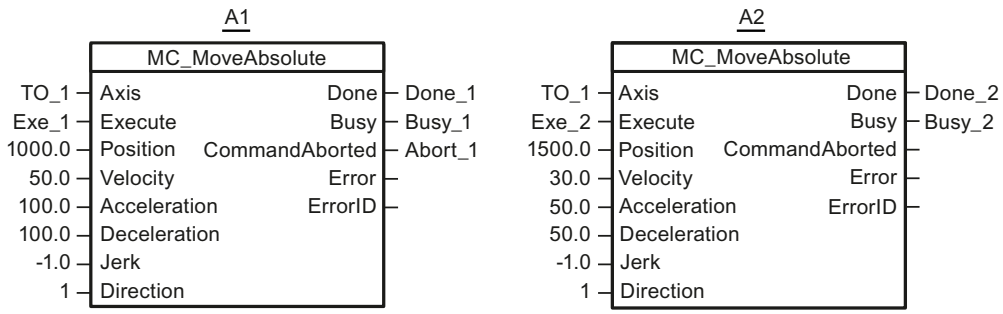
As long as the "Execute" or "Enable" parameter is set to TRUE, the output parameters will be updated. Otherwise the parameters "Done", "Error" and CommandAborted" are correspondingly only set for one cycle.

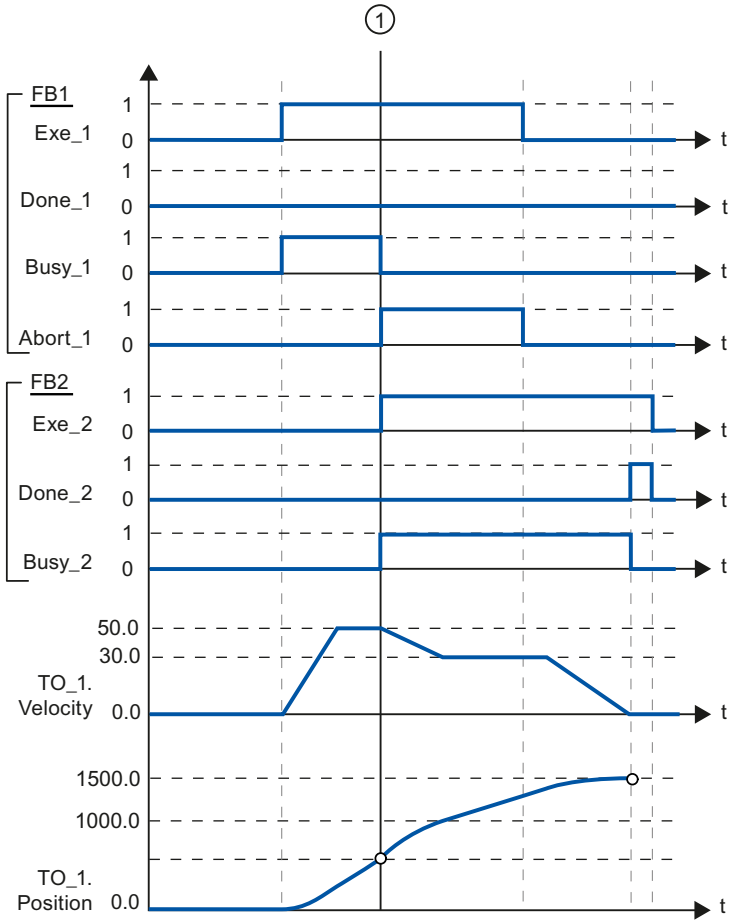
Termination of active jobs

A running Motion Control job is terminated by the initiation of a new Motion Control job. In the process, the current dynamic setpoints (acceleration, deceleration, jerk, velocity) are set to the values of the overriding job.

Example of parameter behavior

The behavior of the parameters of Motion Control instructions is shown by way of the example of two "MC_MoveAbsolute" jobs.





Using "Exe_1", an "MC_MoveAbsolute" job (A1) with target position 1000.0 is initiated. "Busy_1" is set to TRUE. The axis is accelerated to the specified velocity and moved to the target position (see TO_1.Velocity and TO_1.Position). Before the target position is reached, the job is overridden at time ① by another "MC_MoveAbsolute" job (A2). The abort is signaled via "Abort_1", and "Busy_1" is set to FALSE. The axis is braked to the velocity specified in A2, and moved to the new target position 1500.0. When the axis reaches the target position, this is signaled via "Done_2".

6.3.2 Add Motion Control instructions

You add Motion Control instructions to a program block in the same way as other instructions. You control all available functions of the technology object using the Motion Control instructions.

Requirements

The technology object was created.

Procedure

To add Motion Control instructions in your user program, proceed as follows:

1. Double click your program block in the Project Navigator (the program block must be called in the cyclical program).

   The program block is opened in the programming editor, and the available instructions are displayed.

2. In the "Instructions" task card, open the "Technology > Motion Control > S7-1500 Motion Control" folder.

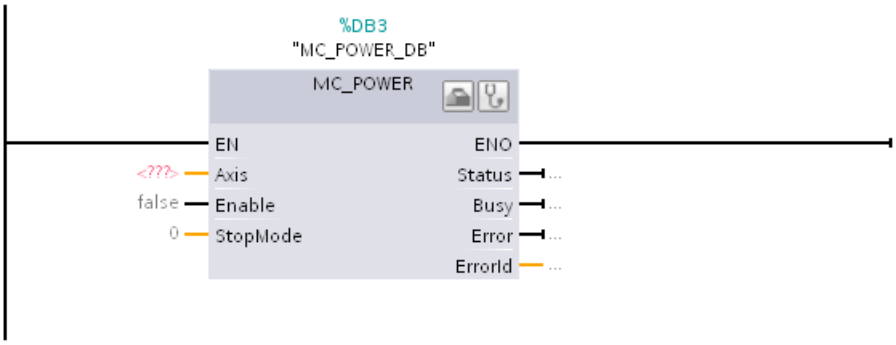
3. Drag and drop the Motion Control instruction, e.g. "MC_Power", into the desired segment of the program block.

   The "Call options" dialog opens.

4. In the dialog, specify a name and a number for the instance data block of the Motion Control instruction.

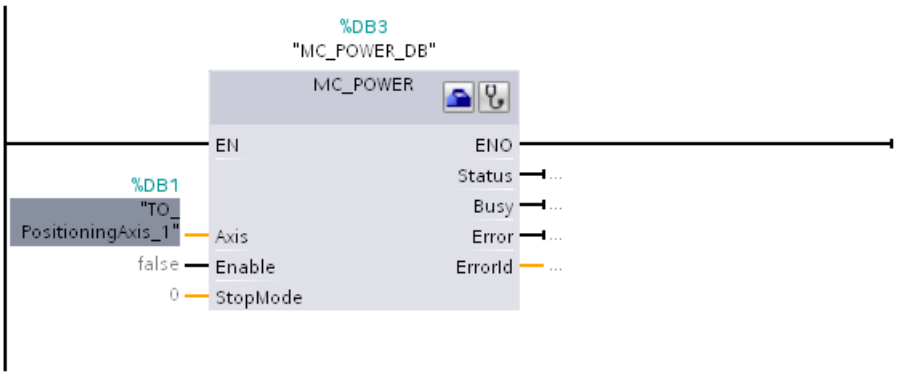
5. Click "OK".

   The Motion Control instruction "MC_Power" is added to the segment.



   The instance data block is automatically created under "Program Blocks > System Blocks > Program Resources".

6. Input parameters without a default value (e.g. "Axis"), must be supplied.
   Mark the technology object in the Project Navigator, and drag and drop it to <...> in the "Axis" parameter.



   After specifying the technology object in the "Axis" parameter, the following buttons are available to you:

   To open the configuration of the technology object, click on the toolbox icon.

   To open the diagnostics of the technology object, click on the stethoscope icon.

7. Add additional Motion Control instructions in accordance with steps 3 through 6.

See also

Tracking active jobs (Page 152)

Technology data block tag (Page 243)

6.4 Starting Motion Control jobs

Description

Motion Control jobs are started by setting the "Execute" or "Enable" parameter of the Motion Control instruction. The call of the Motion Control instructions for a technology object should occur in an execution level.

When executing Motion Control jobs, you should also take note of the status of the technology object.

Starting Motion Control jobs should be performed in the following steps:

1. Query the status of the technology object.
2. Initiate new job for the technology object.
3. Check job status.

These steps are explained using the example of a job for absolute positioning.

1. Query the status of the technology object

Make sure that the technology object is in the appropriate status to perform the desired job:

- **Has the technology object been released?**

  To execute motion jobs, the technology object must be enabled.

  Enabling is performed using the Motion Control instruction "MC_Power".

  The "MC_Power.Status" parameter must show the value TRUE.

- **Is a technology alarm pending?**

  To perform motion jobs, no technology alarms may be pending. After resolving the error, acknowledge any possibly pending alarms using the Motion Control instruction "MC_Reset".

  A list of the technology alarms and alarm responses can be found in the appendix, Technology Alarms (Page 267).

- **Has the technology object been homed?**

  In order to perform a job for absolute positioning, the positioning axis technology object must be homed. The referencing occurs via the Motion Control instruction "MC_Home". The "<TO>.StatusWord.HomingDone " tag of the technology object must show the value TRUE .

2. Initiate new job for the technology object

Initiate a new job.

In the "Position" parameter of the "MC_MoveAbsolute" instruction, specify the position to which the axis should be moved. Start the job with a positive edge at the "Execute" parameter.

3. Check job status

Parameter "Done" of the Motion Control instruction indicates successful completion of a job (target reached, in this case).

If an error is detected, the "Error" parameter of the Motion Control instruction is set to TRUE, and the job is rejected.

You can program an error handling routine for the Motion Control job. For this purpose, evaluate the error indicated in the "Error" parameter. The cause of the error is indicated in the ErrorID parameter. After resolving the cause of the error, restart the job.

Output of the "Error" = TRUE and "ErrorID" = 16#8001 status information during job processing indicates that a technology alarm was triggered.

A list of the ErrorIDs can be found in the appendix, Error Detection (Page 270).

Additional information

An option for the evaluation of the individual status bits, error bits, and warning bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

6.5 Tracking active jobs

6.5.1 Introduction

The current status of the job processing is made available via the output parameters of the Motion Control instruction. These parameters are updated with each call of the Motion Control instruction.

When tracking jobs, a distinction is made between three groups:

- Motion Control instructions with "Done" parameter (Page 152)
- Motion Control instruction "MC_MoveVelocity" (Page 156)
- Motion Control instruction "MC_MoveJog" (Page 159)

6.5.2 Motion Control instructions with "Done" parameter

Description

Jobs for Motion Control instructions with the "Done" parameter are started with a positive edge at the "Execute" parameter. If the job was completed without errors and without interruption by another job (e.g. "MC_ MoveAbsolute": target position reached), then the "Done" parameter shows the value TRUE.

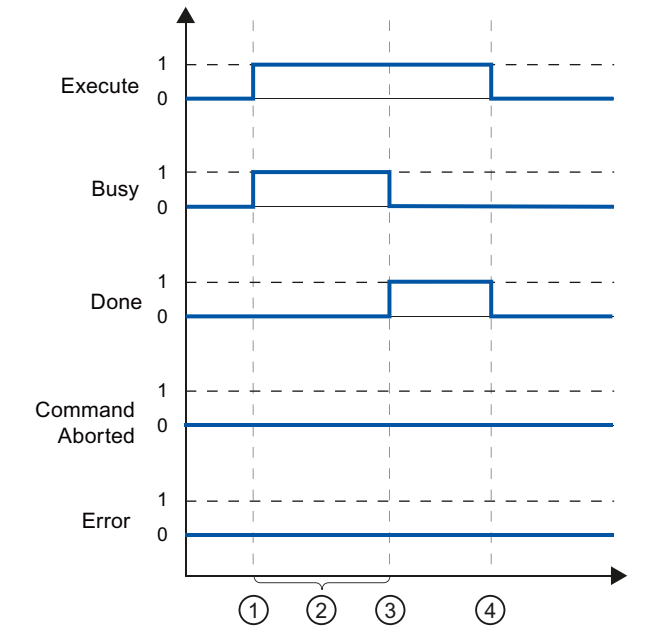
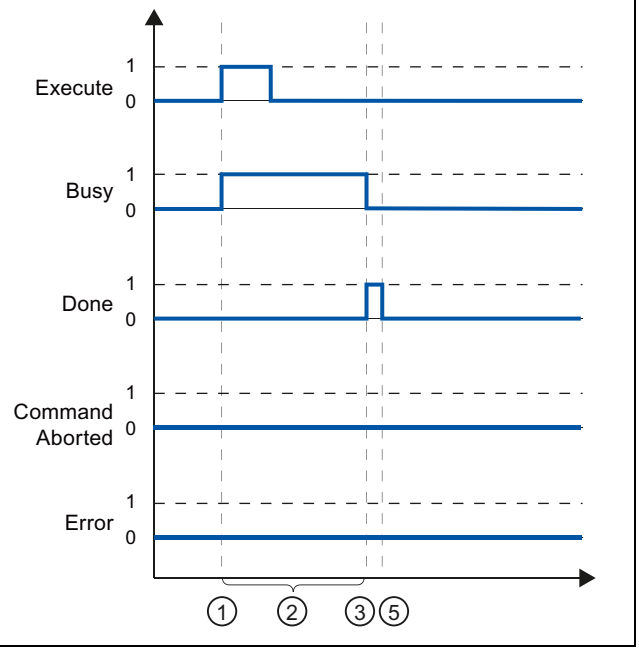
The following Motion Control instructions have a "Done" parameter:

- MC_Home
- MC_MoveRelative
- MC_MoveAbsolute
- MC_Halt
- MC_Reset

The behavior of the parameters is presented by way of example for various situations:

Complete execution of job

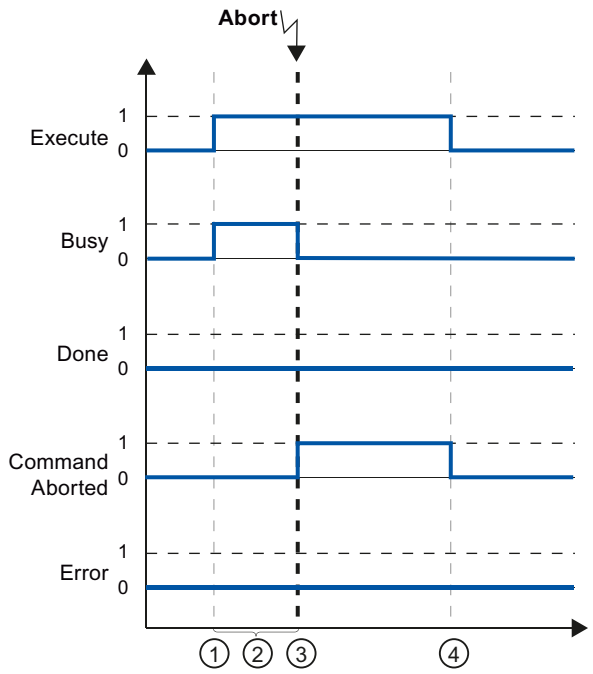
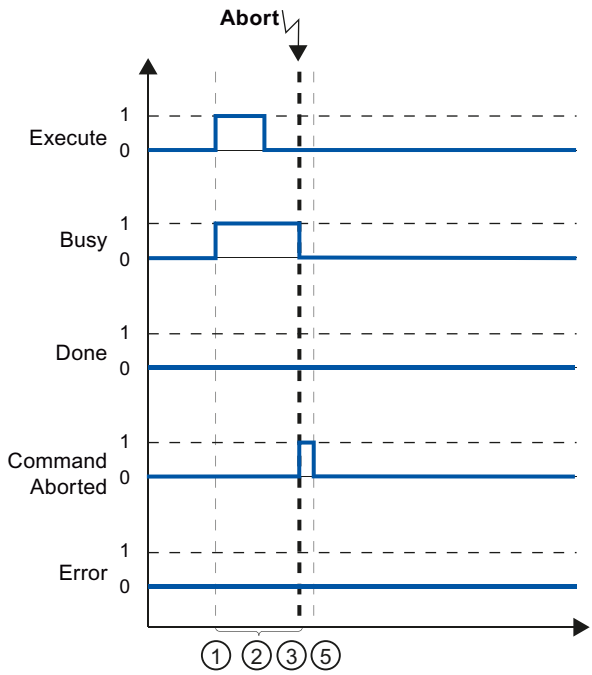
If the Motion Control job has been fully processed to the point of completion, then this is indicated in the "Done" parameter with the value TRUE. The signal status of the "Execute" parameter influences the indication duration in the "Done" parameter:

You set "Execute" **after completion** of the job to FALSE.	You set "Execute" **during processing** of the job to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value while the job is still busy, or retain the TRUE value until the job has been completed.
②	Parameter "Busy" returns the TRUE value while the job is executed.
③	When the job is complete (for example, for Motion Control instruction "MC_MoveAbsolute": target position reached) the "Busy" parameter changes to FALSE, and the "Done" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "Done" parameter also retains the value TRUE.
⑤	If the "Execute" parameter has been set to FALSE before the job is complete, then the "Done" parameter only shows the value TRUE for one execution cycle.

Job termination

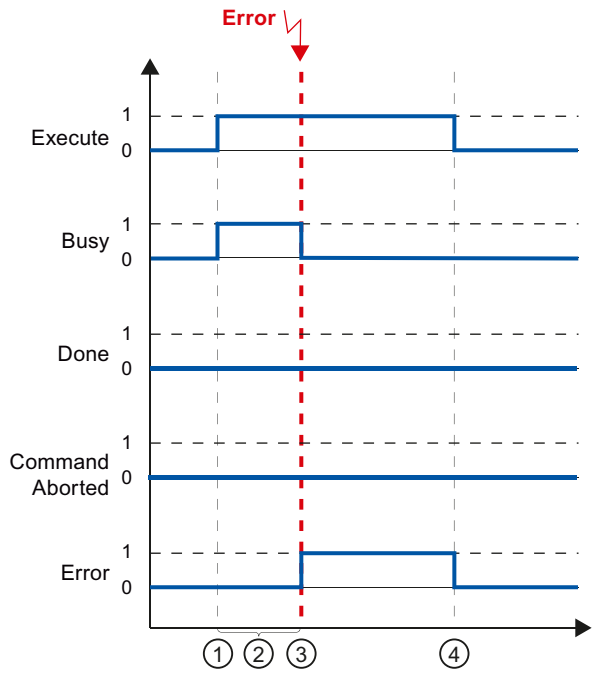
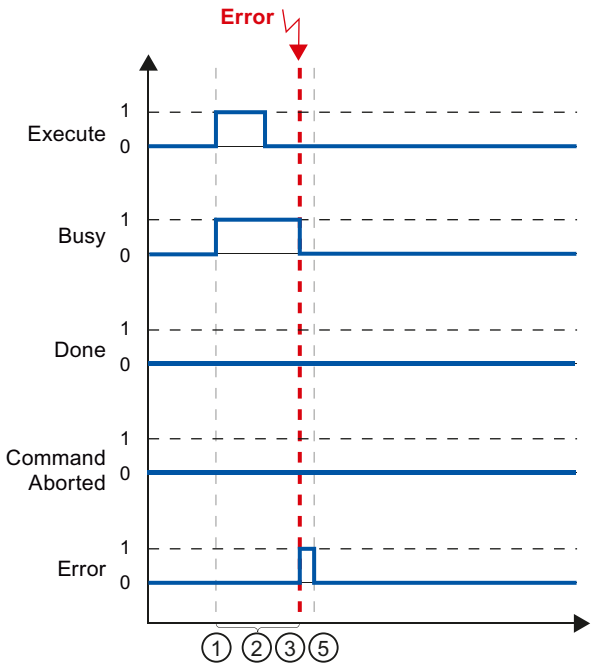
If the Motion Control job is aborted during processing by another job, then this is indicated in the "CommandAborted" parameter with the value TRUE. The signal status of the "Execute" parameter influences the indication duration in the "CommandAborted" parameter:

You set "Execute" **after** the job is aborted to FALSE.	You set "Execute" **before** the job is aborted to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value while the job is still busy, or retain the TRUE value until the job has been completed.
②	While the job is being processed, the "Busy" parameter shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE", and "CommandAborted" changes to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "CommandAborted" parameter also retains the value TRUE.
⑤	If the "Execute" parameter has been set to FALSE before the job is aborted, then the "CommandAborted" parameter only shows the value TRUE for one execution cycle.

Error during job execution

If an error occurs during execution of the Motion Control job, then this is indicated in the "Error" parameter with the value TRUE. The signal status of the "Execute" parameter influences the indication duration in the "Error" parameter:

You set "Execute" **after** the occurrence of the error to FALSE.	You set "Execute" **before** the occurrence of the error to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value while the job is still busy, or retain the TRUE value until the job has been completed.
②	While the job is active, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to "FALSE, and the "Error" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after the occurrence of the error, the "Error" parameter also retains the value TRUE.
⑤	If the "Execute" parameter has been set to FALSE before the occurrence of the error, then the "Error" parameter only shows the value TRUE for one execution cycle.

6.5.3 Motion Control instruction "MC_MoveVelocity"

Description

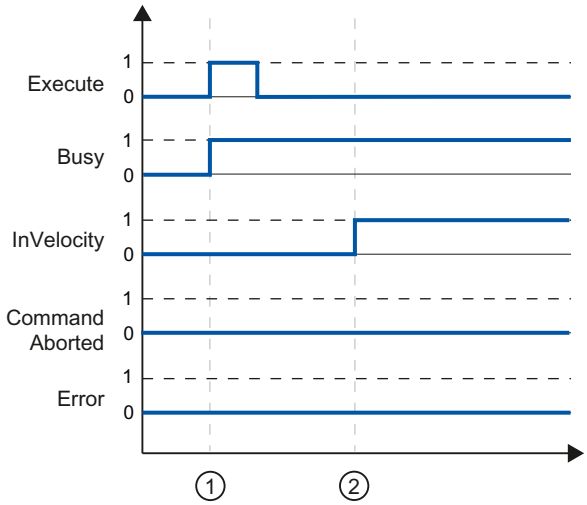
An "MC_MoveVelocity" job is started with a positive edge at the "Execute" parameter. The job objective is fulfilled when the assigned velocity is reached and the axis travels at constant velocity. When the assigned velocity is reached and maintained, this is indicated in the "InVelocity" parameter with the value TRUE.

The motion of the axis can, for example, be stopped with an "MC_Halt" job.

The behavior of the parameters is presented below for various example situations:

The assigned velocity is reached and maintained

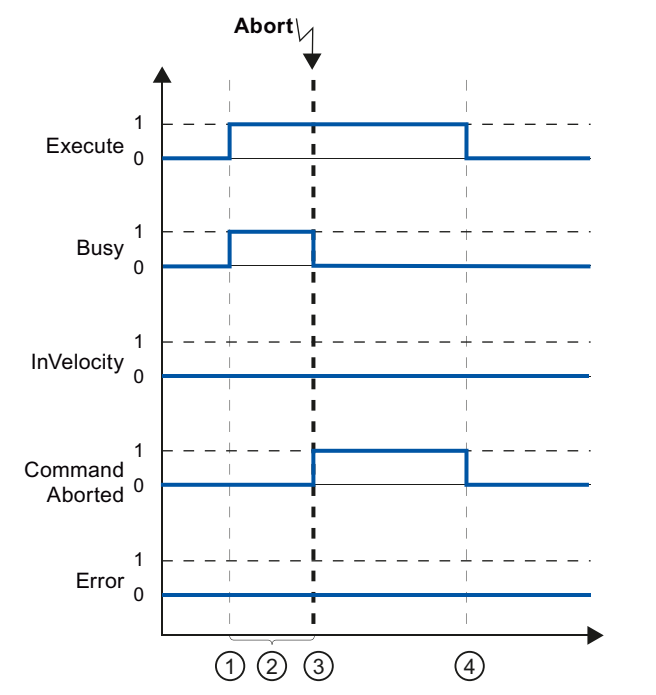
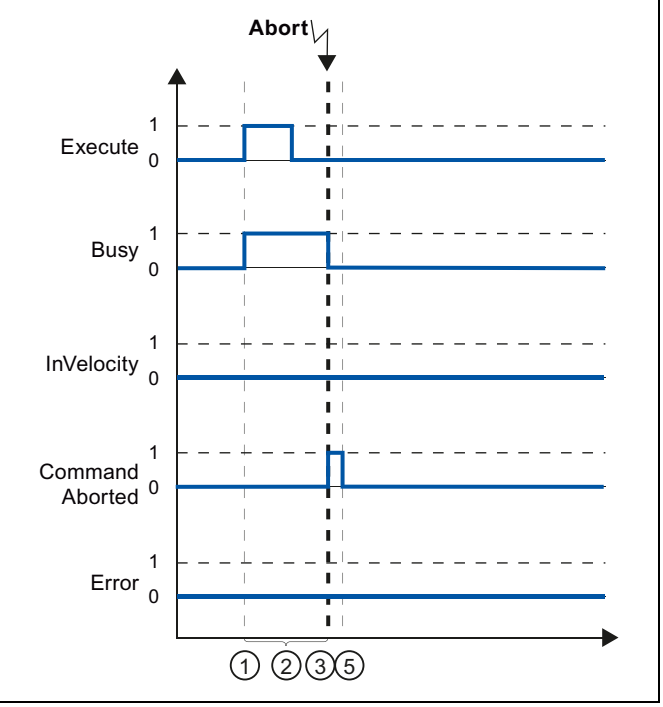
The achievement of the assigned velocity is indicated in the "InVelocity" parameter with the value TRUE. The "Execute" has no effect on the indication duration in the "InVelocity" parameter.



①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value before or after the parameterized velocity has been reached. Parameter "Busy" returns the TRUE value while the job is executed.
②	When the assigned velocity is reached, the "InVelocity" parameter changes to TRUE. The "Busy" and "InVelocity" parameters retain the TRUE value until a different Motion Control job overrides the "MC_MoveVelocity" job.

The job is aborted prior to reaching the assigned velocity

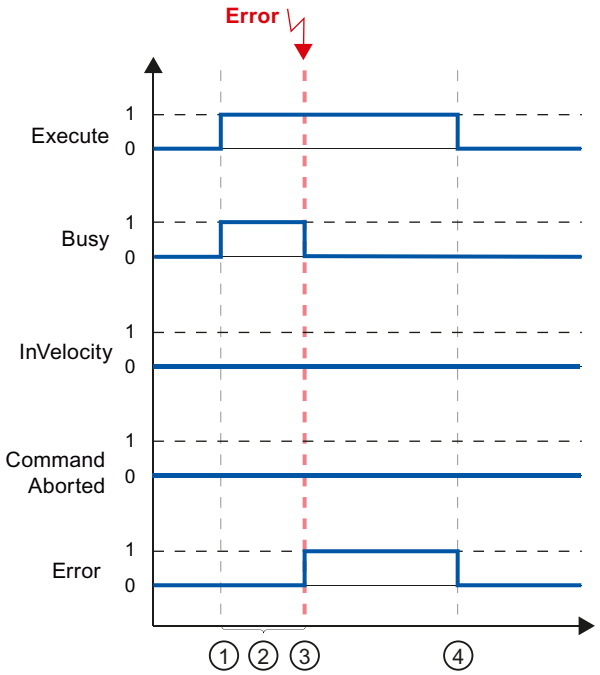
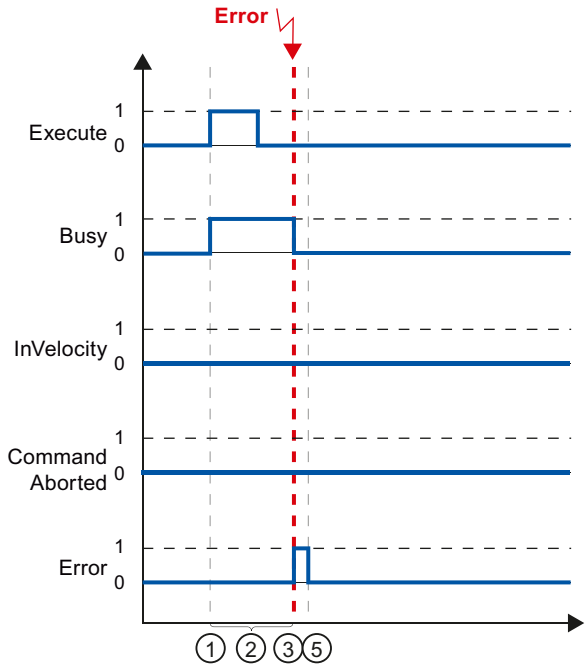
If the Motion Control job is aborted by another job before reaching the assigned velocity, then this is indicated in the "CommandAborted" parameter with the value TRUE.
The signal status of the "Execute" parameter influences the indication duration in the "CommandAborted" parameter.

You set "Execute" **after** the job is aborted to FALSE.	You set "Execute" **before** the job is aborted to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value while the job is still busy, or retain the TRUE value until the job is aborted.
②	While the job is active, the "Busy" parameter shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "CommandAborted" parameter also retains the value TRUE.
⑤	If the "Execute" parameter has been set to FALSE before the job is aborted, then the "CommandAborted" parameter only shows the value TRUE for one execution cycle.

An error has occurred prior to reaching the assigned velocity

If an error occurs during execution of the Motion Control job before the assigned velocity has been reached, this is indicated in the "Error" parameter with the value TRUE. The signal status of the "Execute" parameter influences the indication duration in the "Error" parameter.

You set "Execute" **after** the occurrence of the error to FALSE.	You set "Execute" **before** the occurrence of the error to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the program, "Execute" can be reset to the FALSE value while the job is still busy, or retain the TRUE value until the error has occurred.
②	While the job is active, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to FALSE and the "Error" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "Error" parameter also retains the value TRUE.
⑤	If the "Execute" parameter has been set to FALSE before the job is aborted, then the "Error" parameter only shows the value TRUE for one execution cycle.

6.5.4 Motion Control instruction "MC_MoveJog"

Description

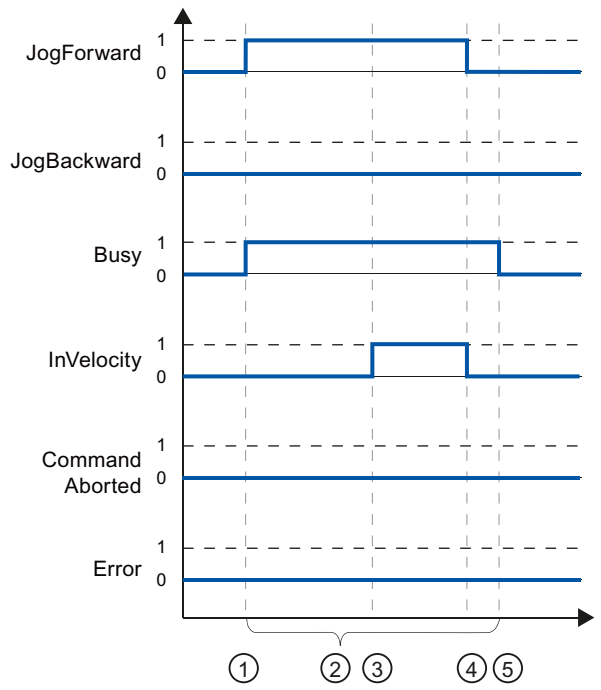
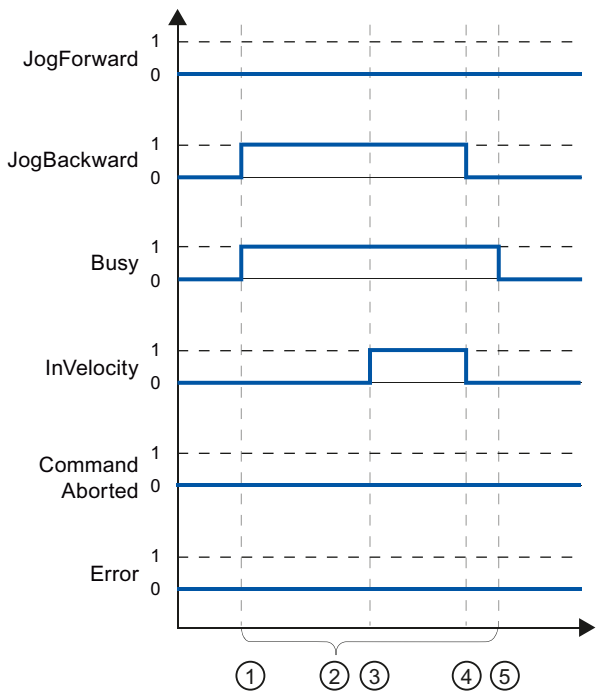
An "MC_MoveJog" job is started by setting the "JogForward" or "JogBackward" parameter. The job objective is fulfilled when the assigned velocity is reached and the axis travels at constant velocity. When the assigned velocity is reached and maintained, this is indicated in the "InVelocity" parameter with the value TRUE.

The job is complete when the "JogForward" or "JogBackward" parameter has been set to the value FALSE and the axis has come to a standstill.

The behavior of the parameters is presented below for various example situations:

The assigned velocity is reached and maintained

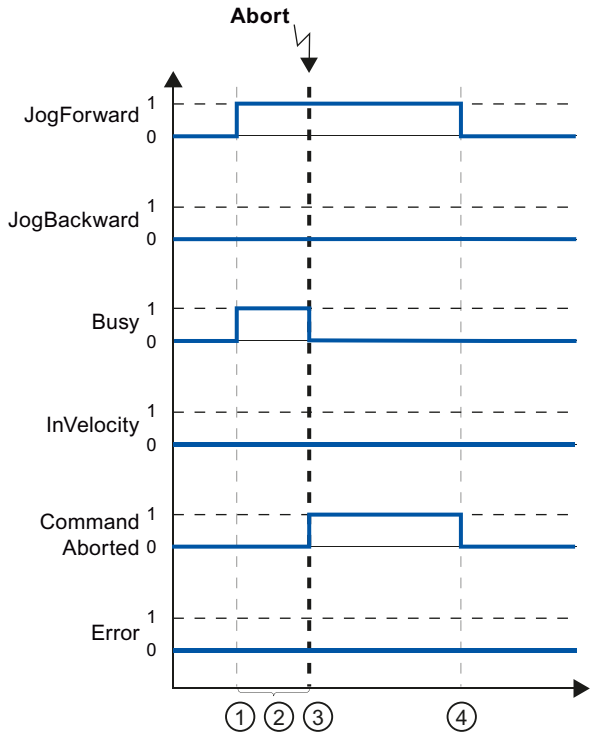
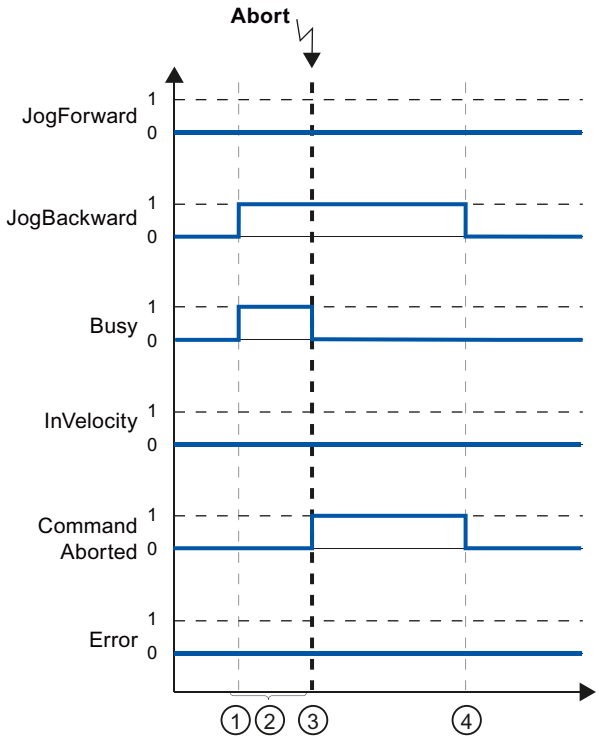
If the Motion Control job has been performed up to the point of reaching the assigned velocity, then this is indicated in the "InVelocity" parameter with the value TRUE.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is active, the "Busy" parameter shows the value TRUE.
③	When the assigned velocity is reached, the "InVelocity" parameter changes to TRUE.
④	When the "JogForward" or "JogBackward" parameter is reset, the motion of the axis ends. The axis decelerates. The "InVelocity" parameter changes to FALSE.
⑤	If the axis has come to a standstill, then the Motion Control job is complete and the "Busy" parameter changes to FALSE.

The job is aborted during execution

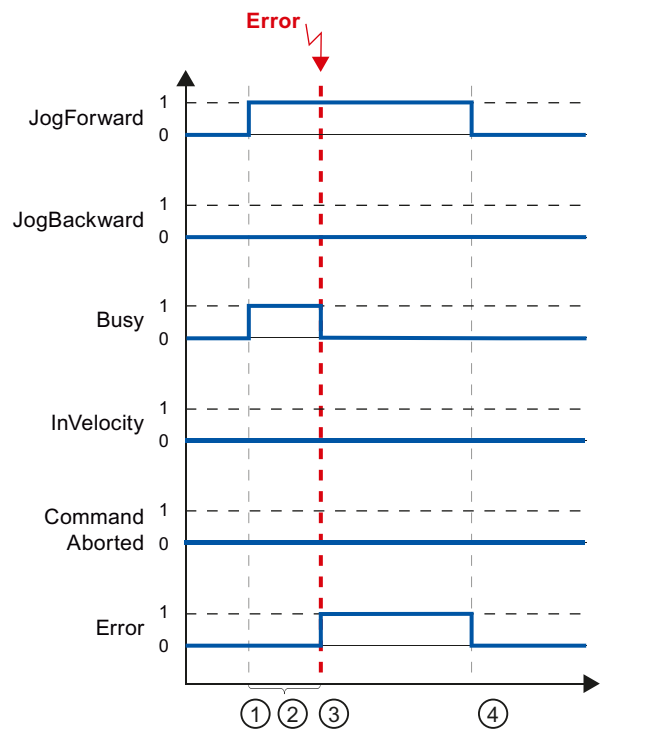
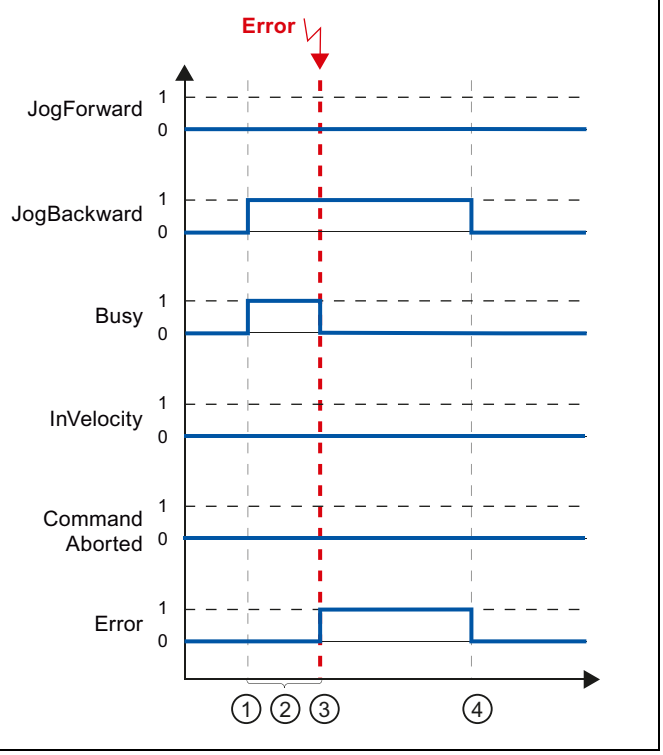
If the Motion Control job is aborted during processing by another job, then this is indicated in the "CommandAborted" parameter with the value TRUE. The behavior of the "CommandAborted" parameter is independent of reaching the assigned velocity.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is processing, the "Busy" parameter shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to TRUE.
④	When the "JogForward" or "JogBackward" parameter is reset, the "CommandAborted" parameter likewise changes to FALSE.

An error occurs during the execution of the job

If an error occurs during execution of the Motion Control job, this is indicated in the "Error" parameter with the value TRUE. The behavior of the "Error" parameter is independent of reaching the assigned velocity.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is active, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to "FALSE", and "Error" changes to TRUE.
④	When the "JogForward" or "JogBackward" is reset to the value FALSE, the "Error" parameter likewise changes to FALSE.

6.6 Ending Motion Control jobs

When ending a job, a distinction is made between error-free completion of the job, and the termination of a motion.

Completion of the job

The completion of a Motion Control job is indicated as described in the Tracking running jobs (Page 152) section.

Termination of a motion

If a motion must be aborted, you can perform the following measures:

- "Execute MC_Halt (Page 236)"

  To abort a motion and stop the axis, you can use the "MC_Halt" instruction.

- "Disable MC_Power (Page 205)"

  In an emergency, you can stop the axis using an emergency stop ramp.
  For this purpose, set the "Enable" parameter of the "MC_Power" instruction to FALSE.
  The axis is decelerated according to the selected "StopMode" and all jobs at the technology object are aborted.

6.7 Restart of technology objects

Description

After the CPU is switched on, or after technology objects are downloaded into the CPU, the system automatically initializes the technology objects with the start values from the technology data blocks. If restart-relevant changes are detected during a reload into the CPU, a restart of the technology object is automatically performed.

If restart-relevant data have been changed in RUN mode by the user program, then the technology object must be reinitialized by the user in order for the changes to be used.

If changes in the technology data block should also be retained after the restart of the technology object, then you must write the changes to the start value in load memory using the extended instruction "WRIT_DBL".

Restart necessary

A necessary TO restart is indicated at "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Online start value changed", as well as in the tag of technology object <TO>.StatusWord.OnlineStartValuesChanged.

Restarting a technology object

A restart of the technology object is triggered by the user by means of the "MC_Reset" Motion Control instruction, with parameter "Restart" = TRUE.

During a restart, all configuration data of the technology object are loaded from load memory into work memory. In the process, the actual values in the technology data block are overwritten.

Note the following during a restart of the technology object:

- A restart resets the "Referenced" status of a technology object with incremental actual values (<TO>.StatusWord.HominDone).
- While a restart is being performed, the technology object cannot perform any jobs.
  An active restart will be indicated under "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Restart active", and in the <TO>.StatusWord.RestartActive tag of the technology object.
- Motion Control jobs are rejected during a restart with the "Error" = TRUE and "ErrorID" = 16#800D parameters (job not executable, because a restart is active).
- While a restart is being executed, you cannot access the technology data block.

See also

Change restart-relevant data (Page 144)

Downloading to CPU 7

Description

When downloading to the CPU S7-1500, it is always verified that the project files are consistent online and offline after the download.

The data of the technology objects are saved in technology data blocks. The conditions for downloading blocks thus apply when loading new or modified technology objects.

You can load the following object groups into the CPU:

Context menu command "Download to device"	Description
Hardware and software	Download all new and modified blocks, and a new or modified hardware configuration
Hardware configuration	Download a new or modified hardware configuration
Software (changes only)	Download all new and modified blocks.
Software (all blocks)	Download all blocks.

Load in RUN mode

When loading in the CPU's RUN mode, it is checked whether a load without restart of the technology objects is possible.

If restart-relevant configuration values were changed, then a restart of the technology object is automatically performed after the load into the CPU.

Loading a technology object is only possible if the technology object is disabled.

Commissioning 8

8.1 Introduction

The following guidelines describe the steps that you should note when commissioning the Motion Control-specific components of your equipment.

The commissioning of other components of your automation system depends on the particular equipment configuration. Commissioning (not Motion Control) is described in the Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

8.2 Commissioning guidelines

These guidelines serve as recommendations for commissioning equipment with Motion Control. The procedure is described using the example of a positioning axis technology object.

Requirements

- The configuration of the following components is complete:
  - CPU
  - BUS communication
  - Drives
  - Technology objects
- The user program has been created.
- The wiring of the CPU and of the associated I/O is complete.
- The commissioning and optimization of the drive is complete.

Procedure

Proceed as follows to commission the Motion Control-specific components of your equipment:

Step	Action to be performed	Supported by TIA Portal
Turn on CPU	Turn on the power supply and the CPU.	-
"Disable" position controller	Set the gain (Kv factor) of the position control loop to zero. (This setting avoids unwanted drive movements that may be caused by incorrect parameterization of the position control loop.)	"Technology object > Configuration > Extended parameters > Control loop"
Load project into the CPU	Bring the CPU to the STOP mode. Download your project to the CPU (load hardware and software).	• "Toolbar > Stop CPU" • "Toolbar > Download to device"
Create online connection to the CPU	Select the "Receive messages" check box under "Online & Diagnostics > Online Access". Configure the interface of the TIA Portal, and create an online connection with the CPU.	• Device configuration • "Online & Diagnostics > Online Access"
Disable Motion Control specific user program	In order to avoid conflicts with the axis control panel, lock the enabling of technology objects in your user program (MC_Power.Enable = FALSE).	• PLC programming • Motion Control instructions
Evaluating pending messages	Evaluate the message display in the inspector window. Resolve the causes of pending technology alarms. Acknowledge the technology alarms (Page 186).	"Inspector window > Diagnostics > Message display"
Check hardware limit switches	Click the hardware limit switches. Check for correct message display (technology alarm 531). Acknowledge the technology alarm.	"Inspector window > Diagnostics > Message display"
Check the connection and configuration of the drive (setpoint)	Bring the CPU into the RUN mode. Open the Axis control panel (Page 170) and take over control. Perform the following steps: • Enable the technology object. ⇒ The drive must turn itself on, and where applicable release the brake. The position is held. • Move the axis in jog mode at low velocity in the positive direction. ⇒ The drive must move. The actual position value must increase (positive direction). • Disable the technology object. ⇒ The drive must turn itself off, and where applicable apply the brake.	"Technology object > Commissioning > Axis control panel"
Check the connection and configuration of the encoder (actual value)	Check the scaling of the actual values (rotation direction, distance evaluation, and resolution of the encoder) ⇒ The change in the actual mechanical position must match the change in the actual values.	• "Technology object > Diagnostics > PROFIdrive frame" • "Technology object > Commissioning > Axis control panel"

Step	Action to be performed	Supported by TIA Portal
Optimize position controller	Use the Optimization (Page 176) commissioning function to optimize the gain (Kv) of the position control loop. For this purpose, adapt following error limits as needed.	"Technology object > Commissioning > Optimization"
Transfer the gain Kv to the project.	Enter the gain Kv that you determined by means of the optimization function in your configuration data. Load your project into the CPU.	"Technology object > Configuration > Extended parameters > Control loop"
Enable Motion Control specific user program	Unlock the enabling technology objects lock in your user program (MC_Power.Enable = TRUE).	• PLC programming • Motion Control instructions
Check the functioning of the user program	Check the programmed functions of your user program.	• Watch and force tables • Online and diagnostic functions
End of commissioning for a positioning axis technology object	To commission additional technology objects, perform the corresponding steps again.	See above.

8.3 Axis control panel

8.3.1 Function and structure of the axis control panel

Description

The axis control panel offers you the option of moving individual axes.

A user program is necessary for the operation of the axis control panel.
Via the TIA Portal, you can take over master control, and control the motions of the axis.

WARNING

Uncontrolled axis motions

During operation with the axis control panel, the axis can execute uncontrolled motions (e.g. due to erroneous configuration of the drive, or of the technology object).

Therefore, perform the following protective measures before operation with the axis control panel:

- Ensure that the EMERGENCY OFF switch is within the reach of the operator.
- Enable the hardware limit switches.
- Enable the software limit switches.
- Ensure that following error monitoring is enabled.

The axis control panel of the speed-controlled axis and positioning axis can be found in the Project Navigator under "Technology object > Commissioning".

The axis control panel is divided into the following areas:

- Master control
- Axis
- Operating mode
- Controller
- Axis status
- Current values

"Master control" area

In this area, you can take over master control of the technology object, or return it to your user program.

- **"Fetch" button**

  Click "fetch" to set up an online connection to the CPU and take over master control for the selected technology object.

  – To take over master control, the technology object must be disabled in the user program.

  – If the online connection to the CPU fails during operation with the axis control panel, then after expiration of the signs of life monitoring, the axis will be stopped with maximum deceleration. In this case, an error message is displayed ("ErrorID" = 16#8013) and the control priority is passed back to the user program.

  – Until master control is returned, the user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with the error ("ErrorID" = 16#8012: axis control panel enabled).

  – When master control is taken over, the configuration of the technology object is applied. Changes to the configuration of the technology object do not become effective until the master control has been returned. For this reason, make any changes that may be necessary before master control is taken over.

- **"Relinquish" button**

  Click the "Relinquish" button to return master control to your user program.

"Axis" area

In this area, you can enable or disable the technology object:

- **"Enable" button**

  Click the "Enable" button to activate the selected technology object.
  The enable is required to execute motion jobs on the axis.

- **"Disable" button**

  Click the "Disable" button to deactivate the selected technology object.

"Operation mode" area

Select the desired function in the drop-down list.

The following functions are available:

- **"Homing"**

  This function corresponds to active homing. The parameters for homing must be configured (see the Homing (Page 34) section).

- **"Set homing point"**

  This function corresponds to direct homing (absolute). Click "Set homing point" in the "Controller" area to set the actual position to the value specified in "Position" and to set the "Homed" state.

- **"Jog mode"**

  Motion commands occur by means of jogging. In the "Controller" area, click the "Forward" or "Backward" button to initiate a motion in the positive or negative direction.
  The motion runs for as long as you hold down the left mouse button.

- **"Predefined velocity"**

  The axis is moved at the specified velocity or speed until you stop the movement.
  The motion commands are performed according to the setpoints assigned under "Controller".

- **"Relative positioning"**

  The positioning is executed as a controlled, relative traversing motion according to the defaults assigned under "Controller".

- **"Absolute positioning"**

  The positioning is executed as a controlled, absolute traversing motion according to the defaults assigned under "Controller".

  If you have enabled the "Modulo" setting of the technology object, the buttons "Forward" and "Backward" are shown in the "Controller" area. You can leave the valid Module range with these buttons.

  If you have not enabled the "Modulo" setting of the technology object, only the "Start" button is shown in the "Controller" area. You can directly approach the entered position.

"Controller" area

You control the selected function in this area:

- Using the axis control panel, configure the following motion parameters according to the selected mode:
  - **"Position"**

    Homing and set homing point modes only
  - **"Distance"**

    Relative positioning mode only
  - **"Target position"**

    Absolute positioning mode only
  - **"Velocity"**

    Velocity specification, jog and positioning modes only

    Default: 10% of default value
  - **"Acceleration"**

    Default: 10% of default value
  - **"Deceleration"**

    Default: 10% of default value
  - **"Jerk"**

    Default: 100% of default value

  Note

  No transfer of the parameters

  The configured parameter values are discarded after master control is returned.

  Transfer the values as needed into your configuration.

- **"Start" button**

  Click the "Start" button to initiate a job in accordance with the selected operating mode.
- **"Forward" and "Backward" buttons**

  Click the "Forward" or "Backward" button to initiate a motion in the positive or negative direction in accordance with the selected operating mode.
- **"Stop" button**

  Click the "Stop" button to abort a job or pause the axis.
- **"Set homing point" button**

  Set homing point mode only

  Click the "Set homing point" button to set the actual position to the value specified in "Position".

"Axis status" area

This area displays the current status of the axis and drive:

- **"Drive switched on"**

  The drive is ready to execute setpoints.

- **"Error"**

  An error has occurred at the technology object.

- **"Enabled"**

  The technology object is enabled. The axis can be controlled with Motion Control instructions.

- **"Homed"**

  The technology object is homed.

- **"More"**

  Click "More" to open the "Technology object > Diagnostics > Status and error bits" dialog.

- **"Pending error"**

  The error that occurred most recently is displayed in the "Pending error" text box.

- **"Acknowledge" button**

  Click "Acknowledge" to acknowledge pending errors.

"Current values" area

The "Position" and "Velocity" fields indicate the actual position and the actual velocity of the axis.

8.3.2 Using the axis control panel

Requirements

- The CPU must be in the RUN mode.
- The project has been created and loaded into the CPU.
- The technology object is disabled.

Procedure

Proceed as follows to enable control the axis using the axis control panel:

1. Click "Fetch" in the "Master control" area to assume master control over the technology object and to set up an online connection to the CPU.

   A warning message is displayed. Click "OK" to confirm.
2. In the "Axis" area, click the "Enable" button to enable the technology object.
3. In the drop-down list in the "Operation mode" area, select the desired function of the axis control panel.
4. In the "Controller" area, specify the corresponding parameter values for your job.
5. Click the "Start", "Forward" or "Backward" button to start the job.
6. Click the "Stop" button to stop the job.
7. Repeat steps 3 through 6 for additional jobs.
8. In the "Axis" area, click the "Disable" button to disable the technology object.
9. In the "Master control" area, click the "Relinquish" button to return master control to your user program.

8.4 Optimization

8.4.1 Function and structure of the optimization

Description

The "Optimization" function supports you in determining the optimal gain (Kv factor) for the position control of the axis. The axis velocity profile is recorded by means of Trace function to this effect for the duration of a configurable positioning movement. Then you can evaluate the recording, and adapt the gain accordingly.

The "Optimization" function for the positioning axis technology object can be found in the Project Navigator under "Technology object > Commissioning".

The "Optimization" dialog is divided into the following areas:

- Master control
- Axis
- Optimize gain
- Trace

"Master control" area

In this area, you can take over master control of the technology object, or return it to your user program.

- **"Fetch" button**

  Click "fetch" to set up an online connection to the CPU and take over master control for the selected technology object.

  – To take over master control, the technology object must be disabled in the user program.

  – If the online connection to the CPU fails during operation with the axis control panel, then after expiration of the signs of life monitoring, the axis will be stopped with maximum deceleration. In this case, master control is returned to the user program.

  – Until master control is returned, the user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with the error ("ErrorID" = 16#8012: axis control panel enabled).

  – When master control is taken over, the configuration of the technology object is applied. Changes to the configuration of the technology object do not become effective until the master control has been returned. For this reason, make any changes that may be necessary before master control is taken over.

- **"Relinquish" button**

  Click the "Relinquish" button to return master control to your user program.

"Axis" area

In this area, you can enable or disable the technology object:

- **"Enable" button**

  Click the "Enable" button to activate the selected technology object.
  The enable is required to execute motion jobs on the axis.

- **"Disable" button**

  Click the "Disable" button to deactivate the selected technology object.

"Optimize gain" area

You make the settings for optimization of the gain in this area:

- **"Gain"**

  This field displays the current gain of the position control (Kv).

  A drop-down list opens when you click the lightning icon.
  The drop-down list contains the following gain values:

  – Online actual value

  – Online start value

  – Start value project

  In the input field for the actual value, enter the new value for the gain.
  The new value is applied by clicking the "Start" button.

- **"Distance"**

  In this field, specify the distance for a test step.

- **"Measurement duration"**

  In this field, specify the duration for a test step.

- **"Adapt dynamic values" checkbox**

  Select this check box, if you want to adapt the dynamic values for acceleration and maximum velocity for the optimization.

- **"Acceleration"**

  This field indicates the default acceleration.

- **"Maximum acceleration"**

  This field indicates the default setting for the maximum acceleration.

- **"Forward" and "Backward" buttons**

  Click the "Forward" or "Backward" button to start a test step for optimization in the positive or negative direction.

Note

No transfer of the parameters

The configured parameter values are discarded after master control is returned.

Transfer the values as needed into your configuration. You can apply the gain value in your configuration using the "Project start value" value.

"Trace" area

The Trace function is displayed In the lower area of the "Optimization" dialog.

When you click the "Forward" or "Backward" button, a trace recording of the required parameters is automatically started and is displayed after completion of the test step.

After returning master control, the trace recording is deleted.

See also

Control (Page 52)

8.4.2 Optimize position controller

Requirements

- The CPU must be in the RUN mode.
- The project has been created and loaded into the CPU.
- The technology object is disabled via your user program (MC_Power.Enable = FALSE).

Optimizing position control gain (Kv)

Proceed as follows to optimize the gain (Kv):

1. In the "Master control" area, click the "Fetch" button to fetch master control for the technology object, and to establish an online connection to the CPU.

   A warning message is displayed. Click "OK" to confirm.
2. In the "Axis" area, click the "Enable" button to enable the technology object.
3. As appropriate, configure values for the distance, duration, and dynamics of a test step.
4. Enter a start value for the gain. Start with a low value.
5. Click the "Start" button to start a test step for the optimization.
   For the specified duration, a setpoint is output in accordance with the specified distance. The axis moves by the specified distance. A trace recording of the motion (setpoint and actual values) is created automatically.

   Note
   Adapt following error limits

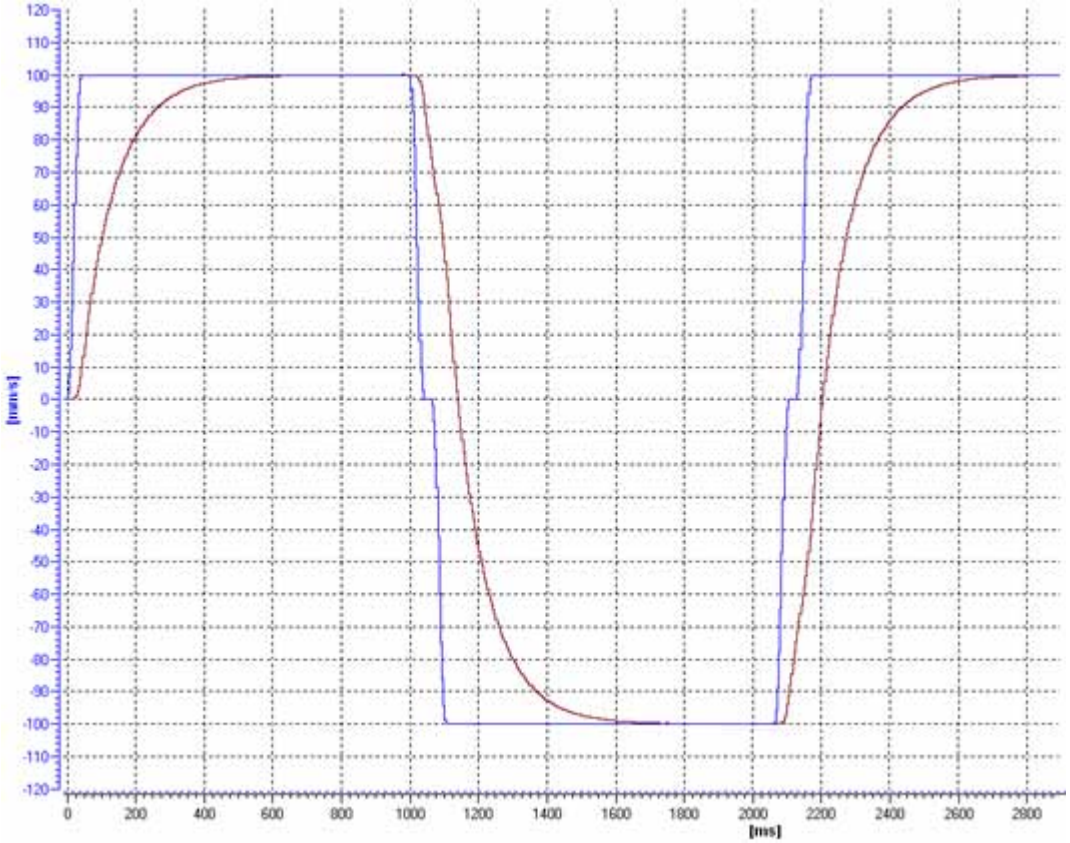
   If error messages from following error monitoring are repeatedly displayed during optimization, temporarily adapt the following error limits.

6. Evaluate the curve of the trace recording. Adapt the gain incrementally. Click the "Start" button after each value that you input. This applies the value and start a new movement and trace recording each time.

When adjusting the gain, pay attention to the following properties of the curve:

- The curve shows a brief compensation time.
- The curve does not show any motion reversal of the actual value.
- When approaching the setpoint, no overshoot occurs.
- The curve shows a stable overall behavior (oscillation-free curve).

The following trace recording shows a curve in which the gain is too low:

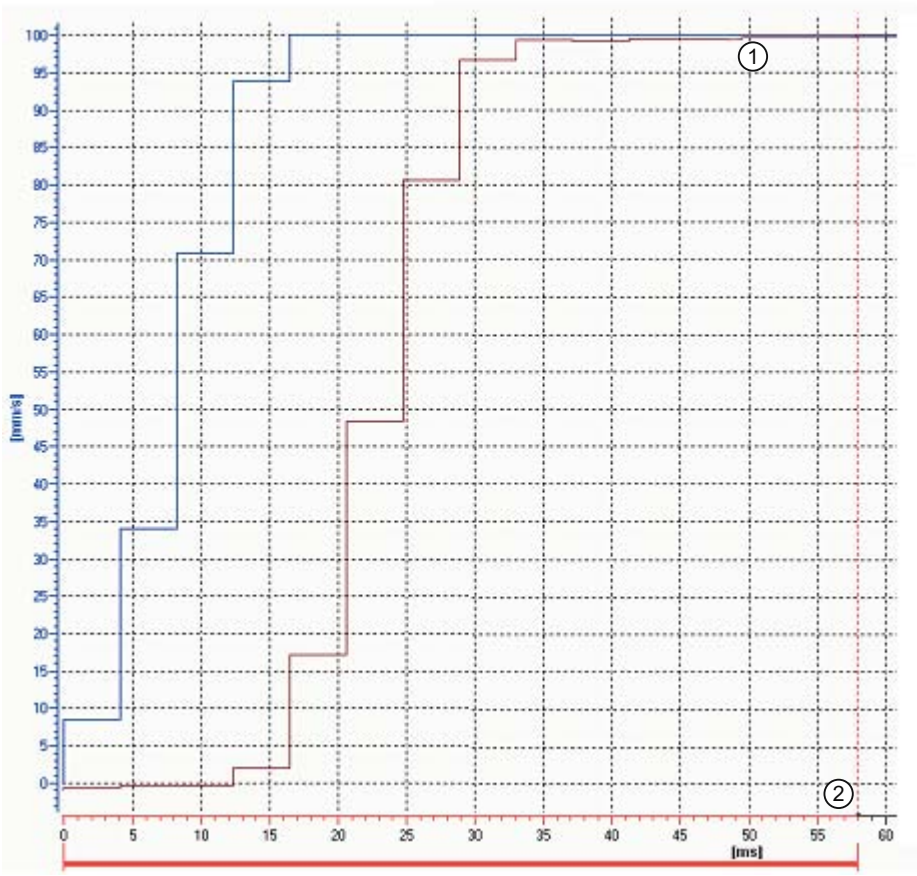


Setpoint velocity of the axis

Actual axis velocity

The curve shown has no overshoot, but shows considerable settling time.
You need to increase the gain to optimize the position controller.

The following trace recording shows a curve in which the gain is optimal (detail view):



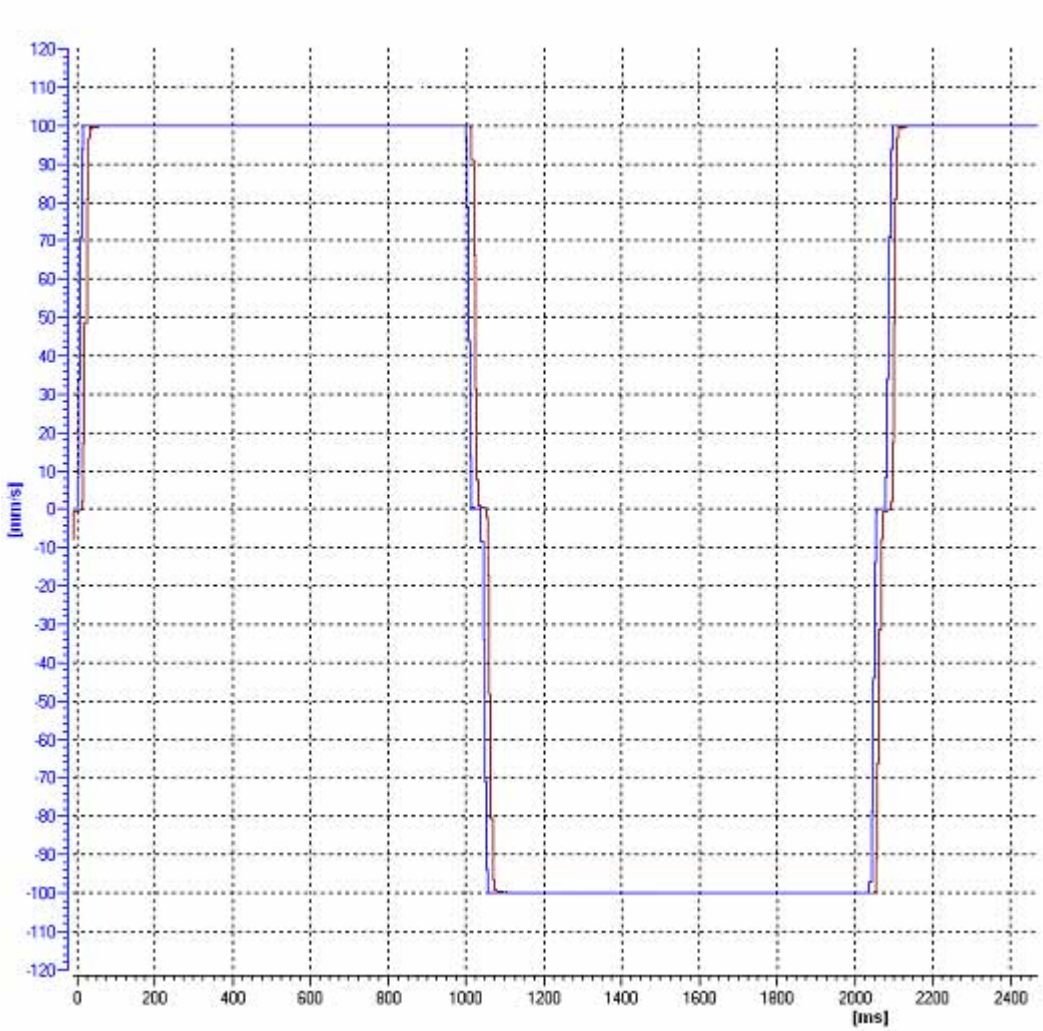
Setpoint velocity of the axis

Actual axis velocity

① No overshoot

② Fast settling time

The following trace recording shows a curve in which the gain is optimal and the overall response is steady:



Setpoint velocity of the axis

Actual axis velocity

Transferring the position control gain (Kv) to the project

Proceed as follows to transfer the determined gain (Kv) into your project:

1. Click on the lightning icon next to the "Gain" field.

   A drop-down list is displayed.
2. Enter the determined gain value in the "Project start value" field of the drop-down list.
3. In the "Axis" area, click the "Disable" button to disable the technology object.
4. In the "Master control" area, click the "Relinquish" button to return master control to your user program.
5. Load your project into the CPU.

Diagnostics 9

9.1 Introduction

The Diagnostics chapter is limited to describing the diagnostic concept for Motion Control, and describing the Diagnostics view of the individual technology objects in the TIA Portal.

For more information about system diagnostics with the S7-1500 CPU, refer to the "System diagnostics" (http://support.automation.siemens.com/WW/view/en/59192926) function manual

9.2 Diagnostic concept

The diagnostic concept encompasses alarms and associated messages, as well as error messages in the Motion Control instructions. The TIA Portal also supports you with consistency checks during configuration of the technology objects, and during the creation of your user program.

All alarms during operation (from the CPU, technology, hardware etc.) are displayed in the Inspector window of the TIA Portal. Diagnostic information that relates to technology objects (technology alarms, status information) are additionally displayed in the Diagnostics window of the respective technology object.

During Motion Control, if an error occurs at a technology object (e.g. approaching a hardware limit switch), then a technology alarm (Page 186) is triggered, and a corresponding message is displayed in the TIA Portal as well as on HMI devices.

In your user program, technology alarms are generally signaled via error bits in the technology data block. The program always displays the technology alarm that has top priority. In order to simplify error evaluation, the "Error" and "ErrorID" parameters of the Motion Control instructions also indicate that a technology alarm is pending.

Program errors (Page 190) can occur during parameter assignment or during the processing sequence of the Motion Control instructions (e.g. invalid parameter specification when calling the instruction, initiation of a job without enablement via MC_Power). Errors in Motion Control instructions are indicated when the instructions are called, by means of the "Error" and "ErrorID" parameters.

9.3 Technology alarms

Description

If an error occurs at a technology object (e.g. approaching a hardware limit switch), then a technology alarm is triggered and indicated. The impact of a technology alarm on the technology object is specified by the alarm response.

Alarm classes

Technology alarms are divided into three classes:

- Warning (can acknowledge)

  The processing of Motion Control jobs continues. The current motion of the axis can be influenced, e.g. by limitation of the current dynamic values to the configured limit values.

- Alarm (must acknowledge)

  Motion jobs are aborted in accordance with the alarm response. In order to continue job processing after resolving the cause of error, you must acknowledge the alarms.

- Fatal error

  Motion jobs are aborted in accordance with the alarm response.

  In order to be able to use the technology object again after a fatal error, you must restart the CPU.

Display of technology alarms

A technology alarm is displayed in the following locations:

- TIA Portal
  - "Technology object > Diagnostics > Status and error bits"

    Display of pending technology alarms for each technology object.
  - "Technology object > Commissioning > Axis control panel"

    Display of the last pending technology alarm for each technology object.
  - "Inspector window > Diagnostics > Message display"

    Select the "Receive messages" check box under "Online & Diagnostics > Online Access" in order to display technology alarms via the message display.

    With an online connection to the CPU, the pending technology alarms for all technology objects are displayed. Additionally, the archive view is available to you.

    The message display can also be enabled at a connected HMI, and displayed.
  - "CPU > Online & diagnostics"

    Display of the technology alarms that have been recorded in the diagnostics buffer.
- User program
  - Tag <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction

    Indication of the number and the response for the last technology alarm that occurred.
  - Tag <TO>.StatusWord

    Via the "Error" bit it is indicated, that a technology alarm is pending.
  - Tag <TO>.ErrorWord

    Indication of alarms and fatal errors.
  - Tag <TO>.WarningWord

    Indication of warnings.
  - Parameter "Error" and "ErrorID"

    In a Motion Control instruction, the parameters "Error" = TRUE and "ErrorID" = 16#8001 indicate that a technology alarm is pending.
- Display of the CPU

  In order to show technology alarms on the CPU display, make the following setting when loading to the CPU:
  In the "Load preview" dialog, select the action "Consistent download" for the "Text libraries" entry.

Alarm response

A technology alarm always contains an alarm response, which describes the impact on the technology object. The alarm response is specified by the system.

The following list shows the possible alarm responses in order of ascending priority:

- **No response (warnings only)**

  <TO>.ErrorDetail.Reaction = 0

  The processing of Motion Control jobs continues. The current motion of the axis can be influenced, e.g. by limitation of the current dynamic values to the configured limit values.

- **Stop with current dynamic values**

  <TO>.ErrorDetail.Reaction = 1

  Active motion commands are aborted. The axis is braked with the dynamic values that are pending in the Motion Control instruction, and brought to a standstill.

- **Stop with maximum dynamic values**

  <TO>.ErrorDetail.Reaction = 2

  Active motion commands are aborted. The axis is braked with the dynamic values configured under "Technology object > Extended parameters > Dynamic limits", and brought to a standstill. The configured maximum jerk is taken into account at the same time.

- **Stop with emergency stop ramp**

  <TO>.ErrorDetail.Reaction = 3

  Active motion commands are aborted. The axis is braked with the emergency stop deceleration configured under "Technology object > Extended parameters > Emergency stop ramp", without any jerk limit, and brought to a standstill.

- **Remove enable**

  <TO>.ErrorDetail.Reaction = 4

  The setpoint zero is output, and the enablement is removed. The axis is braked depending on the configuration in the drive, and is brought to a standstill.

Acknowledging technology alarms

You can acknowledge technology alarms as follows:

- TIA Portal
  - "Technology object > Diagnostics > Status and error bits"

    Click "Acknowledge" to acknowledge all alarms and warnings pending for the selected technology object.
  - "Technology object > Commissioning > Axis control panel"

    Click "Acknowledge" to acknowledge all alarms and warnings pending for the selected technology object.
  - "Inspector window > Diagnostics > Message display"

    You can acknowledge the alarms and warnings for all technology objects either individually, or all at once.

    At an HMI with enabled message display, you can likewise acknowledge the alarms and warnings for all technology objects either individually, or all at once.
- User program

  Acknowledge pending alarms at a technology object using the Motion Control instruction "MC_Reset".

Additional information

A list of the technology alarms and alarm responses can be found in the appendix, Technology Alarms (Page 267).

9.4 Errors in Motion Control instructions

Description

Errors in Motion Control instructions (e.g. invalid parameter value setting) are indicated at the "Error" and "ErrorID" output parameters.

Under the following conditions, "Error" = TRUE and "ErrorID" = 16#8xxx are indicated at the Motion Control instruction:

- Invalid status of the technology object, which prevents the execution of the job.
- Invalid parameter assignment of the Motion Control instruction, which prevents the execution of the job.
- As a result of the alarm response for an error at the technology object.

Error indication

If an error occurs in a Motion Control instruction, the "Error" parameter shows the value TRUE. The cause of the error can be found in the value of the ErrorID" parameter.

Jobs at the technology object are rejected when "Error" = TRUE. Running jobs are not influenced by rejected jobs.

If "Error" = TRUE and "ErrorID" = 16#8001 are indicated during the job processing, then a technology alarm has occurred. In this case, evaluate the indication of the technology alarm.

If "Error" = TRUE is displayed during the execution of a "MC_MoveJog" job, the axis is braked and brought to a standstill. In this case, the deceleration configured with the "MC_MoveJog" instruction takes effect.

Acknowledge errors

Acknowledging errors in Motion Control instructions is not required.

Restart a job after resolving the error.

Additional information

A list of the ErrorIDs can be found in the appendix, Error Detection (Page 270).

9.5 Speed-controlled axis technology object

9.5.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the most important status and error messages for the technology object. The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Enabled	The technology object is enabled. The axis can be controlled with Motion Control instructions. (<TO>.StatusWord.Enable)
Error	An error has occurred at the technology object. Detailed information about the error is available in the "Errors" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.Error)
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.RestartActive)
Axis control panel enabled	The axis control panel is enabled. The axis control panel has master control over the technology object. The axis cannot be controlled from the user program. (<TO>.StatusWord.ControlPanelActive)
Drive switched on	The drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no active job)	No motion job is active at the technology object. (<TO>.StatusWord.Done)
Jog mode	The axis is being moved by a jog mode job from the Motion Control instruction "MC_MoveJog", or from the axis control panel. (<TO>.StatusWord.JogCommand)
Speed preset	The axis is traversed by means of a job with speed preset in Motion Control instruction "MC_MoveVelocity", or using the axis control panel. (<TO>.StatusWord.VelocityCommand)
Constant speed	The axis is being moved with constant speed. (<TO>.StatusWord.ConstantVelocity)
Accelerating	The axis is being accelerated. (<TO>.StatusWord.Accelerating)
Decelerating	The axis is being decelerated. (<TO>.StatusWord.Decelerating)

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration adapted	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.ConfigurationFault)
Job rejected	Instruction cannot be executed. A Motion Control instruction cannot be executed, because necessary preconditions are not met. (<TO>.WarningWord.CommandNotAccepted)
Dynamic response limiting	Dynamic values were limited to the dynamic limits. (<TO>.WarningWord.DynamicError)

Error

The following table shows the possible errors:

Error	Description
System	An internal system error has occurred. (<TO>.ErrorWord.SystemFault)
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.ConfigurationFault)
User program	Error in the user program in a Motion Control instruction, or in its utilization. (<TO>.ErrorWord.UserFault)
Drive	Error in the drive. (<TO>.ErrorWord.DriveFault)
Data transmission	Error in communication with a connected device. (<TO>.ErrorWord.CommunicationFault)
I/O	Error accessing a logical address. (<TO>.ErrorWord.PeripheralError)
Job rejected	Instruction cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been fulfilled (e.g. TO not homed). (<TO>.ErrorWord.CommandNotAccepted)
Dynamic response limiting	Dynamic values were limited to the dynamic limits. (<TO>.ErrorWord.DynamicError)

Acknowledge

Click "Acknowledge" to acknowledge alarms and warnings pending.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

9.5.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The Diagnostics function is available in online operation.

"Setpoints" area

This area displays the current setpoints.

The following table shows the meaning of the status data:

Status	Description
Current speed	Current speed setpoint for the axis (<TO>.Velocity)
Current speed override	Speed setpoint correction as percentage The speed setpoints specified in Motion Control instructions or at the axis control panel are superimposed with an override signal and corrected to a percentage value. Valid speed correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Dynamic limits" area

This area displays the limit values for the following dynamic parameters:

- Speed

  (<TO>.DynamicLimits.MaxVelocity)
- Acceleration

  (<TO>.DynamicLimits.MaxAcceleration)
- Deceleration

  (<TO>.DynamicLimits.MaxDeceleration)

9.5.3 PROFIdrive frame

Description

The "Technology object > Diagnostics > PROFIdrive frame" diagnostics function is used in the TIA Portal to monitor the PROFIdrive frame that the drive returns to the controller. The Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive frame that the drive returns to the controller:

- Status words "SW1" and "SW2"
- The setpoint speed that was output to the drive (NSET)
- The actual speed that was signaled from the drive (NACT)

9.6 Positioning axis technology object

9.6.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the most important status and error messages for the technology object. The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Enabled	The technology object is enabled. The axis can be controlled with Motion Control instructions. (<TO>.StatusWord.Enable)
Homed	The technology object is homed. The relationship between the position at the technology object and the mechanical position was successfully created. (<TO>.StatusWord.HomingDone)
Error	An error has occurred at the technology object. Detailed information about the error is available in the "Errors" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.Error)
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.RestartActive)
Axis control panel enabled	The axis control panel is enabled. The axis control panel has master control over the technology object. The axis cannot be controlled from the user program. (<TO>.StatusWord.ControlPanelActive)
Drive switched on	The drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Encoder valid	The encoder values are valid. (<TO>.StatusSensor[n].State)
Online start value changed	Restart-relevant data was changed. The changes will not be applied until after reinitialization (restart) of the technology object. (<TO>.StatusWord.OnlineStartValuesChanged)

Status limit switches

The following table shows possible enablements of the software and hardware limit switches:

Limit switch	Description
Negative software limit switch approached	The negative software limit switch was approached. (<TO>.StatusWord.SWLimitMinActive)
Positive software limit switch approached	The positive software limit switch was approached. (<TO>.StatusWord.SWLimitMaxActive)
Negative hardware limit switch approached	The negative hardware limit switch was approached. (<TO>.StatusWord.HWLimitMinActive)
Positive hardware limit switch approached	The positive hardware limit switch was approached or passed. (<TO>.StatusWord.HWLimitMaxActive)

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no active job)	No motion job is active at the technology object. (<TO>.StatusWord.Done)
Homing job	The technology object is executing a homing job from the Motion Control instruction "MC_Home", or from the axis control panel. (<TO>.StatusWord.HomingCommand)
Jog mode	The axis is being moved by a jog mode job from the Motion Control instruction "MC_MoveJog", or from the axis control panel. (<TO>.StatusWord.JogCommand)
Velocity setpoint	A job traverses the axis at the speed setpoint specified in Motion Control instruction "MC_MoveVelocity" or at the axis control panel. (<TO>.StatusWord.VelocityCommand)
Positioning job	The axis is being moved by a positioning job from the Motion Control instructions "MC_MoveAbsolute", "MC_MoveRelative", or from the axis control panel. (<TO>.StatusWord.PositioningCommand)
Constant velocity	The axis is being moved with constant velocity. (<TO>.StatusWord.ConstantVelocity)
Standstill	The axis is at a standstill. (<TO>.StatusWord.StandStill)
Accelerating	The axis is being accelerated. (<TO>.StatusWord.Accelerating)
Decelerating	The axis is being decelerated. (<TO>.StatusWord.Decelerating)

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration adapted	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.ConfigurationFault)
Job rejected	Instruction cannot be executed. A Motion Control instruction cannot be executed, because necessary preconditions are not met. (<TO>.WarningWord.CommandNotAccepted)
Dynamic response limiting	Dynamic values were limited to the dynamic limits. (<TO>.WarningWord.DynamicError)

Error

The following table shows the possible errors:

Error	Description
System	An internal system error has occurred. (<TO>.ErrorWord.SystemFault)
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.ConfigurationFault)
User program	Error in the user program in a Motion Control instruction, or in its utilization. (<TO>.ErrorWord.UserFault)
Drive	Error in the drive. (<TO>.ErrorWord.DriveFault)
Encoder	Error in the encoder system. (<TO>.ErrorWord.SensorFault)
Data transmission	Error in communication with a connected device. (<TO>.ErrorWord.CommunicationFault)
I/O	Error accessing a logical address. (<TO>.ErrorWord.PeripheralError)
Job rejected	Instruction cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been fulfilled (e.g. TO not homed). (<TO>.ErrorWord.CommandNotAccepted)
Homing	Error during a homing process. (<TO>.ErrorWord.HomingFault)
Positioning	The axis was not correctly positioned at the end of a positioning motion. (<TO>.ErrorWord.PositioningFault)

Error	Description
Dynamic response limiting	Dynamic values were limited to the dynamic limits. (<TO>.ErrorWord.DynamicError)
Following error	The maximum permitted following error was exceeded. (<TO>.ErrorWord.FollowingErrorFault)
SW limit switches	A software limit switch has been reached. (<TO>.ErrorWord.SwLimit)
Hardware limit switches	A hardware limit switch has been reached or overshot. (<TO>.ErrorWord.HWLimit)

Acknowledge

Click "Acknowledge" to acknowledge alarms and warnings pending.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

9.6.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The Diagnostics function is available in online operation.

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Target position	Current target position of an active positioning job The target position value is only valid while a positioning job is busy. (<TO>.StatusPositioning.TargetPosition)
Current position	Actual axis position If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Current velocity	Actual axis velocity (<TO>.ActualVelocity)
Current velocity override	Percentage correction of the velocity override The velocity setpoints specified in Motion Control instructions or at the axis control panel are superimposed with an override signal and corrected to a percentage value. Valid velocity correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Dynamic limits" area

The limit values for the following dynamic parameters are displayed in this area:

- Velocity

  (<TO>.DynamicLimits.MaxVelocity)
- Acceleration

  (<TO>.DynamicLimits.MaxAcceleration)
- Deceleration

  (<TO>.DynamicLimits.MaxDeceleration)

9.6.3 PROFIdrive frame

Description

The "Technology object > Diagnostics > PROFIdrive frame" diagnostics function is used in the TIA Portal to monitor the PROFIdrive frame returned by the drive and encoder. The display of the Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive frame that the drive returns to the controller:

- Status words "SW1" and "SW2"
- The setpoint speed that was output to the drive (NSET)
- The actual speed that was signaled from the drive (NACT)

"Encoder" area

This area displays the following parameters contained in the PROFIdrive frame that the encoder returns to the controller:

- The status word "Gn_SW"
- The actual position value "Gn_XIST1" (cyclical actual encoder value)
- The actual position value "Gn_XIST2" (absolute value of the encoder)

9.7 External encoder technology object

9.7.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the most important status and error messages for the technology object. The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Encoder status

The following table shows the possible external encoder status values:

Status	Description
Enabled	The technology object is enabled. (<TO>.StatusWord.Enable)
Homed	The technology object is homed. The relationship between the position at the technology object and the mechanical position was successfully created. (<TO>.StatusWord.HomingDone)
Error	An error has occurred at the technology object. Detailed information about the error is available in the "Errors" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.Error)
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.RestartActive)
Encoder valid	The encoder values are valid. (<TO>.StatusSensor[n].State)

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no active job)	No active Motion Control job at the TO. (Release by "MC_Power" job excepted) (<TO>.StatusWord.Done)
Homing job	The technology object is executing a homing job from the Motion Control instruction "MC_Home". (<TO>.StatusWord.HomingCommand)

Errors

The following table shows the possible errors:

Error	Description
System	An internal system error has occurred. (<TO>.ErrorWord.SystemFault)
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.ConfigurationFault)
User program	Error in the user program in a Motion Control instruction, or in its utilization. (<TO>.ErrorWord.UserFault)
Encoder	Error in the encoder system. (<TO>.ErrorWord.SensorFault)
Data transmission	Missing or faulty communication. (<TO>.ErrorWord.CommunicationFault)

Acknowledgement

Click "Acknowledge" to acknowledge alarms and warnings pending.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

9.7.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the encoder values. The Diagnostics function is available in online operation.

The following table shows the meaning of the status data:

Status	Description
Current position	The "Current position" field displays the actual position value. If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Current velocity	The "Current velocity" field displays the actual velocity value. (<TO>.ActualVelocity)

9.7.3 PROFIdrive frame

Description

The "Technology object > Diagnostics > PROFIdrive interface" diagnostic function is used in the TIA Portal to monitor the PROFIdrive frame of the encoder. The display of the diagnostics function is available in the online mode TO.

"Encoder" area

This area displays the following parameters contained in the PROFIdrive frame that the encoder returns to the controller:

- The status word "Gn_SW"
- The actual position value "Gn_XIST1" (cyclical actual encoder value)
- The actual position value "Gn_XIST2" (absolute value of the encoder)

Reference 10

10.1 S7-1500 Motion Control

10.1.1 MC_Power

10.1.1.1 MC_Power: Enable, disable technology objects

Description

The Motion Control instruction "MC_Power" is used to enable and disable technology objects.

Applies to

- Positioning axis
- Speed-controlled axis
- External encoder

Requirements

- The technology object has been configured correctly.

Override response

- A MC_Power job cannot be aborted by any other Motion Control job.
- A MC_Power job with the parameter Enable = TRUE enables a technology object, but does not thereby abort any other Motion Control instructions.
- Disabling the technology object (parameter "Enable" = FALSE) aborts all Motion Control jobs at the corresponding technology object in accordance with the selected "StopMode". This process cannot be aborted by the user.

Parameter

The following table shows the parameters of the "MC_POWER" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_Axis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The technology object is enabled.
				FALSE	The technology object is disabled. All current jobs at the technology object are aborted in accordance with the configured "StopMode".
StopMode	INPUT	INT	0	Not applicable to the external encoder technology object. If you disable a technology object with a falling edge at the Enable parameter, then the axis decelerates in accordance with the selected StopMode.	
				0	Emergency stop When the technology object is disabled, the axis brakes to a standstill without any jerk limitation, using the emergency stop deceleration configured in Technology object > Configuration > Extended parameters > Emergency stop ramp. Enabling is then removed. (<TO>.DynamicDefaults. EmergencyDeceleration)
				1	Immediate stop When a technology object is disabled, the setpoint zero is output, and the enabling is removed. The axis is braked depending on the configuration in the drive, and is brought to a standstill.
				2	Stop with maximum dynamic values When the technology object is disabled, the axis brakes to a standstill using the maximum deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic limits". The configured maximum jerk is taken into account at the same time. Enabling is then removed. (<TO>.DynamicLimits.MaxDeceleration; <TO>.DynamicLimits.MaxJerk)

Parameter	Declaration	Data type	Default value	Description	
Status	OUTPUT	BOOL	FALSE	Technology object enable status	
				FALSE	Disabled - A positioning axis or speed-controlled axis does not accept any Motion Control jobs. - Speed control and position control are not active. - The actual values of the technology object are not checked for validity.
				TRUE	Enabled - An enabled positioning axis or speed-controlled axis accepts Motion Control jobs. - Speed control and positioning control are active. - The actual values of the technology object are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred in Motion Control instruction MC_Power. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Enabling technology objects

To enable a technology object, set the Enable parameter to TRUE.

If the Status parameter shows the value TRUE, then the technology object is enabled.

If an axis is in motion when the technology object is enabled (actual velocity is present), then the axis brakes to the setpoint zero, using the maximum deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic limits" (<TO>.DynamicLimits.MaxDeceleration). This braking ramp can be overridden by Motion Control jobs.

Note

Automatic enabling after acknowledgement of a technology alarm

If the technology object is disabled due to a technology alarm, then it will automatically be enabled again after the cause has been eliminated and the alarm has been acknowledged. This requires the Enable parameter to have retained the value TRUE during this process.

Disabling technology objects

To disable a technology object, set the Enable parameter to FALSE.

If an axis is in motion, then it will be braked to a standstill according to the selected "StopMode".

If the "Busy" and "Status" parameters show the value FALSE , then the disabling of the technology object has been completed.

Drive connection by means of PROFIdrive

When coupling a drive with PROFIdrive, the setpoint, enabling, and drive status are transmitted via the PROFIdrive frame.

- **Enable technology object and drive**

  The parameter ""Enable" = TRUE" is used to enable the technology object.
  The drive is enabled according to the PROFIdrive standard.

  If the tag <TO>.StatusDrive.InOperation shows the value TRUE , then the drive is ready to execute setpoints. The "Status" parameter is set to the value TRUE .

- **Disable technology object and drive**

  With the parameter "Enable" = FALSE, the "Status" parameter is set to the value FALSE, and the axis is braked according to the selected "StopMode". The drive is disabled according to the PROFIdrive standard.

Analog drive connection

The setpoint is output via an analog output. Optionally, you can configure an enabling signal via digital output (<TO>.Actor.Interface.EnableDriveOutput), and a readiness signal via digital input (<TO>.Actor.Interface.DriveReadyInput).

- **Enable technology object and drive**

  With the parameter "Enable" = TRUE, the enabling output ("Enable drive output") is set.

  If the drive reports back the readiness signal via the ready input ("Drive ready input"), then the "Status" parameter and the technology object's <TO>.StatusDrive.InOperation tag are set to TRUE, and the setpoint is switched at the analog output.

- **Disable technology object and drive**

  With the parameter "Enable" = FALSE, the "Status" parameter is set to the value FALSE, and the axis is braked according to the selected "StopMode". When the setpoint zero is reached, the enabling output is set to FALSE.

Additional information

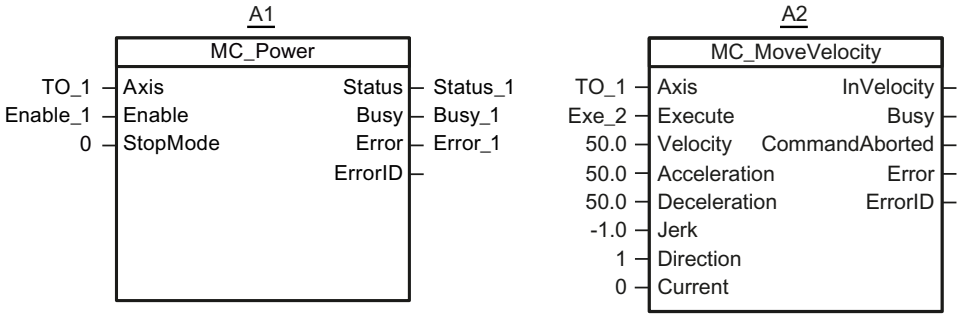
Additional information on enabling and disabling technology objects and drives can be found in the appendix, MC_Power Function Charts (Page 272).

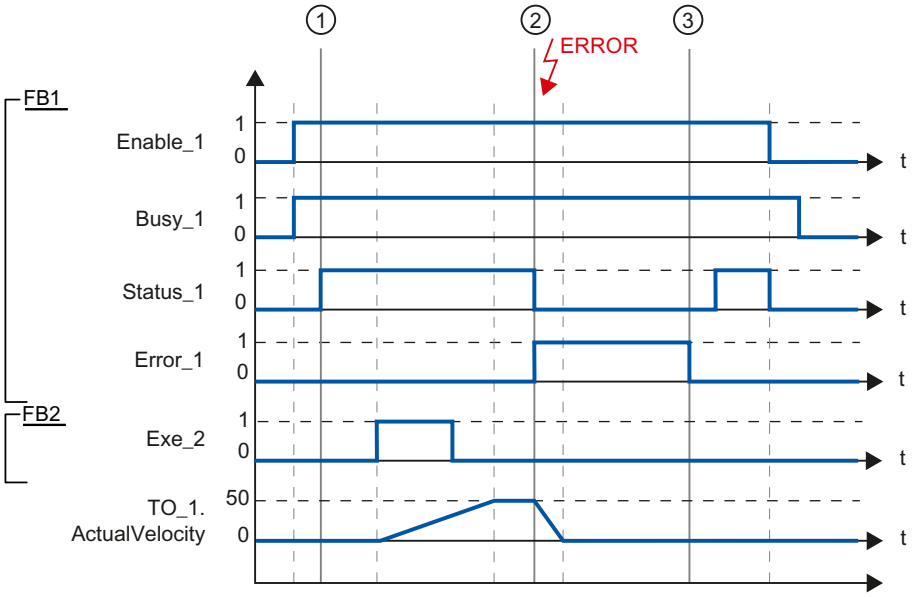
See also

Error ID (Page 270)

10.1.1.2 MC_Power: Function chart

Function chart: Enabling a technology object, and example for alarm response





A technology object is enabled with "Enable_1= TRUE". Successful enabling can be read from "Status_1" at time ①. The axis will then move with an "MC_MoveVelocity" job (A2). The velocity profile of the axis can be read from "Velocity Axis_1".

At time ② an error occurs in the technology object, which results in the disabling of the technology object (alarm response: remove enable). The axis is braked depending on the configuration in the drive, and is brought to a standstill. When the technology object is disabled, Status_1 is reset. Since the axis was not disabled using "Enable_1" = FALSE, the selected "StopMode" does not apply. The cause of the error is corrected and the alarm is acknowledged at time ③.

Since "Enable_1" is still set, the technology object is enabled again. Successful enabling can be read from "Status_1". Next the technology object is disabled with "Enable_1" = FALSE.

10.1.2 MC_Home

10.1.2.1 MC_Home: Homing technology objects, setting home position

Description

With the Motion Control instruction "MC_Home", you create the relationship between the position in the technology object and the mechanical position. The position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

The homing process occurs according to the mode selected with the "Mode" parameter, and the configuration under "Technology object > Configuration > Extended parameters > Homing".

The preset values under "Technology object > Configuration > Extended parameters > Dynamic default values" are used for the dynamic values Acceleration, Deceleration and Jerk.

Applies to

- Positioning axis
- External encoder

The following table shows which modes are possible with each of the technology objects:

Operating mode	Positioning axis with incremental encoder	Positioning axis with absolute encoder	External incremental encoder	External absolute encoder
Active homing (Mode = 4, 5)	X	-	-	-
Passive homing (Mode = 2, 3, 8)	X	-	X	-
Setting a positioning value ("Mode" = 0)	X	X	X	X
Relative shift of the actual value ("Mode" = 1)	X	X	X	X
Homing absolute encoder ("Mode" = 6, 7)	-	X	-	X

Requirements

- The technology object has been configured correctly.
- "Mode" = 2, 3, 4, 5, 8
  The technology object must be enabled.
- "Mode" = 0, 1, 2, 6, 7
  The encoder values must be valid. (<TO>.StatusSensor[n].State = 2)

Override response

- An MC_Home job for passive homing is aborted by:
  - Disabling the technology object by means of "MC_Power.Enable" = FALSE
  - "MC_Home" job with parameter "Mode" = 4, 5, 9
- An "MC_Home" job for passive homing does not abort any other Motion Control jobs.
- An "MC_Home" job for active homing is aborted by:
  - Disabling the technology object with "MC_Power.Enable" = FALSE
  - "MC_Home" job "Mode" = 4, 5
  - "MC_Halt" job
  - "MC_MoveAbsolute" job
  - "MC_MoveRelative" job
  - "MC_MoveVelocity" job
  - "MC_MoveJog" job
- An "MC_Home" job for active homing aborts the following running Motion Control jobs.
  - "MC_Home" job with parameter "Mode" = 2, 3, 4, 5
  - "MC_Halt" job
  - "MC_MoveAbsolute" job
  - "MC_MoveRelative" job
  - "MC_MoveVelocity" job
  - "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_Home" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_Axis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge	
Position	INPUT	LREAL	0.0	The specified value is used according to the selected "Mode".	
Mode	INPUT	INT	0	Operating mode	
				0	Direct homing (absolute) The current position of the technology object is set to the value of parameter "Position".
				1	Direct homing (relative) The current position of the technology object is shifted by the value of parameter "Position".
				2	Passive homing When the homing mark is detected, the actual value is set to the value of the "Position" parameter.
				3	Passive homing ("Position" parameter has no effect) When the homing mark is detected, the actual value is set to the home position configured under "Technology object > Configuration > Extended parameters > Homing > Passive homing". (<TO>.Homing.HomePosition)
				4	Active homing The TO positioning axis performs a homing movement according to the configuration. After the completion of the movement, the axis is positioned at the value of the "Position" parameter.
				5	Active homing ("Position" parameter has no effect) The TO positioning axis performs a homing movement according to the configuration. After completion of the movement, the axis is positioned at the home position configured under "Technology object > Configuration > Extended parameters > Homing > Active homing". (<TO>.Homing.HomePosition)

Parameter	Declaration	Data type	Default value	Description	
				6	Absolute value adjustment (relative) The current position is set to the value of the parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[n].AbsEncoderOffset)
				7	Absolute value adjustment (absolute) The current position is set to the value of the parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[n].AbsEncoderOffset)
				8	Passive homing (without reset) Functions like mode 2, with the difference that the "homed" status is **not** reset when the function is enabled.
				9	Canceling passive homing A running job for passive homing is aborted.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Resetting the "Homed" status

The "Homed" status of a technology object is reset under the following conditions (<TO>.StatusWord.HomingDone):

- **Technology objects with incremental actual values:**
  - Starting an "MC_Home" job with "Mode" = 2, 3, 4, 5

    (After successful completion of the homing operation, the "Homed" status is reset.)
  - Error in the encoder system, or encoder failure
  - Restart of the technology object
  - After POWER OFF -> POWER ON of the CPU
  - Memory reset
  - Modification of the encoder configuration
- **Technology objects with absolute actual values:**
  - Restoration of the CPU factory settings
  - Modification of the encoder configuration
  - Replacement of the CPU

Homing a technology object with "Mode" = 1..8

To home a technology object, follow these steps:

1. Check the requirements indicated above.
2. Specify the desired homing function in the "Mode" parameter.
3. Initialize the necessary parameters with values, and start the homing operation with a positive edge at the "Execute" parameter.

If the "Done" parameter shows the value TRUE, then the "MC_Home" job has been completed according to the selected "Mode". The "Homed" status of the technology object is indicated under "Technology object > Diagnostics > Status and error bits > Motion status > Homed" (<TO>.StatusWord.HomingDone).

Termination of a passive homing process with "Mode" = 9

With "Mode" = 9, the technology object is not homed. If a running "MC_Home" job for passive homing ("Mode" = 2, 3, 8) is overridden by another "MC_Home" job with "Mode" = 9, then the running job is terminated with the parameter "CommandAborted" = TRUE.
The overriding job with "Mode" = 9 signals successful execution with the parameter "Done" = TRUE.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

See also

Error ID (Page 270)

10.1.3 MC_MoveJog

10.1.3.1 MC_MoveJog: Moving axes in jog mode

Description

With the Motion Control instruction "MC_MoveJog", you can move an axis in jog mode.

Dynamic behavior during movement is defined with the parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

- Positioning axis:

  A velocity is specified in the "Velocity" parameter.
- Speed-controlled axis:

  A speed is specified at the "Velocity" parameter.

Applies to

- Positioning axis
- Speed-controlled axis

Requirements

- The technology object has been configured correctly.
- The technology object is enabled.

Override response

The "MC_MoveJog" job is aborted by:

- Disabling the axis with "MC_Power.Enable" = FALSE
- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Starting a "MC_MoveJog" job aborts the following active Motion Control jobs:

- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_MoveJog" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_SpeedAxis	-	Technology object	
JogForward	INPUT	BOOL	FALSE	As long as the parameter is TRUE, the axis moves in the positive direction at the velocity specified in parameter "Velocity".	
JogBackward	INPUT	BOOL	FALSE	As long as the parameter is TRUE, the axis moves in the negative direction at the velocity specified in parameter "Velocity".	
Velocity	INPUT	LREAL	100.0	Setpoint speed / setpoint speed for the motion process Value > 0.0: The specified value is used. Value < 0.0: The specified value is used. ("Velocity" = 0.0 is permitted)	
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used. Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The setpoint velocity / setpoint speed was reached and will be maintained.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.

Parameter	Declaration	Data type	Default value	Description	
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Behavior with setpoint velocity / setpoint speed zero (Velocity" = 0.0)

An "MC_MoveJog" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the setpoint velocity / setpoint speed zero is reached, the parameter "InVelocity" will indicate the value TRUE.

Under "Technology object > Diagnostics > Status and error bits > Motion status", "constant velocity" and "standstill" will be displayed (<TO>.StatusWord.ConstantVelocity; <TO>.StatusWord.Standstill).

Moving an axis in jog mode

Proceed as follows to move an axis in jog mode:

1. Check the requirements indicated above.
2. Move the axis in the positive direction with "JogForward", or in the negative direction with "JogBackward".

The current motion state is indicated in "Busy", "InVelocity" and "Error".

Note

Behavior when changing the override

If the velocity / speed is influenced during constant motion by a change in the override (<TO>.Override.Velocity), then the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity is reached ("Velocity" × "Override" %), then "InVelocity" is set again.

Additional information

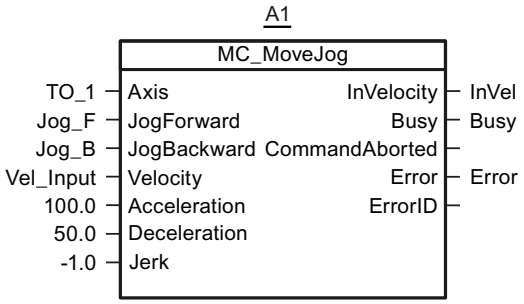
An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

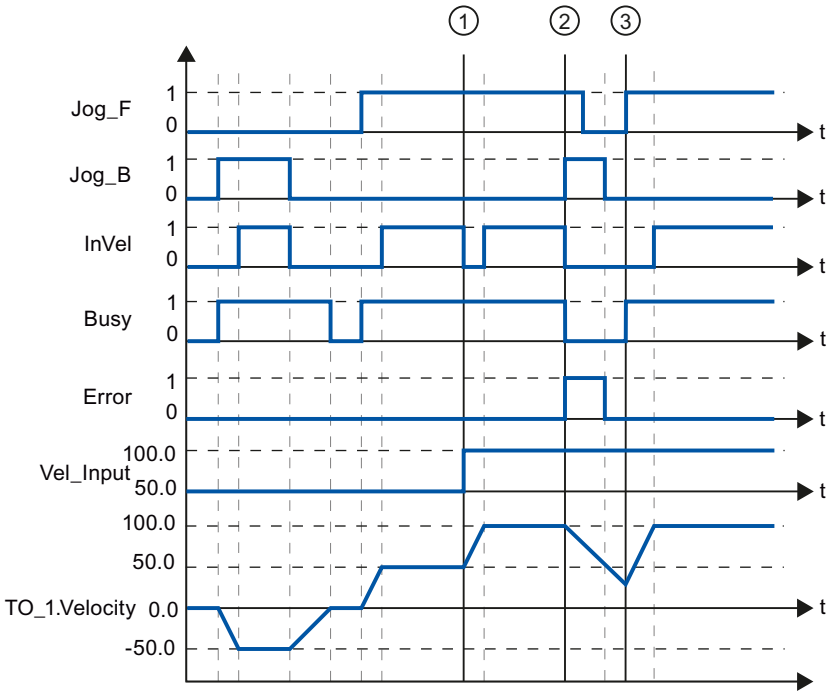
See also

Error ID (Page 270)

10.1.3.2 MC_MoveJog: Function chart

Function chart: Moving an axis in jog mode





The axis is moved in the negative direction in jog mode via "Jog_B". When the setpoint velocity -50.0 is reached, this is signaled via "InVel" = TRUE. After "Jog_B" is reset, the axis is braked and brought to a standstill. Then the axis is moved in the positive direction via "Jog_F". When the setpoint velocity 50.0 is reached, this is signaled via "InVel" = TRUE.

At time ①, if "Jog_F" is set, the setpoint velocity is changed to 100.0 by means of "Vel_Input". Alternatively, you can also change the setpoint velocity via the velocity override. "InVel" is reset. The axis is being accelerated. When the new setpoint velocity 100.0 is reached, this is signaled via "InVel" = TRUE.

If "Jog_F" is set, "Jog_B" is likewise set at time ②. If both "Jog_F" and "Jog_B" are set, then the axis is braked with the last applicable deceleration. An error is indicated via "Error", and the "ErrorID" of the error 16#8007 (incorrect direction specification) is output.

This error is resolved by resetting the two inputs "Jog_F" and "Jog_B".

During the braking ramp, "Jog_F" is set at time ③. The axis is accelerated to the last configured velocity. When the setpoint velocity 100.0 is reached, this is signaled via "InVel" = TRUE.

10.1.4 MC_MoveVelocity

10.1.4.1 MC_MoveVelocity: Moving axes with the specified speed

Description

With the Motion Control instruction "MC_MoveVelocity", you can move an axis with a constant velocity.

Dynamic behavior during movement is defined with the parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

- Positioning axis:

  A velocity is specified in the "Velocity" parameter.
- Speed-controlled axis:

  A speed is specified at the "Velocity" parameter.

Applies to

- Positioning axis
- Speed-controlled axis

Requirements

- The technology object has been configured correctly.
- The technology object is enabled.

Override response

The "MC_MoveVelocity" is aborted by:

- Disabling the axis with "MC_Power.Enable" = FALSE
- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Starting a "MC_MoveVelocity" job aborts the following active Motion Control jobs:

- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_MoveVelocity" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_SpeedAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge	
Velocity	INPUT	LREAL	100.0	Setpoint speed / setpoint speed for the motion process ("Velocity" = 0.0 is permitted)	
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used. Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Direction	INPUT	INT	0	Direction of rotation of the axis	
				0	The sign of the velocity specified at the "Velocity" parameter defines the direction of rotation.
				1	Positive direction of rotation Value of "Velocity" is used.
				2	Negative direction of rotation Value of "Velocity" is used.

Parameter	Declaration	Data type	Default value	Description	
Current	INPUT	BOOL	FALSE	Maintain current velocity	
				FALSE	Disabled The values of parameters "Velocity" and "Direction" are taken into account.
				TRUE	Enabled The values at the parameters "Velocity" and "Direction" are **not** taken into account. The current velocity and direction at function start are retained. When the axis resumes motion at the velocity that was current at function start, the "InVelocity" parameter returns the value TRUE.
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The setpoint velocity / setpoint speed was reached and will be maintained.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Behavior with setpoint velocity / setpoint speed zero (Velocity" = 0.0)

An "MC_MoveVelocity" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the setpoint velocity / setpoint speed zero is reached, the parameter "InVelocity" will indicate the value TRUE.

Under "Technology object > Diagnostics > Status and error bits > Motion status", "constant velocity" and "standstill" will be displayed (<TO>.StatusWord.ConstantVelocity; <TO>.StatusWord.Standstill).

The parameters "InVelocity" and "Busy" show the value TRUE, until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Moving an axis with constant velocity / speed

Proceed as follows to move an axis with constant velocity / speed:

1. Check the requirements indicated above.
2. At the parameter "Velocity", specify the velocity / speed, with which the axis should be moved.
3. Start the "MC_MoveVelocity" job with a positive edge at the parameter "Execute".

The current motion state is indicated in "Busy", "InVelocity" and "Error".

If the "InVelocity" parameter shows the value TRUE, then the setpoint velocity / setpoint speed was reached. The axis continues moving at this constant velocity. The parameters "InVelocity" and "Busy" show the value TRUE, until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Note

Behavior when changing the override

If the velocity / speed is influenced during constant motion by a change in the override (<TO>.Override.Velocity), then the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity / speed is reached ("Velocity" × "Override" %), then "InVelocity" is reset.

Additional information

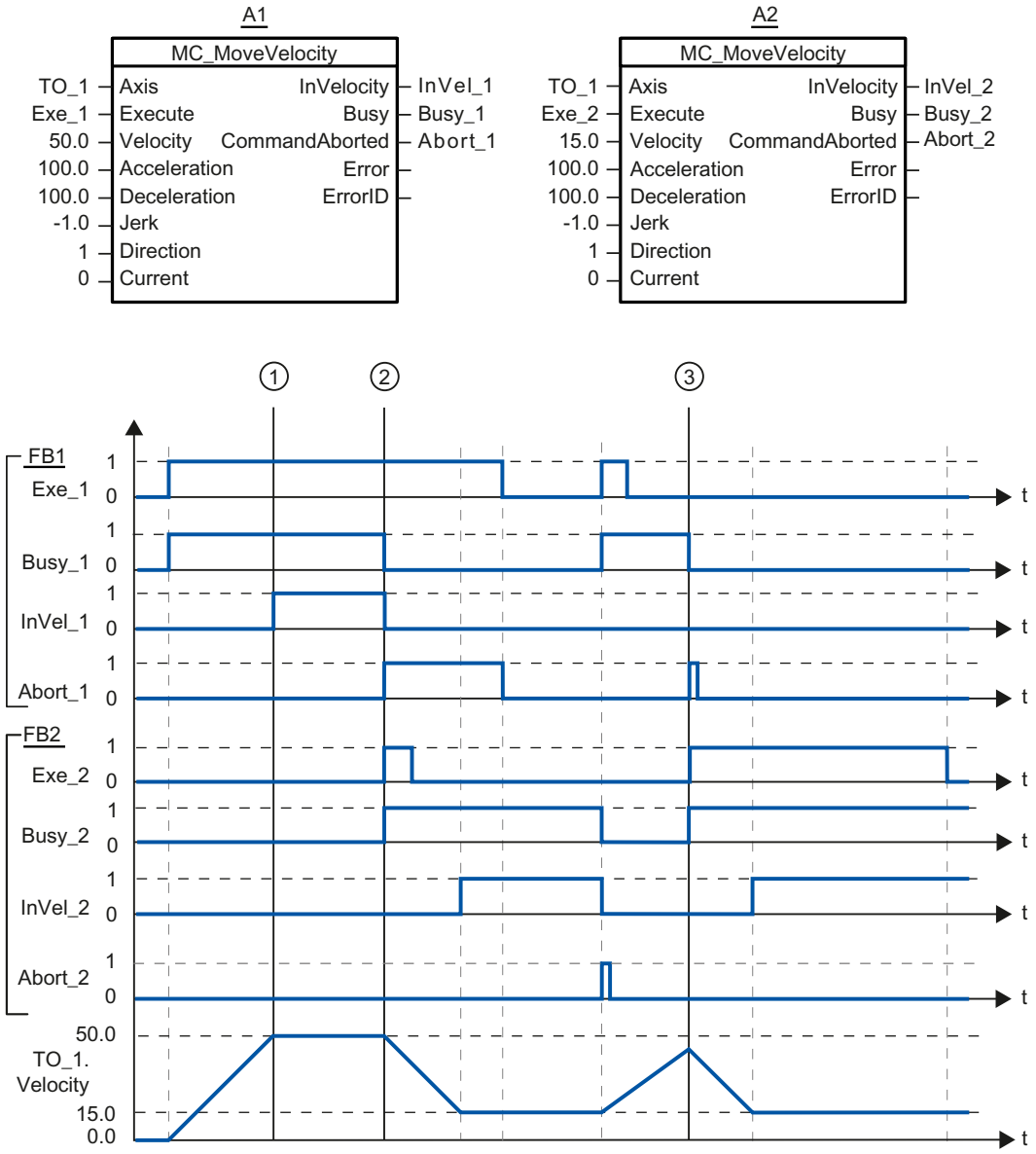
An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

See also

Error ID (Page 270)

10.1.4.2 MC_MoveVelocity: Function chart

Function chart: Moving an axis with specification of velocity, and the response to an overriding job



A "MC_MoveVelocity" job (A1) initiated via "Exe_1" accelerates the axis and signals at time ① via "InVel_1" that the setpoint velocity 50.0 has been reached.

At time ②, the task is overridden via another "MC_MoveVelocity" job (A2). The abort is signaled via "Abort_1". When the new setpoint velocity 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

The running "MC_MoveVelocity" job (A2) is overridden by another "MC_MoveVelocity" job (A1). The abort is signaled via "Abort_2". The axis is accelerated to the new setpoint velocity 50.0. Before the setpoint velocity is reached, the current "MC_MoveVelocity" job A1) is overridden at time ③ by another "MC_MoveVelocity" job A2). The abort is signaled via "Abort_1". When the new setpoint velocity 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

10.1.5 MC_MoveRelative

10.1.5.1 MC_MoveRelative: Relative positioning of axes

Description

With the Motion Control instruction "MC_MoveRelative", you can move an axis relative to the position that exists at the beginning of job processing.

Dynamic behavior during movement is defined with the parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

Applies to

- Positioning axis

Requirements

- The technology object has been configured correctly.
- The technology object is enabled.

Override response

The "MC_MoveRelative" job is aborted by:

- Disabling the axis with "MC_Power.Enable" = FALSE
- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Starting a "MC_MoveRelative" job aborts the following active Motion Control jobs:

- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_MoveRelative" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_Positioning Axis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge	
Distance	INPUT	LREAL	0.0	Distance for the positioning process (negative or positive)	
Velocity	INPUT	LREAL	-1.0	Setpoint velocity for the positioning Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The velocity configured in "Technology object > Configuration > Advanced parameters > Default dynamics" is used. (<TO>.DynamicDefaults.Velocity)	
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Done	OUTPUT	BOOL	FALSE	TRUE	Target position reached
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.

Parameter	Declaration	Data type	Default value	Description	
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Moving an axis relative to the starting position

Proceed as follows to move an axis relative to the starting position:

1. Check the requirements indicated above.
2. Specify distance to be moved in the "Distance" parameter.
3. Start the "MC_MoveRelative" job with a positive edge at the parameter "Execute".

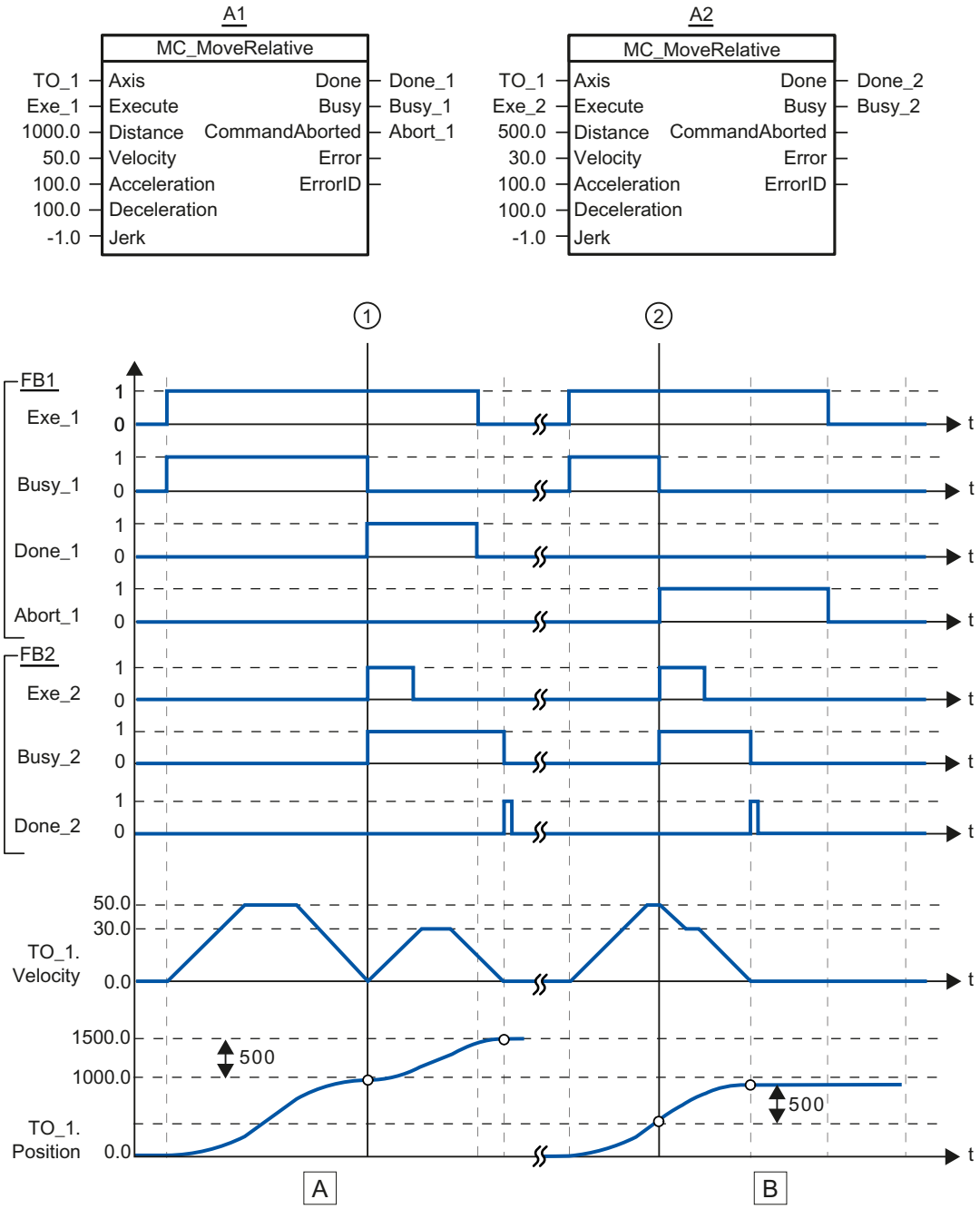
The current motion state is indicated in "Busy", "Done" and "Error".

See also

Error ID (Page 270)

10.1.5.2 MC_MoveRelative: Function chart

Function chart: Relative positioning of an axis, and the response to an overriding job



Section A	The axis is moved by an "MC_MoveRelative" job (A1) by the distance ("Distance") 1000.0 (the starting position here is 0.0). When the axis reaches the target position, this is signaled at time ① via "Done_1". At this time ①, another "MC_MoveRelative" job (A2) with distance 500.0 is started. When the axis reaches the new target position, this is signaled via "Done_2". Since "Exe_2" was previously reset, "Done_2" is applied only to one cycle.
Section B	A running "MC_MoveRelative" job (A1) is overridden by another "MC_MoveRelative" job (A2). The abort is signaled at time ② via "Abort_1". The axis is then moved at the new velocity by the distance ("Distance") 500.0. When the new target position is reached, this is signaled via "Done_2".

10.1.6 MC_MoveAbsolute

10.1.6.1 MC_MoveAbsolute: Absolute positioning of axes

Description

With the Motion Control instruction "MC_MoveAbsolute", you can move an axis to an absolute position.

Dynamic behavior during movement is defined with the parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

Applies to

- Positioning axis

Requirements

- The technology object has been configured correctly.
- The technology object is enabled.
- The technology object is homed.

Override response

The "MC_MoveAbsolute" job is aborted by:

- Disabling the axis with "MC_Power.Enable" = FALSE
- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Starting a "MC_MoveAbsolute" job aborts the following active Motion Control jobs:

- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_MoveAbsolute" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description
Axis	InOut	TO_Positioning Axis	-	Technology object
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge
Position	INPUT	REAL	0.0	Absolute target position
Velocity	INPUT	LREAL	-1.0	Setpoint velocity for the positioning Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The velocity configured in "Technology object > Configuration > Advanced parameters > Default dynamics" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
Direction	INPUT	INT	3	Direction of rotation of the axis Is only evaluated with "modulo" enabled. "Technology object > Configuration > Basic parameters > Enable modulo
				1 Positive direction of rotation
				2 Negative direction of rotation
				3 Shortest path
Done	OUTPUT	BOOL	FALSE	TRUE Target position reached.

Parameter	Declaration	Data type	Default value	Description	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Moving an axis to an absolute position

Proceed as follows to move an axis to an absolute position:

1. Check the requirements indicated above.
2. Specify the desired target position at the "Position" parameter.
3. Start the "MC_MoveAbsolute" job with a positive edge at the parameter "Execute".

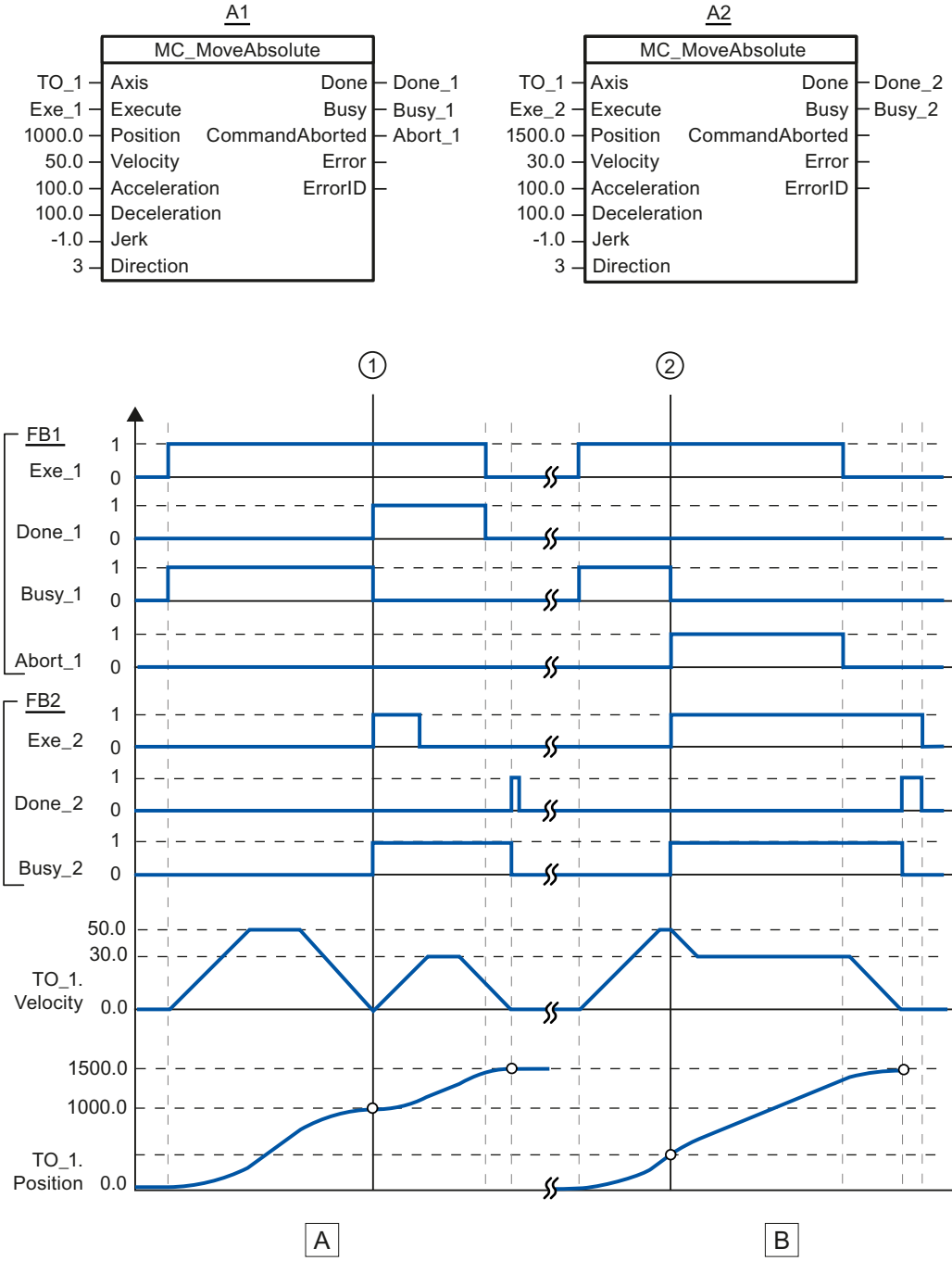
The current motion state is indicated in "Busy", "Done" and "Error".

See also

Error ID (Page 270)

10.1.6.2 MC_MoveAbsolute: Function chart

Function chart: Absolute positioning of an axis, and the response to an overriding job



Section A	An axis is moved to absolute position 1000.0 with an "MC_MoveAbsolute" job (A1). When the axis reaches the target position, this is signaled at time ① via "Done_1". At this time ①, another "MC_MoveAbsolute" job (A2) with target position 1500.0 is started. When the axis reaches the target position 1500.0, this is signaled via "Done_2". Since "Exe_2" was previously reset, "Done_2" is applied only to one cycle.
Section B	A running "MC_MoveAbsolute" job (A1) is overridden at time ② by another "MC_MoveAbsolute" job (A2). The abort is signaled via "Abort_1". The axis is braked to the changed velocity and moved to the new target position 1500.0. When the new target position is reached, this is signaled via "Done_2".

10.1.7 MC_Halt

10.1.7.1 MC_Halt: Halt axis

Description

With the Motion Control instruction "MC_Halt", you can brake an axis to a standstill.

Dynamic behavior during the braking process is defined with the parameters "Jerk" and "Deceleration".

Applies to

- Positioning axis
- Speed-controlled axis

Requirements

- The technology object has been configured correctly.
- The technology object is enabled.

Override response

The "MC_Halt" job is aborted by:

- Disabling the axis with "MC_Power.Enable" = FALSE
- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Starting a "MC_Halt" job aborts the following active Motion Control jobs:

- "MC_Home" job "Mode" = 4, 5
- "MC_Halt" job
- "MC_MoveAbsolute" job
- "MC_MoveRelative" job
- "MC_MoveVelocity" job
- "MC_MoveJog" job

Parameter

The following table shows the parameters of the "MC_Halt" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_Speed Axis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Done	OUTPUT	BOOL	FALSE	TRUE	Zero velocity reached
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Braking an axis with "MC_Halt"

Proceed as follows to decelerate an axis to a standstill:

1. Check the requirements indicated above.
2. Supply the parameters "Deceleration" and "Jerk" with the desired values.
3. Start the "MC_Halt" job with a positive edge at the parameter "Execute".

The current motion state is indicated in "Busy", "Done" and "Error". The standstill of the axis is indicated under "Technology object > Diagnostics > Status and error bits > Motion status > Standstill" (<TO>.StatusWord.Standstill).

Additional information

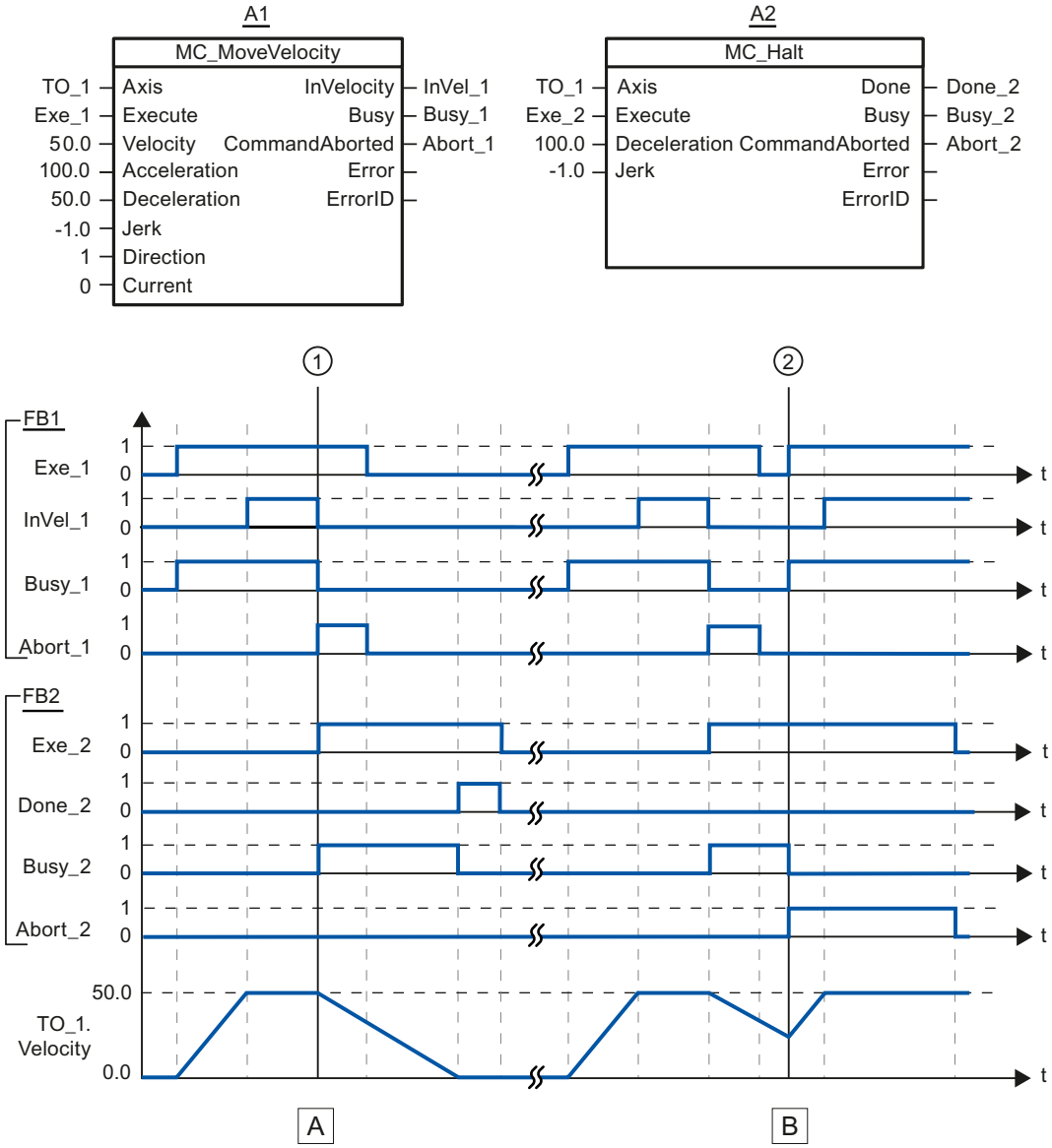
An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

See also

Error ID (Page 270)

10.1.7.2 MC_Halt: Function chart

Function chart: Stopping an axis, and the response to an overriding job



Section A	An axis is moved with an "MC_MoveVelocity" job (A1). When the setpoint velocity 50.0 is reached, this is signaled via "InVel_1". At time ①, the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job termination is signaled via "Abort_1". The axis is braked to a standstill. Successful completion of the "MC_Halt" job is signaled via "Done_2".
Section B	The axis is moved with an "MC_MoveVelocity" job (A1). When the setpoint velocity 50.0 is reached, this is signaled via "InVel_1". Next the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job termination is signaled via "Abort_1". During the braking process the "MC_Halt" job is overridden at time ② by an "MC_MoveVelocity" job (A1). The job termination is signaled via "Abort_2". When the setpoint velocity 50.0 is reached, this is signaled via "InVel_1". The axis is then moved with constant velocity.

10.1.8 MC_Reset

10.1.8.1 MC_Reset: Acknowledging alarms, restarting technology objects

Description

All technology alarms that can be acknowledged in the user program are acknowledged with the Motion Control instruction "MC_Reset". Acknowledgment also resets the "Error" and "Warning" bits in the technology data block.

Technology objects are reinitialized (restarted) using the Motion Control instruction "MC_Reset" with "Restart" = TRUE. Upon restart of the technology object, the new configuration data are applied in the technology data block.

Applies to

- Positioning axis
- Speed-controlled axis
- External encoder

Requirements

- The cause of the error for a pending technology alarm has been resolved.
- For a restart, the technology object must be disabled.
  ("MC_Power.Status" = FALSE and "MC_Power.Busy" = FALSE)

Override response

- Parameter "Restart" = FALSE:

Processing of the instruction "MC_Reset" can be aborted by other Motion Control jobs. The MC_Reset job does not abort any running Motion Control jobs.

- Parameter "Restart" = TRUE:

The processing of the instruction "MC_Reset" with parameter "Restart" = TRUE cannot be aborted by any other Motion Control job.

Parameter

The following table shows the parameters of the "MC_Reset" Motion Control instruction:

Parameter	Declaration	Data type	Default value	Description	
Axis	InOut	TO_Axis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start of the job with a positive edge	
Restart	INPUT	BOOL	FALSE	TRUE	"Restart" Reinitialization of the technology object and acknowledgment of pending technology alarms. The technology object is reinitialized with the configured initial values.
				FALSE	Acknowledgement of queued technology alarms.
Done	OUTPUT	BOOL	FALSE	TRUE	Error has been acknowledged. Restart has been executed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being executed.
Command Aborted	OUTPUT	BOOL	FALSE	TRUE	During execution the job was aborted by another job.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 270) for parameter "Error"	

Acknowledging technology alarms

To acknowledge technology alarms, follow these steps:

1. Check the requirements indicated above.
2. Set the parameter "Restart" = FALSE.
3. Start the acknowledgement of the error with a positive edge at parameter "Execute".

If the Done parameter shows the value TRUE, then the error was acknowledged.

Note

Acknowledging with "Restart" = FALSE

If only the technology alarms are to be acknowledged, set "Restart" = FALSE,
The technology object cannot be used during a restart.

Restarting a technology object

Proceed as follows to restart a technology object:

1. Check the requirements indicated above.
2. Set the parameter "Restart" = TRUE.
3. Perform the restart with a positive edge at the input parameter "Execute".

If the "Done" parameter shows the value TRUE, then the restart of the technology object has been completed.

Additional information on a restart can be found in the Restarting Technology Objects (Page 163) section.

See also

Error ID (Page 270)

Appendix A

A.1 Technology data block tags

A.1.1 Legend

D | P | E	Tag present at technology object: D - Speed-controlled axis | P - Positioning axis | E - External Encoder	
Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (Without specific value input, the value range limits of the respective data type or the specification under "Description".)	
W	Efficacy of changes in the technology data block	
	DIR	Immediate: Changes in the value occur by direct assignment, and are immediately effective.
	RES	Restart: Changes to the start value in load memory occur via the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed.
Description	Description of the tag	

L - Linear specification R - Rotary specification

Access to the tags occurs via "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.1.2 Actual values and setpoints

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		Position	LREAL	-	RON	Setpoint position
X	X		Velocity	LREAL	-	RON	Setpoint velocity / setpoint speed
	X	X	ActualPosition	LREAL	-	RON	Actual position
	X	X	ActualVelocity	LREAL	-	RON	Actual velocity
X	X		ActualSpeed	LREAL	-	RON	Actual speed of the motor (with analog setpoint = 0.0)
X	X		Acceleration	LREAL	-	RON	Setpoint acceleration
	X	X	ActualAcceleration	LREAL	-	RON	Actual acceleration

A.1.3 Actor. tag

The tag structure <TO>.Actor.<tag name> contains the controller-side configuration for the drive.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		Actor.	STRUCT			
X	X		Type	DINT	-	RON	Drive connection 1: PROFIdrive frame 0: Analog output
X	X		InverseDirection	BOOL	-	RES	Inversion of the setpoint FALSE: no TRUE: yes
			Interface.	STRUCT			
X	X		AddressIn	UDINT	0 to 65535	RON	Input address for the PROFIdrive frame
X	X		AdressOut	UDINT	0 to 65535	RON	Output address for the PROFIdrive frame or the analog setpoint

D	P	E	Tag	Data type	Values	W	Description
X	X		Telegram	UDINT	-	RON	PROFIdrive frame of the drive 1: NSET (16 bit), NACT (16 bit) 2: NSET (32 bit), NACT (32 bit), signs of life 3: NSET (32 bit), NACT (32 bit), actual encoder value, signs of life 5: NSETP (32-bit), NACT (32-bit), actual encoder value, sign-of-life, DSC (NSET - setpoint speed, NACT - actual speed value)
X	X		EnableDriveOutput	BOOL	-	RON	"Enable output" for analog drives FALSE: disabled TRUE: enabled
X	X		EnableDriveOutput Address	UDINT	0 to 65535	RON	Byte number for the "enable output"
X	X		EnableDriveOutput BitNumber	UDINT	0 to 7	RON	Bit number for the "enabling output"
X	X		DriveReadyInput	BOOL	-	RON	"Ready input" for analog drives The analog drive signals its readiness to receive setpoint speeds. FALSE: disabled TRUE: enabled
X	X		DriveReadyInput Address	UDINT	0 to 65535	RON	Byte number for the "ready input"
X	X		DriveReadyInputBit Number	UDINT	0 to 7	RON	Bit number for the "ready input"
			DriveParameter.				
X	X		ReferenceSpeed	LREAL	0 to 1.0E12	RES	Reference value (100%) for the setpoint speed of the drive (N-set) The setpoint speed is transmitted in the PROFIdrive frame as a standardized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.
X	X		MaxSpeed	LREAL	0 to 1.0E12	RES	Maximum value for the setpoint speed of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)

See also

Evaluating the technology data block (Page 140)

A.1.4 Sensor[n]. tag

The tag structure <TO>.Sensor[n].<tag name> contains the CPU-side configuration for the encoder, and the configuration for active and passive homing.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		Sensor[n].	ARRAY [1..1] OF STRUCT			
	X	X	Type	DINT	-	RES	Encoder type: 0: Incremental 1: Absolute 2: Cyclically absolute
	X	X	InverseDirection	BOOL	-	RES	Inversion of the setpoint FALSE: no TRUE: yes
	X	X	System	DINT	-	RES	Encoder system 0: Linear encoder 1: Rotary encoder
	X	X	MountingMode	DINT	-	RES	Mounting type of the encoder 0: Incremental 1: Absolute 2: External
	X	X	Interface.				
	X	X	AddressIn	UDINT	0 to 65535	RON	Input address for the PROFIdrive frame
	X	X	AddressOut	UDINT	0 to 65535	RON	Output address for the PROFIdrive frame
	X	X	Telegram	UDINT	-	RON	PROFIdrive frame of the encoder 3: Actual values via drive frame (NSET (32 bit), NACT (32 bit), actual encoder value, signs of life) 5: Actual values from drive frame (NSETP (32-bit), NACT (32-bit), actual encoder value, sign-of-life, DSC) 81: Actual values via your own encoder telegram (actual encoder value, signs of life) 83: Actual values via your own encoder telegram (NACT (32 bit), actual encoder value, signs of life) For the technology object of external encoders, only frames 81 and 83 are valid. (NSET - setpoint speed, NACT - actual speed value)
	X	X	Parameter.				

D	P	E	Tag	Data type	Values	W	Description
	X	X	Resolution	LREAL	1.0E-12 to 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)
	X	X	StepsPerRevolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution
	X	X	FineResolutionXist1	UDINT	0 to 31	RES	Number of bits for fine resolution Gn_XIST1 (cyclical actual encoder value)
	X	X	FineResolutionXist2	UDINT	0 to 31	RES	Number of bits for fine resolution Gn_XIST2 (absolute value of the encoder)
	X	X	Determinable Revolutions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute value encoder (For a single-turn absolute value encoder = 1; for an incremental encoder = 0)
	X	X	DistancePer Revolution	LREAL	0.0 to 1.0E12	RES	Load distance per revolution of an externally mounted encoder
	X		ActiveHoming.	STRUCT			
	X		Mode	DINT	-	RES	Homing mode 0: Homing mark only 1: Homing mark and proximity switch 2: Digital input
	X		SideInput	BOOL	-	DIR	Side of the digital input for active homing: FALSE: Negative side TRUE: Positive side
	X		Direction	DINT	-	DIR	Homing direction / homing mark approach direction 1: Positive homing direction 2: Negative homing direction
	X		DigitalInputAddress	UDINT	0 to 65535	RON	Byte number of the digital input
	X		DigitalInputBit Number	UDINT	0 to 7	RON	Bit number of the digital input
	X		HomePositionOffset	LREAL	-1.0E12 to 1.0E12	DIR	Home position offset
	X	X	PassiveHoming.	STRUCT			
	X	X	Mode	DINT	-	RES	Homing mode 0: Homing mark only 1: Homing mark and proximity switch 2: Digital input
	X	X	SideInput	BOOL	-	DIR	Side of the digital input for passive homing: FALSE: Negative side TRUE: Positive side
	X	X	Direction	DINT	-	DIR	Homing direction / homing mark approach direction 0: Current homing direction 1: Positive homing direction 2: Negative homing direction

D	P	E	Tag	Data type	Values	W	Description
	X	X	DigitalInputAddress	UDINT	0 to 65535	RON	Byte number of the digital input
	X	X	DigitalInputBit Number	UDINT	0 to 7	RON	Bit number of the digital input

See also

Evaluating the technology data block (Page 140)

A.1.5 Mechanics

The following tags contain the configuration of the mechanics.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Value range	W	Description
X	X	X	LoadGear.	STRUCT			
X	X	X	Numerator	UDINT	1 to 4294967295	RES	Load gear counter
X	X	X	Denominator	UDINT	1 to 4294967295	RES	Load gear denominator
	X	X	Properties.				
	X	X	MotionType	DINT		RON	Indication of axis or motion type: 0: Linear axis or motion 1: Rotary axis or motion
	X		Mechanics.				
	X		LeadScrew	LREAL	0.0 to 1.0E12	RES	Leadscrew pitch

See also

Evaluating the technology data block (Page 140)

A.1.6 Modulo. tag

The tag structure <TO>.Modulo.<tag name> contains the modulo configuration.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X	X	Modulo.	STRUCT			
	X	X	Enable	BOOL	-	RES	FALSE: Modulo conversion disabled TRUE: Modulo conversion enabled When modulo conversion is enabled, a check is made for modulo length > 0.0
	X	X	Length	LREAL	0.001 to 1.0E12	RES	Modulo length
	X	X	StartValue	LREAL	-1.0E12 to 1.0E12	RES	Modulo start value

See also

Evaluating the technology data block (Page 140)

A.1.7 DynamicLimits. tag

The tag structure <???>.DynamicLimits.<tag name> contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you have specified greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values were limited).

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		DynamicLimits.	STRUCT			
X	X		MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
X	X		MaxAcceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible acceleration of the axis
X	X		MaxDeceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible deceleration of the axis
X	X		MaxJerk	LREAL	0.0 to 1.0E12	DIR	Maximum permissible jerk on the axis

See also

Evaluating the technology data block (Page 140)

A.1.8 DynamicDefaults. tag

The tag structure <???><TO>.DynamicDefaults.<tag name> contains the configuration of the dynamic defaults. These settings will be used, if you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: MC_MoveJog.Velocity, MC_MoveVelocity.Velocity). Changes to the dynamic defaults will be applied with the next rising edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		DynamicDefaults.	STRUCT			
X	X		Velocity	LREAL	0.0 to 1.0E12	DIR	Default velocity
X	X		Acceleration	LREAL	0 to 1.0E12	DIR	Default acceleration
X	X		Deceleration	LREAL	0 to 1.0E12	DIR	Default deceleration
X	X		Jerk	LREAL	0 to 1.0E12	DIR	Default jerk
X	X		EmergencyDeceleration	LREAL	0 to 1.0E12	DIR	Emergency stop deceleration

See also

Evaluating the technology data block (Page 140)

A.1.9 PositionLimits_SW. tag

The tag structure <???><TO>.PositionLimits_SW.<tag name> contains the configuration for position monitoring with software limit switches. Software limit switches are used to limit the traversing range of a positioning axis.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		PositionLimits_SW.	STRUCT			
	X		Active	BOOL	-	DIR	FALSE: Monitoring disabled TRUE: Monitoring enabled
	X		MinPosition	LREAL	-1.0E12 to 1.0E12	DIR	Position of negative software limit switches
	X		MaxPosition	LREAL	-1.0E12 to 1.0E12	DIR	Position of positive software limit switches ("MaxPosition" > "MinPosition")

See also

Evaluating the technology data block (Page 140)

A.1.10 PositionLimits_HW. tag

The tag structure <???><TO>.PositionLimits_HW.<tag name> contains the configuration for position monitoring with hardware limit switches. Hardware limit switches are used to limit the traversing range of a positioning axis.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		PositionLimits_HW.	STRUCT			
	X		Active	BOOL	-	RES	FALSE: Monitoring disabled TRUE: Monitoring enabled With "Active", both (negative and positive) hardware limit switches are enabled or disabled.
	X		MinSwitchLevel	BOOL	-	RES	Level selection for enablement of the negative hardware limit switch: FALSE: Lower level (low-enabled) TRUE: Upper level (high-enabled)
	X		MinSwitchAddress	UDINT	0 to 65535	RON	Byte number for the negative hardware limit switch
	X		MinSwitchBitNumber	UDINT	0 to 7	RON	Byte number for the negative hardware limit switch
	X		MaxSwitchLevel	BOOL	-	RES	Level selection for enablement of the positive hardware limit switch: FALSE: Lower level (low-enabled) TRUE: Upper level (high-enabled)
	X		MaxSwitchAddress	UDINT	0 to 65535	RON	Byte number for the positive hardware limit switch
	X		MaxSwitchBitNumber	UDINT	0 to 7	RON	Bit number for the positive hardware limit switch

See also

Evaluating the technology data block (Page 140)

A.1.11 Homing. tag

The tag structure <TO>.Homing.<tag name> contains the configuration for homing the TO.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X	X	Homing.	STRUCT			
	X		AutoReversal	BOOL	-	RES	Reversal at the hardware limit switches FALSE: no TRUE: yes
	X		ApproachDirection	BOOL	-	DIR	Direction of approach to the homing position switch FALSE: Negative side TRUE: Positive direction
	X		ApproachVelocity	LREAL	L: 0.0 to 10000.0 mm/s R: 0.0 to 360000°/s	DIR	Approach velocity Velocity during active homing, with which the axis moves toward the proximity switch and toward home position.
	X		ReferencingVelocity	LREAL	L: 0.0 to 1000.0 mm/s R: 0.0 to 36000°/s	DIR	Homing velocity Velocity during active homing, with which the axis is moved toward home position.
	X	X	HomePosition	LREAL	-1.0E12 to 1.0E12	DIR	Home position

See also

Evaluating the technology data block (Page 140)

A.1.12 Override. tag

The tag structure <???><TO>.Override.<tag name> contains the configuration for the override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		Override.	STRUCT			
X	X		Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity/speed

See also

Evaluating the technology data block (Page 140)

A.1.13 PositionControl. tag

The tag structure <TO>.PositionControl.<tag name> contains the settings for position control.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		PositionControl.				
	X		Kv	LREAL	0.0 to 2147480	DIR	Proportional gain in the position control ("Kv" > 0.0)
			Kpc	LREAL	0.0 to 150.0%	DIR	Velocity pre-control in the position control Recommended setting: • Isochronous drive connection via PROFIdrive: 100.0% • Non-isochronous drive connection via PROFIdrive: 0.0 to 100.0% • Analog drive connection: 0.0 to 100.0%
	X		EnableDSC	BOOL	-	RES	Dynamic Servo Control (DSC) FALSE: DSC disabled TRUE: DSC enabled DSC is only possible if frame 5 is used.

See also

Evaluating the technology data block (Page 140)

A.1.14 FollowingError. tag

The tag structure <???><TO>.FollowingError.<tag name> contains the configuration for following error monitoring.

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm response: remove enable).

When the warning level is reached, a warning is output (technology alarm 522).

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		FollowingError.	STRUCT			
	X		EnableMonitoring	BOOL	-	RES	FALSE: Following error monitoring disabled TRUE: Following error monitoring enabled
	X		MinValue	LREAL	-1.0E12 to 1.0E12	DIR	Permissible following error at velocities below the value of "MinVelocity".
	X		MaxValue	LREAL	-1.0E12 to 1.0E12	DIR	Maximum permissible following error, which may be reached at the maximum velocity.
	X		MinVelocity	LREAL	-1.0E12 to 1.0E12	DIR	"MinValue" is permissible below this velocity, and is held constant.
	X		WarningLevel	LREAL	0.0 to 100.0	DIR	Warning level: Percentage value relative to the valid maximum following error.

See also

Evaluating the technology data block (Page 140)

A.1.15 PositioningMonitoring. tag

The tag structure <???><TO>.PositioningMonitoring.<tag name> contains the configuration for position monitoring at the end of a positioning motion.

If the actual position value at the end of a positioning motion is reached within the tolerance time and remains in the positioning window for the minimum dwell time, then <TO>.StatusWord.Done is set in the technology data block. This completes a Motion Control job.

If the tolerance time is exceeded, then technology alarm 541 "Positioning monitoring" with supplemental value 1: "Target area not reached within the positioning tolerance time" will be indicated.

If the minimum dwell time is not met, then technology alarm 541 "Positioning monitoring" with supplemental value 2: "Target area exited within the minimum dwell time" will be indicated.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		PositioningMonitoring.	STRUCT			
	X		ToleranceTime	LREAL	0.0 to 1.0E12	DIR	Tolerance time Maximum permitted duration from reaching velocity setpoint zero, until entrance into the positioning window.
	X		MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time in the positioning window:
	X		Window	LREAL	0.0 to 1.0E12	DIR	Positioning window

See also

Evaluating the technology data block (Page 140)

A.1.16 StandstillSignal. tag

The tag structure <???><TO>.StandstillSignal.<tag name> contains the configuration for the standstill signal.

If the actual velocity value is below the velocity threshold, and does not exceed it during the minimum dwell time, then the standstill signal <TO>.StatusWord.Standstill is set.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		StandstillSignal.	STRUCT			Configuration for the standstill signal
	X		VelocityThreshold	LREAL	0.0 to 1.0E12	DIR	Velocity threshold If velocity is below this threshold, then the minimum dwell time begins.
	X		MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time

See also

Evaluating the technology data block (Page 140)

A.1.17 StatusPositioning. tag

The tag structure <TO>.StatusPositioning.<tag name> indicates the status of a positioning motion.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X		StatusPositioning.	STRUCT			
	X		Distance	LREAL	-	RON	Distance to the target position
	X		TargetPosition	LREAL	-	RON	Target position
	X		FollowingError	LREAL	-	RON	Current following error

See also

Evaluating the technology data block (Page 140)

A.1.18 StatusDrive. tag

The tag structure <TO>.StatusDrive.<tag name> indicates the status of the drive.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		StatusDrive	STRUCT			
X	X		InOperation	BOOL	-	RON	Operational status of the drive FALSE: Drive not ready. Setpoints will not be executed. TRUE: Drive ready. Setpoints can be executed.
X	X		CommunicationOK	BOOL	-	RON	Cyclical BUS communication between controller and drive FALSE: Not established TRUE: Established
X	X		Error	BOOL	-	RON	FALSE: No error at the drive TRUE: Error at the drive

See also

Evaluating the technology data block (Page 140)

A.1.19 StatusSensor[n]. tag

The tag structure <TO>.StatusSensor[n].<tag name> indicates the status of the measuring system.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
	X	X	StatusSensor[n].	ARRAY [1..1] OF STRUCT			
	X	X	State	DINT	-	RON	Status of the actual encoder value: 0: "NOT_VALID (not valid) 1: "Waiting_FOR_VALID (waiting for valid status) 2: "VALID (valid)
	X	X	CommunicationOK	BOOL	-	RON	Cyclical BUS communication between controller and encoder FALSE: Not established TRUE: Established
	X	X	Error	BOOL	-	RON	FALSE: No error in the measuring system TRUE: Error in the measuring system.
	X	X	AbsEncoderOffset	LREAL	-	RON	Home point offset to the value of an absolute value encoder. The value will be retentively stored in the CPU.

See also

Evaluating the technology data block (Page 140)

A.1.20 StatusWord. tag

The <TO>.StatusWord tag contains the status data of the technology object.

Notes on the evaluation of the individual bits (e.g. bit 5, "HomingDone") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

Tags

Legend (Page 243)

D	P	E	Tag		Data type	Values	W	Description
X	X	X	StatusWord		DWORD	-	RON	Status data of the technology object
X	X	X	0	Enable				Enablement status 0: Technology object disabled 1: Technology object enabled
X	X	X	1	Error				0: No error present 1: Error present
X	X	X	2	RestartActive				0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
X	X	X	3	OnlineStart ValuesChanged				0: "Restart" tag unchanged 1: Change in "Restart" tag. For the changes to be applied, the technology object must be reinitialized.
X	X		4	ControlPanel Active				Axis control panel 0: disabled 1: enabled
	X	X	5	HomingDone				Homing status 0: Technology object not homed 1: Technology object homed
X	X	X	6	Done				0: Motion job in process, or axis control panel enabled 1: No motion job in process and axis control panel disabled
	X		7	Standstill				Standstill signal 0: Axis in motion 1: Axis at a standstill
	X		8	Positioning Command				0: No positioning job active 1: Positioning job active ("MC_MoveReleative", "MC_MoveAbsolute")
X	X		9	JogCommand				0: No "MC_MoveJog" frame active 1: "MC_MoveJog" job
X	X		10	Velocity Command				0: No "MC_MoveVelocity" job active 1: "MC_MoveVelocity" job active
	X	X	11	Homing Command				0: No "MC_Home" job in process 1: "MC_Home" job in process
X	X		12	ConstantVelocity				0: The axis is being accelerated, decelerated, or is at a standstill. 1: Velocity setpoint reached. The axis is being moved at this constant velocity.

D	P	E	Tag		Data type	Values	W	Description
X	X		13	Accelerating				0: No acceleration process active 1: Acceleration process active
X	X		14	Decelerating				0: No deceleration process active 1: Deceleration process active
	X		15	SWLimitMin Active				Negative software limit switch 0: disabled 1: enabled
	X		16	SWLimitMax Active				Positive software limit switch 0: disabled 1: enabled
	X		17	HWLimitMin Active				Negative hardware limit switch 0: disabled 1: enabled
	X		18	HWLimitMax Active				Positive hardware limit switch 0: disabled 1: enabled
X	X		19	ErrorStopActive				Stop as a result of alarm response 0: not active 1: active
X	X		20	MC_PowerStop Active				Stop as a result of disablement via "MC_Power" 0: not active 1: active
			21 ... 31					Reserved

See also

Evaluating the technology data block (Page 140)

A.1.21 ErrorWord. tag

The <TO>.ErrorWord tag indicates errors at the technology object (technology alarms).

Notes on the evaluation of the individual bits (e.g. bit 3, CommandNotAccepted) can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

Tags

Legend (Page 243)

D	P	E	Tag		Data type	Values	W	Description
			ErrorWord		DWORD	-	RON	
X	X	X	0	SystemFault				System error
X	X	X	1	Configuration Fault				Configuration error One or more configuration parameters are inconsistent or invalid.
X	X	X	2	UserFault				Error in the user program in a Motion Control instruction, or in its utilization
X	X	X	3	CommandNot Accepted				Instruction cannot be executed. A Motion Control instruction cannot be executed, because necessary preconditions are not met.
X	X		4	DriveFault				Error in the drive
	X	X	5	SensorFault				Error in the encoder system.
X	X		6	DynamicError				Specified dynamic values are limited to permissible values.
X	X	X	7	Communication Fault				Communication error Missing or faulty communication.
	X		8	SWLimit				Software limit switch reached or overshot.
	X		9	HWLimit				Hardware limit switch reached or overshot.
	X	X	10	HomingFault				Error during homing process The homing cannot be completed.
	X		11	FollowingError Fault				Following error limits exceeded
	X		12	PositioningFault				Positioning error
X	X	X	13	PeripheralError				Error when accessing a logical address
			14 ... 31					Reserved

See also

Evaluating the technology data block (Page 140)

A.1.22 ErrorDetail. tag

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm response to the technology alarm that is currently pending at the technology object.

A list of the technology alarms and alarm responses can be found in the appendix, Technology Alarms (Page 267).

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X	X	ErrorDetail.	STRUCT			
X	X	X	Number	UDINT	-	RON	Alarm number
X	X	X	Reaction	DINT	0 to 4	RON	Effective alarm response 0: No response 1: Stop with current dynamic values 2 Stop with maximum dynamic values 3: Stop with emergency stop ramp 4: Remove enable For the external encoder technology object, only alarm responses 0 and 4 are possible.

See also

Evaluating the technology data block (Page 140)

Technology alarms (Page 186)

A.1.23 WarningWord. tag

The <TO>.WarningWord tag indicates pending warnings at the technology object.

Notes on the evaluation of the individual bits (e.g. bit 11, "FollowingErrorWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 143) section.

Tags

Legend (Page 243)

D	P	E	Tag		Data type	Values	W	Description
			WarningWord		DWORD	-	RON	
			0					Reserved
X	X	X	1	Configuration Fault				Configuration error One or several configuration parameters are adjusted internally.
			2					Reserved
X	X	X	3	CommandNot Accepted				Instruction cannot be executed. A Motion Control instruction cannot be executed, because necessary preconditions are not met.
			4					Reserved
			5					Reserved
X	X		6	DynamicError				Specified dynamic values are limited to permissible values.
			7					Reserved
			8					Reserved
			9					Reserved
			10					Reserved
	X		11	FollowingError Warning				Warning level of the following error monitoring reached / exceeded
			12					Reserved
			13					Reserved
			14 ... 31					Reserved

See also

Evaluating the technology data block (Page 140)

A.1.24 ControlPanel. tag

The tag structure <TO>.ControlPanel.<tag name> contains no application-relevant data. This tag structure is internally used.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X		ControlPanel.	STRUCT			
X	X		Input.	STRUCT			
X	X		Command.	ARRAY[1..2] OF STRUCT			
X	X		ReqCounter	UDINT	-	DIR	-
X	X		Type	UDINT	-	DIR	-
X	X		Position	LREAL	-	DIR	-
X	X		Velocity	LREAL	-	DIR	-
X	X		Acceleration	LREAL	-	DIR	-
X	X		Deceleration	LREAL	-	DIR	-
X	X		Jerk	LREAL	-	DIR	-
X	X		Param	LREAL	-	DIR	-
X	X		TimeOut	LREAL	-	DIR	-
X	X		EsLifeSign	UDINT	-	DIR	-
X	X		Output.	STRUCT			
X	X		Command.	ARRAY[1..2] OF STRUCT			
X	X		AckCounter	UDINT	-	RON	-
X	X		Error	BOOL	-	RON	-
X	X		ErrorID	UDINT	-	RON	-
X	X		Done	BOOL	-	RON	-
X	X		Aborted	BOOL	-	RON	-
X	X		RTLifeSign	UDINT	-	RON	-

See also

Evaluating the technology data block (Page 140)

A.1.25 InternalTOTrace. tag

The tag structure <TO>.InternalTOTrace.<tag name> contains no application-relevant data. This tag structure is internally used.

Tags

Legend (Page 243)

D	P	E	Tag	Data type	Values	W	Description
X	X	X	InternalTOTrace.	ARRAY[1..4] OF STRUCT			
X	X	X	Id	DINT	-	DIR	-
X	X	X	Value	LREAL	-	RON	-

See also

Evaluating the technology data block (Page 140)

A.2 Technology alarms

The following table shows an overview of the technology alarms and the corresponding alarm responses. When a technology alarm occurs, evaluate the entire indicated alarm text, in order to find the precise cause.

You can find the FAQs with remedies for technology alarms on the Internet (http://support.automation.siemens.com/WW/view/en/66958052).

Legend

No.	Number of the technology alarm (corresponds to <TO>.ErrorDetail.Number)
Response	Effective alarm response (corresponds to <TO>.ErrorDetail.Reaction)
Error bit	Bit that is set in <TO>.ErrorWord when the technology alarm occurs
Warning bit	Bit that is set in <TO>.WarningWord when the technology alarm occurs
Restart	To acknowledge the technology alarm, the technology object must be reinitialized (restart).
Alarm text	Indicated alarm test (limited)

List of the technology alarms

No.	Response	Error bit	Warning bit	Restart	Alarm text
101	Remove enable	Configuration Fault	-	X	Error in the configuration of the technology object
104	Stop with maximum dynamic values	Configuration Fault	-	X	Error in the specification of software limit switches
105	Remove enable	Configuration Fault	-	X	Error in the configuration of the drive
106	Remove enable	Configuration Fault	-	X	Error in the configuration of the drive's driver
107	Remove enable	Configuration Fault	-	X	Error in the configuration of the encoder
108	Remove enable	Configuration Fault	-	X	Error in the configuration of the encoder driver
109	Remove enable	Configuration Fault	-	-	Range exceedance of the incremental actual value
110	No response	-	Configuration Fault	-	Configuration is being internally adapted.
201	Remove enable	SystemFault	-	-	Internal error
202	No response	SystemFault	-	-	Internal configuration error
203	Remove enable	SystemFault	-	-	Internal error
204	Remove enable	SystemFault	-	-	Internal error
304	Stop with emergency stop ramp	UserFault	-	-	Maximum permissible velocity is zero.
305	Stop with emergency stop ramp	UserFault	-	-	Maximum permissible acceleration/deceleration is zero.
306	Stop with emergency stop ramp	UserFault	-	-	Maximum permissible jerk is zero.
307	Stop with maximum dynamic values	UserFault	-	-	Internal traversing range limit was reached.
308	Remove enable	UserFault	-	-	Internal traversing range limit was overshot.
321	Stop with emergency stop ramp	Command Not Accepted	-	-	The axis is not homed.
322	No response	-	Command Not Accepted	-	Restart of the technology object was not executed.
323	No response	-	Command Not Accepted	-	The internal traversing range would be exceeded as a result of the job.
342	Stop with emergency stop ramp	HomingFault	-	-	Reference cam / encoder zero mark was not found.
341	Remove enable	HomingFault	-	-	Error in the homing configuration

No.	Response	Error bit	Warning bit	Restart	Alarm text
401	Remove enable	Peripheral Error	-	-	Error accessing a logical address
411	Remove enable	SensorFault	-	-	Error in the encoder system.
412	Remove enable	SensorFault	-	-	Violation of the range limit for the incremental actual value
421	Remove enable	DriveFault	-	-	Error in the drive
431	Remove enable	Communication Fault	-	-	Error in the BUS communication
501	No response	-	Dynamic Error	-	Programmed velocity limited.
502	No response	-	Dynamic Error	-	Programmed acceleration/deceleration limited.
503	No response	-	Dynamic Error	-	Programmed jerk limited.
504	No response	-	Dynamic Error	-	Rotational speed monitoring active
521	Remove enable	Following Error Fault	-	-	The maximum permitted following error was exceeded.
522	No response		Following ErrorFault		The warning level of the following error was reached.
531	Remove enable	HWLimit	-	X	Hardware limit switch was reached. Only one traversing direction is possible.
533	Stop with maximum dynamic values	SWLimit	-	-	Software limit switch was reached.
534	Remove enable	SWLimit	-	-	Software limit switch was overshot.
541	Remove enable	Postioning Fault	-	-	Positioning error

See also

Technology alarms (Page 186)

A.3 Error ID

Errors in Motion Control instructions are reported by means of "Error" and "ErrorID" parameters.

Under the following conditions, "Error" = TRUE and "ErrorID" = 16#8xxx are indicated at the Motion Control instruction:

- Invalid status of the technology object, which prevents the execution of the job.
- Invalid parameter assignment of the Motion Control instruction, which prevents the execution of the job.
- As a result of the alarm response for an error at the technology object.

ErrorIDs and remedies

The following table lists all "ErrorIDs" that can be indicated in Motion Control instructions. Along with the cause of the error, the table lists corresponding troubleshooting routines:

ErrorID	Description	Remedy
16#0000	No error	-
16#8001	A technology alarm (TO error) occurred while processing the Motion Control instruction.	An error message is output in the technology data block's "ErrorDetail.number" tag. A list of the technology alarms and alarm responses can be found in the appendix, Technology Alarms (Page 267).
16#8002	Invalid value in the "Axis" parameter.	Check the value in the "Axis" parameter
16#8003	Invalid velocity	Set a valid velocity value at parameter "Velocity".
16#8004	Invalid acceleration	Set a valid acceleration value at parameter "Acceleration".
16#8005	Invalid deceleration	Set a valid deceleration value at parameter "Deceleration".
16#8006	Invalid jerk	Set a valid jerk value at parameter "Jerk".
16#8007	Invalid direction	Set a valid directional value at parameter "Direction".
	When the axis is at a standstill, "Direction" = 4 (current direction) is not permitted.	
	Invalid input Both the "JogForward" and "JogBackward" parameters set to TRUE at the same time. The axis decelerates with the most recently valid deceleration.	Reset both the "JogForward" parameter and the "JogBackward" parameter.
16#8008	Invalid distance specification	Set a valid distance value at parameter "Distance".
16#8009	Invalid position specification	Set a valid position value at parameter "Position".
16#800A	Invalid operating mode	Set a valid operating mode at parameter "Mode".
16#800B	Invalid stop mode	Set a valid stop mode at parameter "StopMode".
16#800C	Only one instance of the "MC_Power" instruction is allowed per technology object.	A technology object was specified in several instances of the "MC_Power" instruction, in the "Axis" parameter. Ensure that the technology object is only specified in one "MC_Power" instruction.

ErrorID	Description	Remedy
16#800D	Job not permitted in current mode. "Restart" is being executed.	Wait until the "Restart" of the technology object is complete.
16#800E	If the axis is activated, a "Restart" is not possible.	Before a "Restart", deactivate the technology object with "MC_Power.Enable"FALSE.
16#800F	The technology object is disabled. The job cannot be executed.	Enable the technology object with "MC_Power.Enable" = TRUE. Restart the job.
16#8010	Invalid homing mode for incremental encoder.	Absolute value adjustment is not possible at an incremental encoder ("Mode" = 6, 7). Start a homing process for an incremental encoder using parameter "Mode" = 0, 1, 2, 3, 4, 5, 8.
16#8011	Invalid homing mode for absolute encoder.	Passive and active homing ("Mode" = 2, 3, 4, 5) are not possible for an absolute value encoder. Start a homing process for an absolute encoder using parameter "Mode" = 0, 1, 6, 7.
16#8012	Command cannot be executed, because the axis control panel is enabled.	Return master control to the user program. Restart the job.
16#8013	The online connection between the CPU and the TIA Portal is down.	Check the online connection to the CPU.
16#8014	No internal job memory available.	The maximum number of motion control jobs has been reached. Reduce the number of jobs to be executed (parameter "Execute" = FALSE).
16#8015	"Restart" not possible. Error in the configuration of the technology object.	Check the configuration of the technology object.
16#8016	The actual values are not valid.	The actual values must be valid in order to execute a MC_Home job. Check the status of the actual values. The "<TO>.StatusSensor[n].State" tag of the technology object must show the value 2 (valid).
16#8FFF	Unspecified error	Please contact the Siemens agent at your local agency or branch. You will find information on whom to contact at: Contact information for Industry Automation and Drive Technologies (http://www.siemens.com/automation/partner)

See also

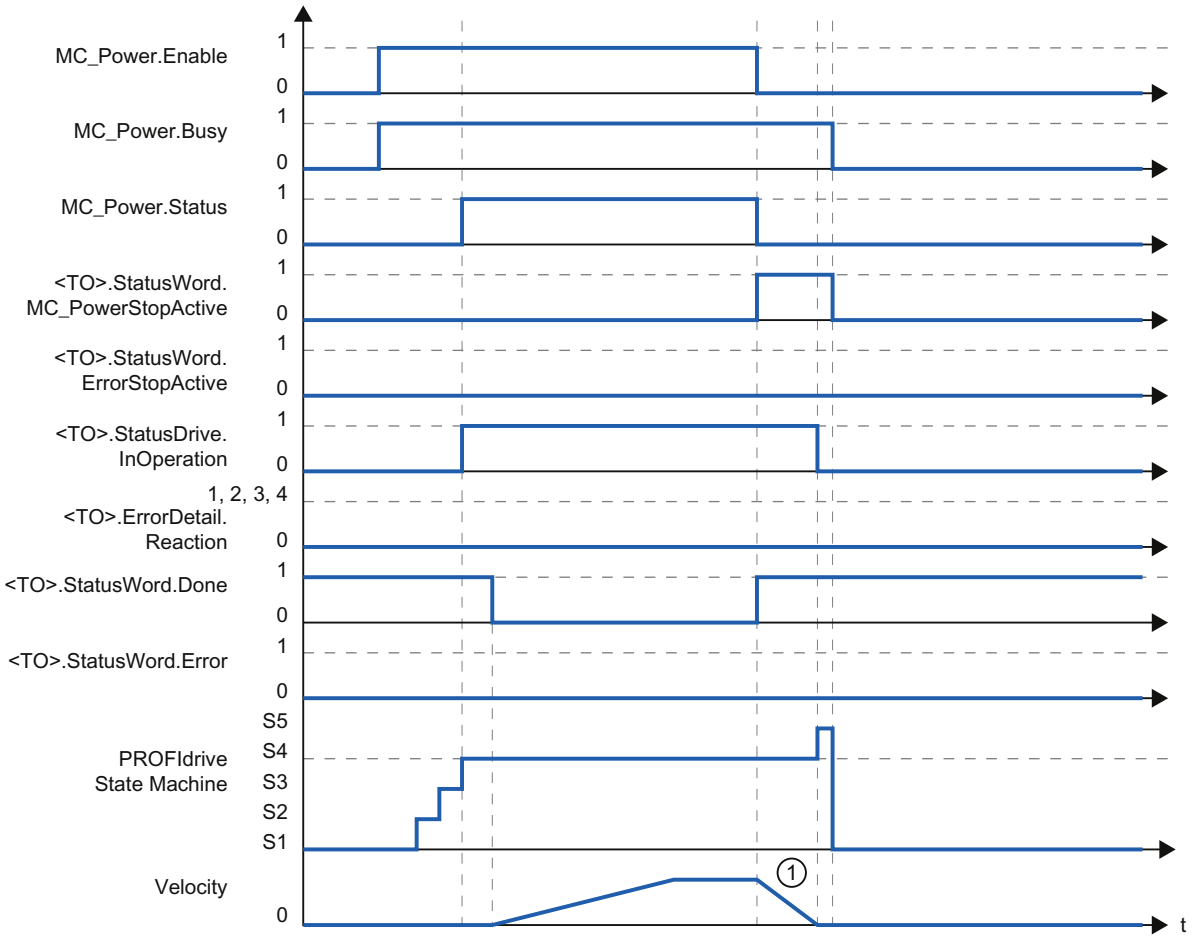
Errors in Motion Control instructions (Page 190)

A.4 MC_Power function chart

A.4.1 Drive connection via PROFIdrive

A.4.1.1 StopMode 0

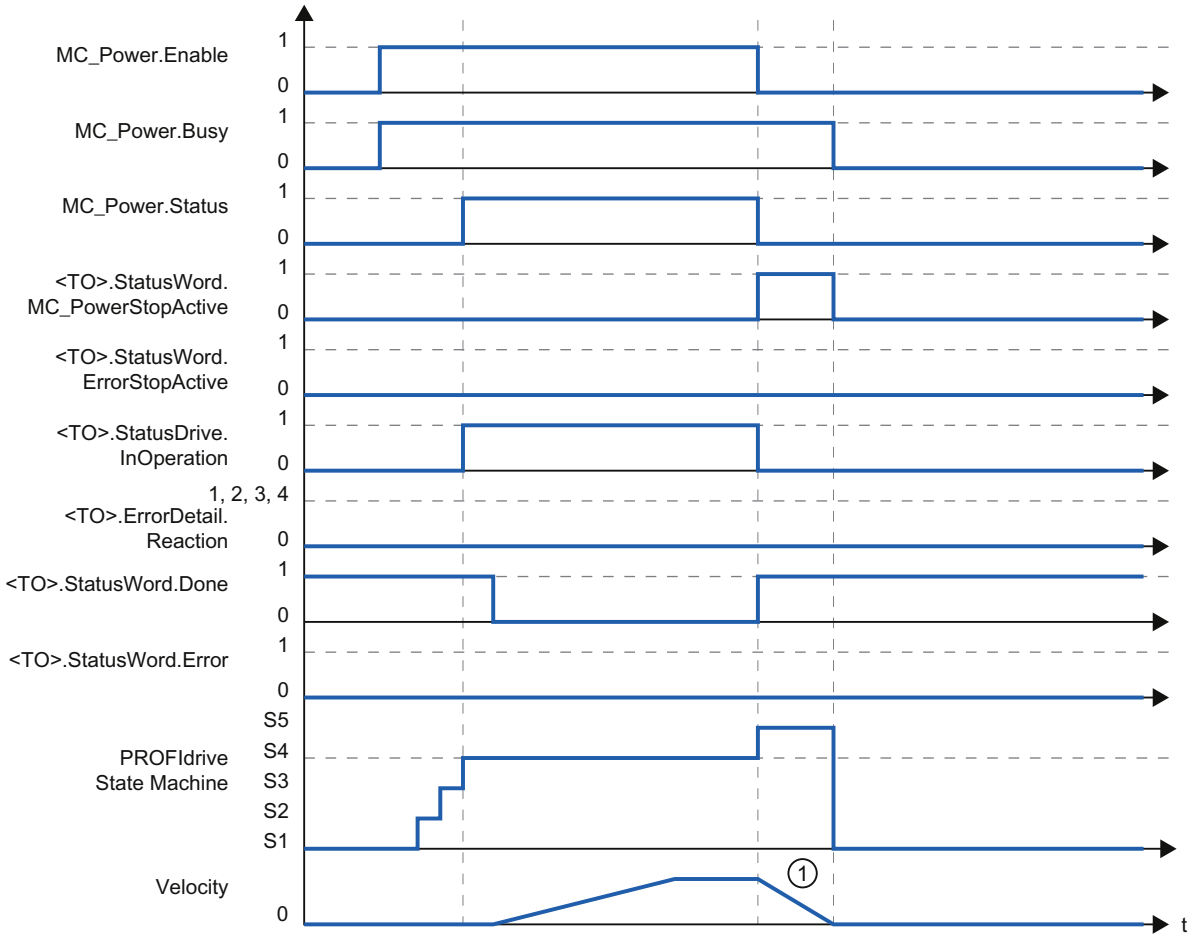
Function chart: Enabling a technology object and disabling with "StopMode" = 0



① The axis decelerates with the configured emergency stop deceleration.

A.4.1.2 StopMode 1

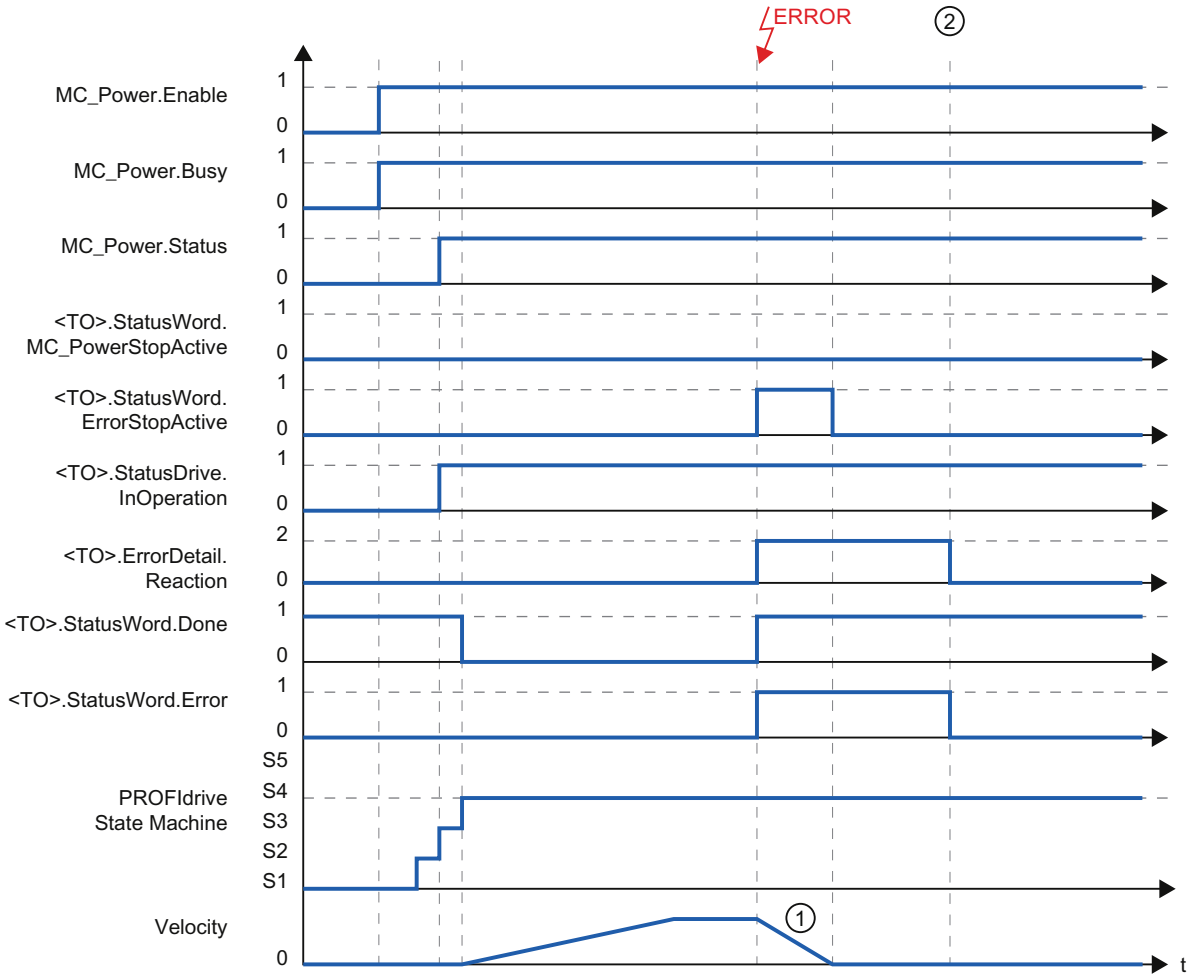
Function chart: Enabling a technology object and disabling with "StopMode" = 1



① The deceleration ramp depends on the configuration in the drive.

A.4.1.3 Alarm response "Stop with maximum dynamic values"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm response "Stop with maximum dynamic values"

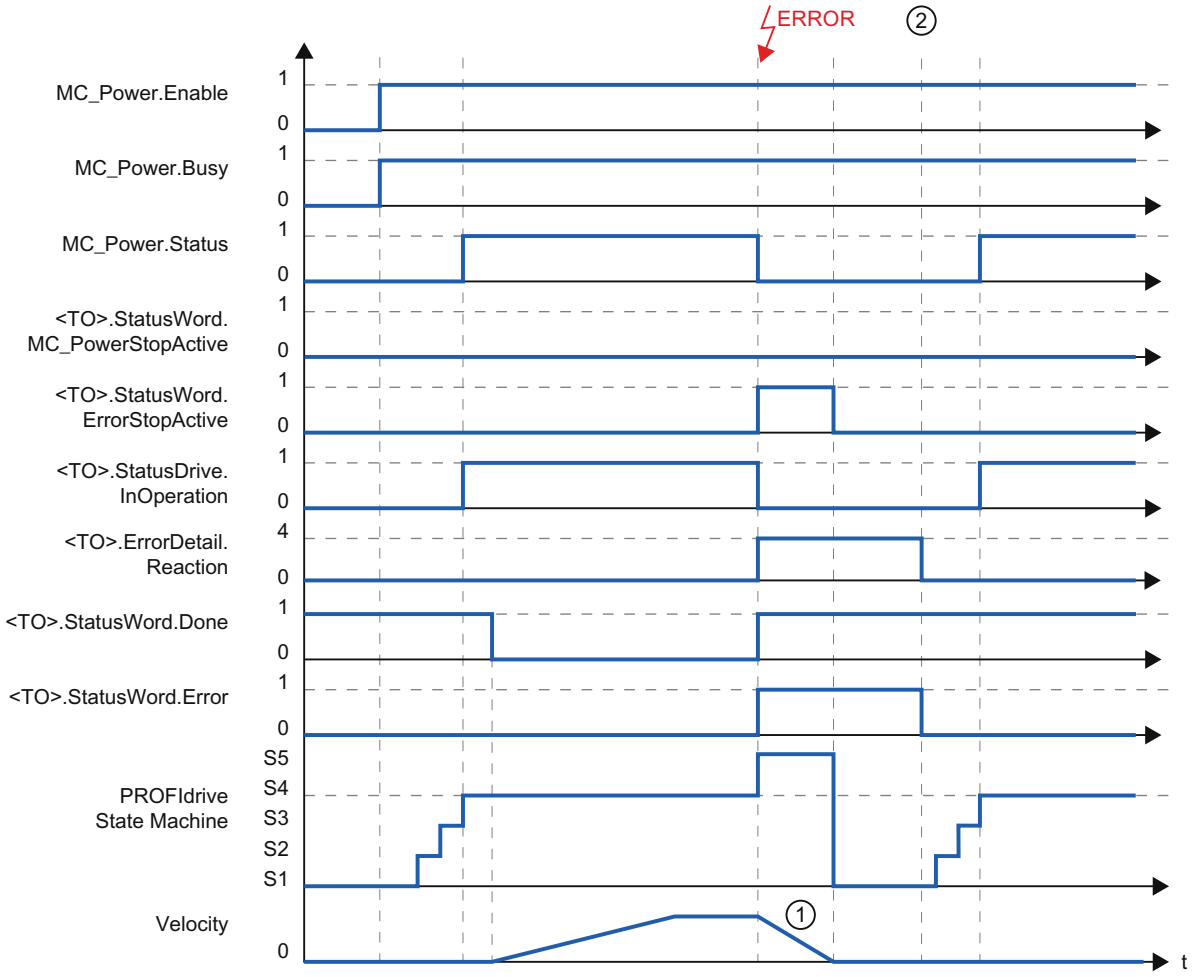


① The axis decelerates with the configured maximum deceleration.

② The technology alarm is acknowledged.

A.4.1.4 Alarm response "Remove enable"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm response "Remove enable"



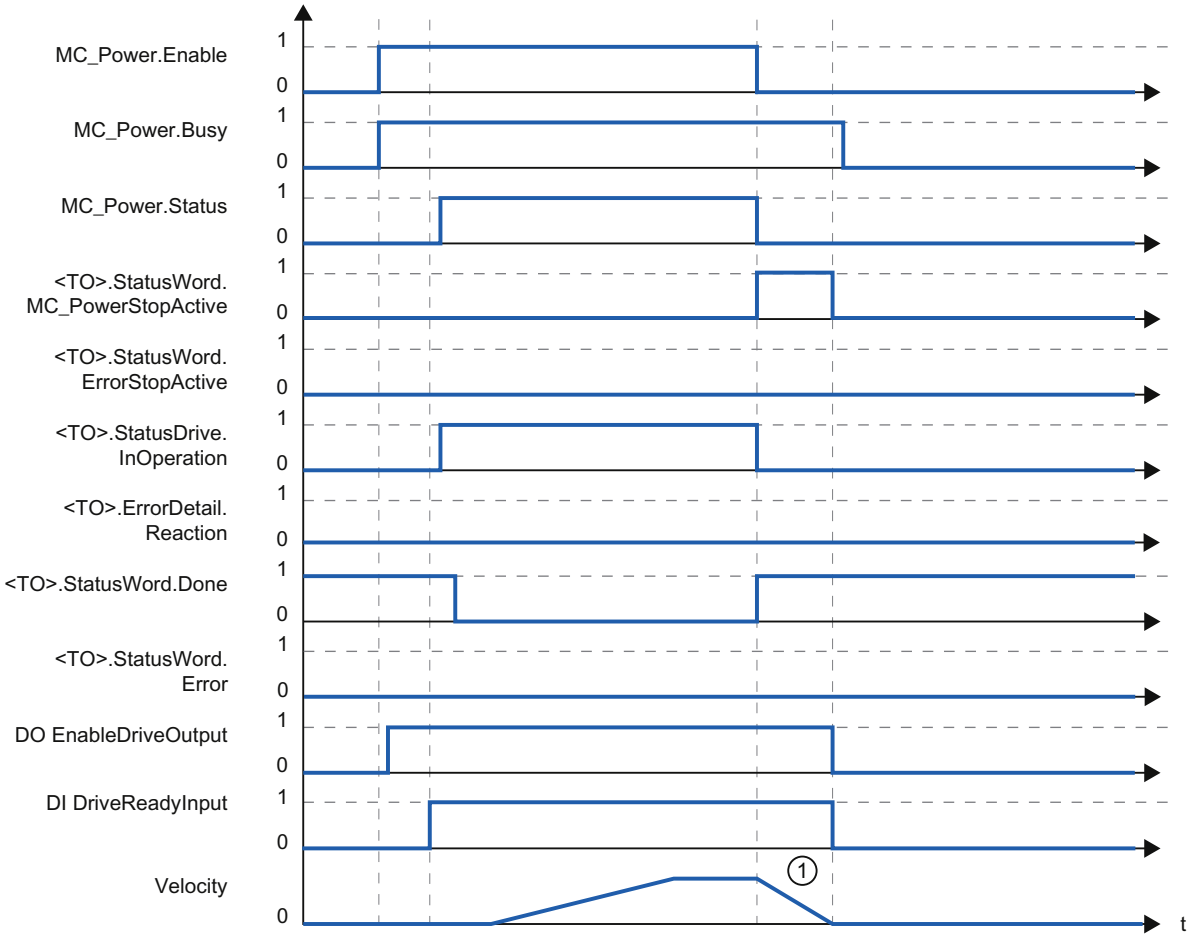
① The deceleration ramp depends on the configuration in the drive.

② The technology alarm is acknowledged at time ②.

A.4.2 Analog drive connection

A.4.2.1 StopMode 0

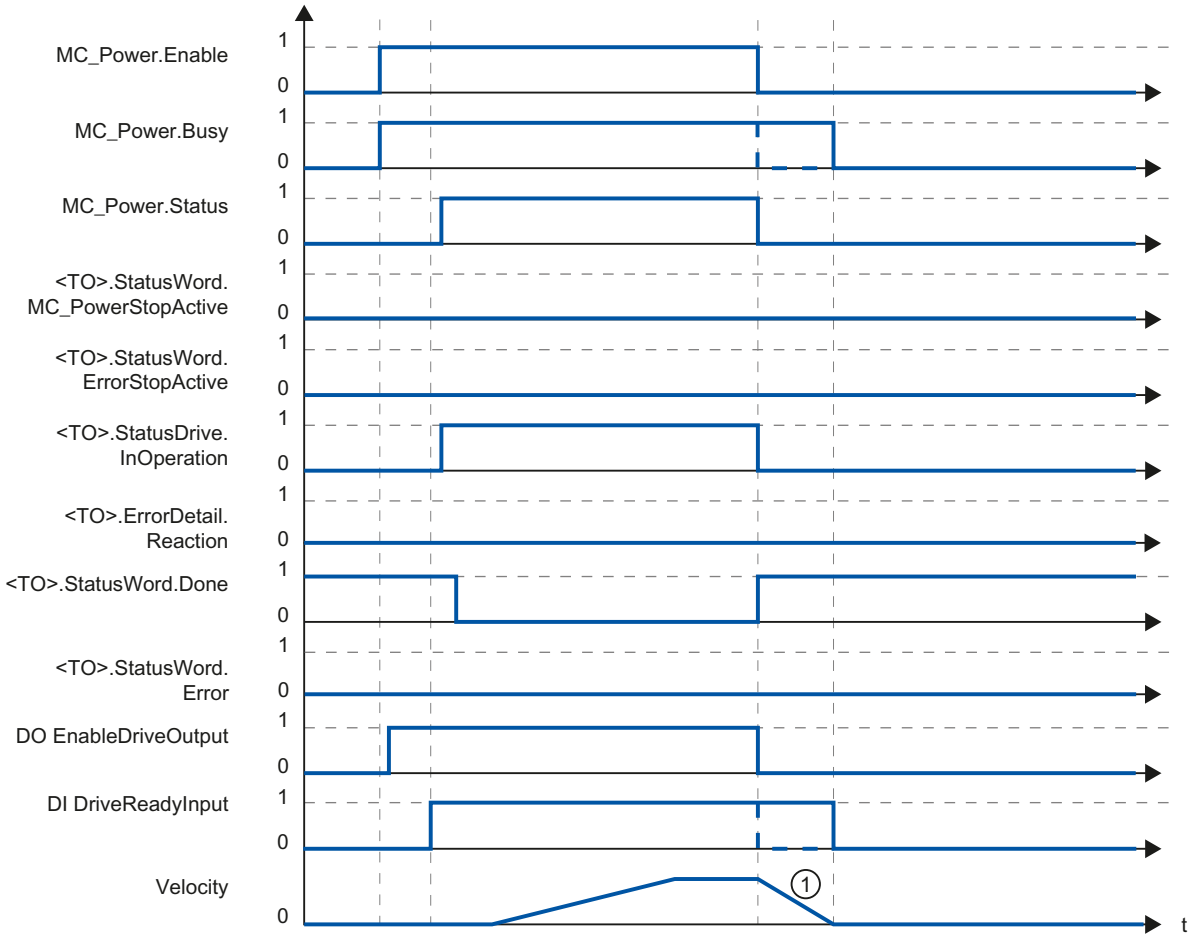
Function chart: Enabling a technology object and disabling with "StopMode" = 0



① The axis decelerates with the configured emergency stop deceleration.

A.4.2.2 StopMode 1

Function chart: Enabling a technology object and disabling with "StopMode" = 1

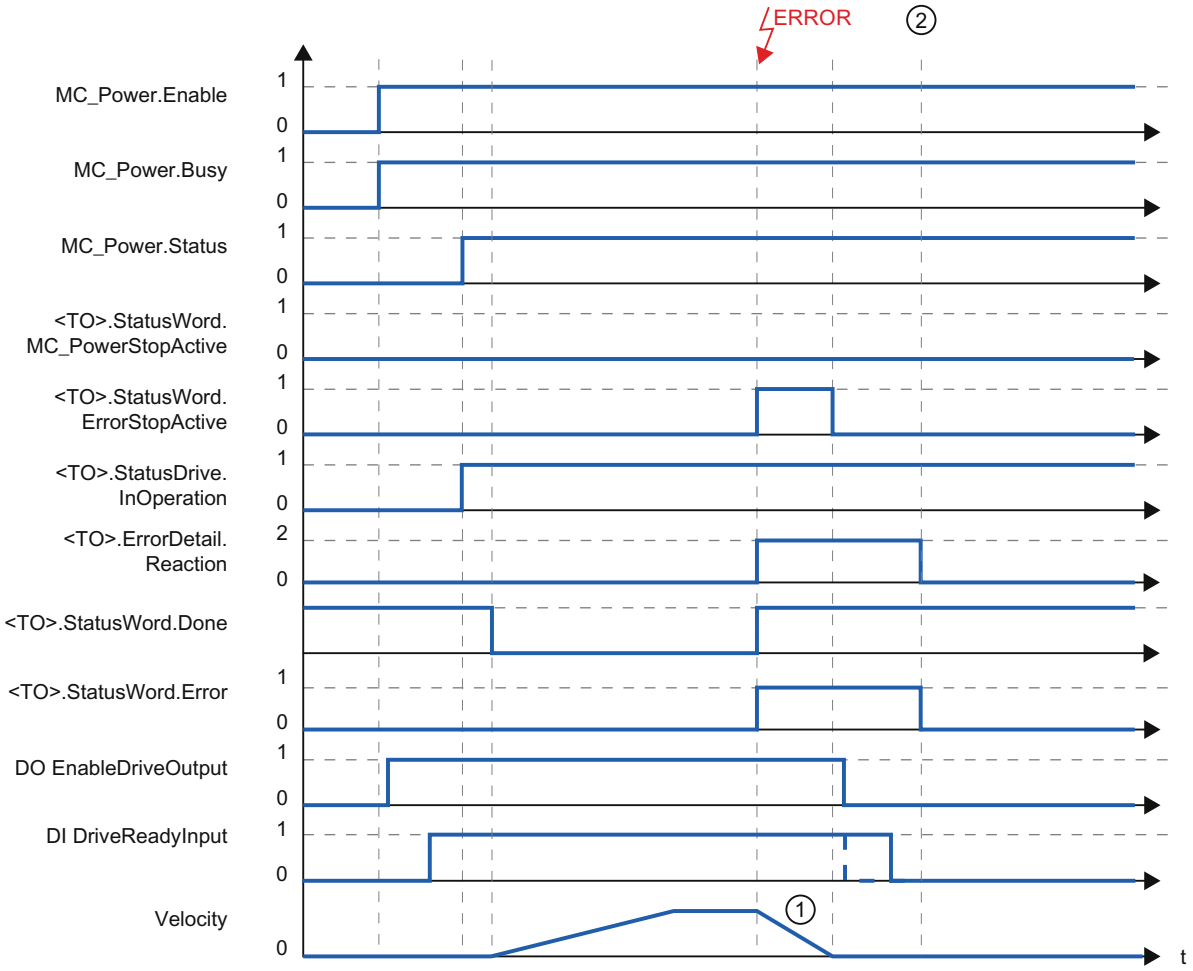


① The deceleration ramp depends on the configuration in the drive.

– – – The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

A.4.2.3 Alarm response "Stop with maximum dynamic values"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm response "Stop with maximum dynamic values"



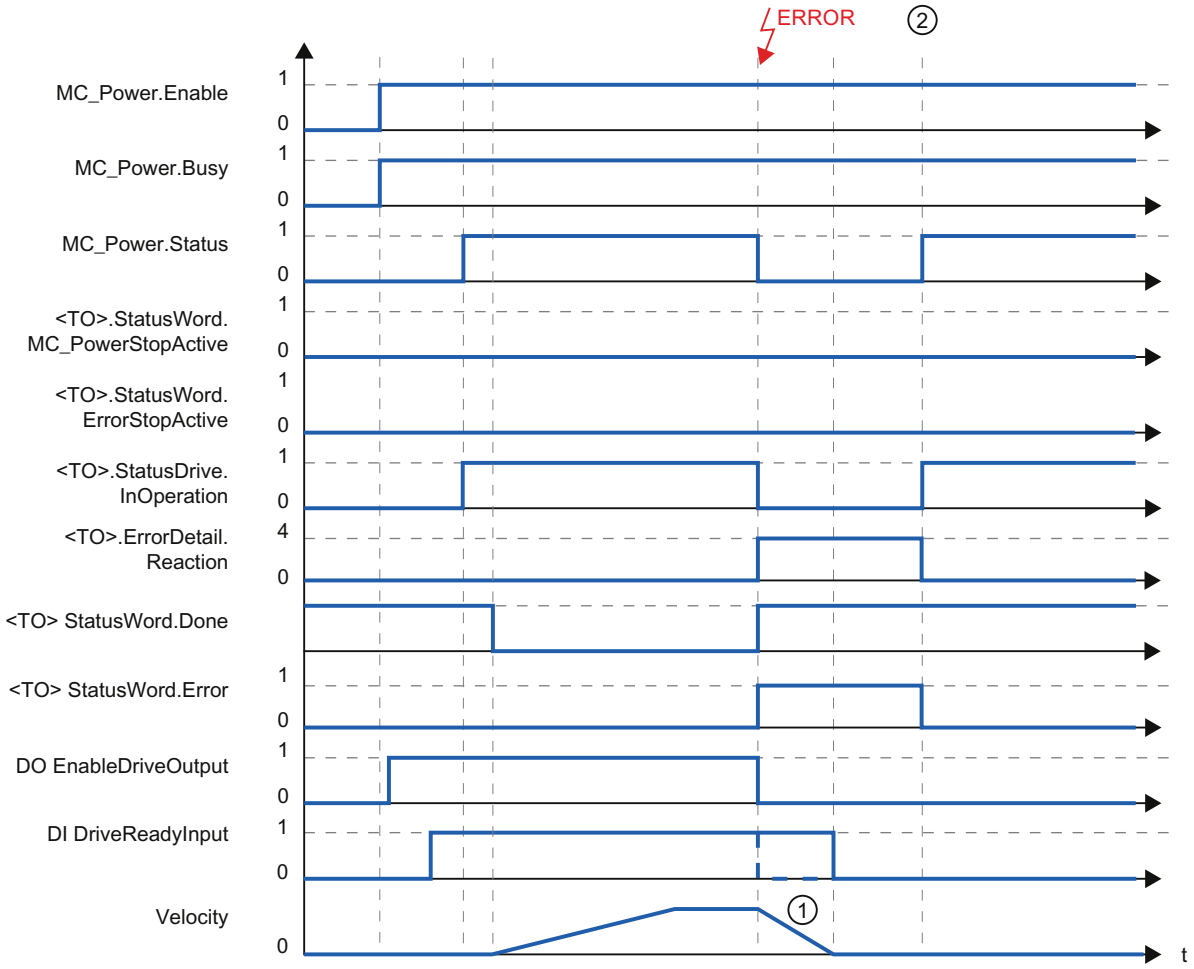
① The axis decelerates with the configured maximum deceleration.

② The technology alarm is acknowledged at time ②.

- - - The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

A.4.2.4 Alarm response "Remove enable"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm response "Remove enable"



① The deceleration ramp depends on the configuration in the drive.

② The technology alarm is acknowledged at time ②.

– – – The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

A.5 SINAMICS drives

A.5.1 Active homing for SINAMICS drives with external zero mark

For SINAMICS drives with external zero mark, synchronization during active homing must always occur on the left side of the external zero mark's signal. That is to say, with a positive direction of travel synchronization is done on a positive edge, and with a negative direction of travel synchronization is done on a negative edge.

By inverting the signal, synchronization can also be done on the right sight of the signal of the external zero mark. The inversion can be configured in the drive using SINAMICS parameter P490.

Homing to an encoder zero mark or an external zero mark is configured in SINAMICS parameter P495.

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Industry Automation

SINAMICS/SIMATIC
Using the trace and logic analyzer function

Function Manual

12/2012
A5E31277292-AA

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indicates that minor personal injury can result if proper precautions are not taken.

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Preface

Purpose of the documentation

The diagnostics options available with the trace and logic analyzer function are described in this documentation. Depending on the device used, the recording options can vary.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- Knowledge about the use of Windows-based computers
- S7-1200/1500 CPUs
  - Knowledge of working with the SIMATIC industrial automation system
  - Knowledge of working with STEP 7 >= V12.0
- SINAMICS G120
  - Knowledge of working with the drive

Validity of the documentation

This documentation applies to all products of the S7-1200, S7-1500 and SINAMICS G120 product family.

Conventions

This documentation contains pictures of the devices described. The pictures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Further support

- The range of technical documentation for the individual SIMATIC products and systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the online ordering system is available on the Internet (http://mall.automation.siemens.com).

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Description 1

1.1 Supported hardware

The following devices (Page 37) support the trace and logic analyzer function:

- SIMATIC S7-1200 CPUs (as of firmware version V4.x)
- SIMATIC S7-1500 CPUs
- SINAMICS G120

1.2 Recording of measured values with the trace function

Introduction

The trace and logic analyzer function can be called in the device folder in the project navigator under the name "Traces" (Page 11).

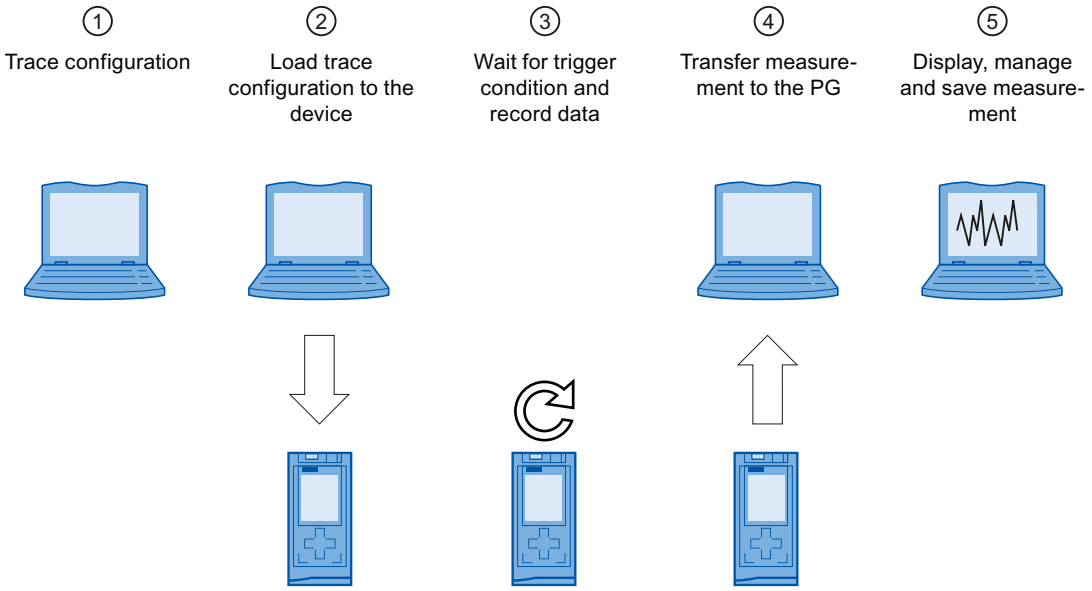
You record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The maximum recording duration is limited by the memory size. How much memory is available for the recording depends on the hardware used.

The recordings are saved on the device and, when required, can be read out with the engineering system (ES) and saved permanently. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The recorded values are overwritten when "Installed traces" is activated again.

Depending on the device (Page 37) used, the recording options can vary.

A quick start (Page 23) for working with the trace and logic analyzer function can be found in the Operation section.

The following figure shows the method of operation of the "Traces":



① Trace configuration on the programming device (PG) in the TIA Portal

You can specify the signals to be recorded, the duration of the recording and the trigger condition in the trace configuration. The trace configuration depends on the device and is described at the respective device (Page 37).

② Transferring the trace configuration from the PG to the device

You can transfer the complete trace configuration (Page 30) to the device when an online connection is established.

③ Waiting for the recording

If the installed trace configuration is activated (Page 31), then the recording is performed independently of the PG. The recording is started as soon as the trigger condition is satisfied.

④ Transferring the measurement from the device to the PG

The saving of the measurement in the project (Page 32) stores the measurement in the opened project of the TIA Portal.

⑤ Evaluating, managing and saving the measurement

Numerous options are available for the evaluation of the measurement in the curve diagram and in the signal table (Page 32). Various display types are possible, for example, a bit representation for binary signals.
Measurements can also be exported and imported as a file.
With the saving of the project (Page 32) in the TIA Portal, the measurements transferred to the project are also saved.

1.3 Trace configuration, recording and measurement

This section explains the meaning of the terms: trace configuration, recording and measurement.

Trace configuration

You can make the following settings in the trace configuration :

- Signals to be recorded
- Trigger condition
- Duration of the recording

Recording

A recording is performed in the device. There is only one recording for each installed trace configuration. When a new recording is started, the old recording is overwritten.

An installed recording is not retentive (it is lost when the device is switched off/on) and can be saved permanently in the project as a measurement.

Installed traces

An installed trace consists of a trace configuration and optionally a recording.

The maximum number of installed traces depends on the device.

The status of an installed trace can be viewed online.

Measurement

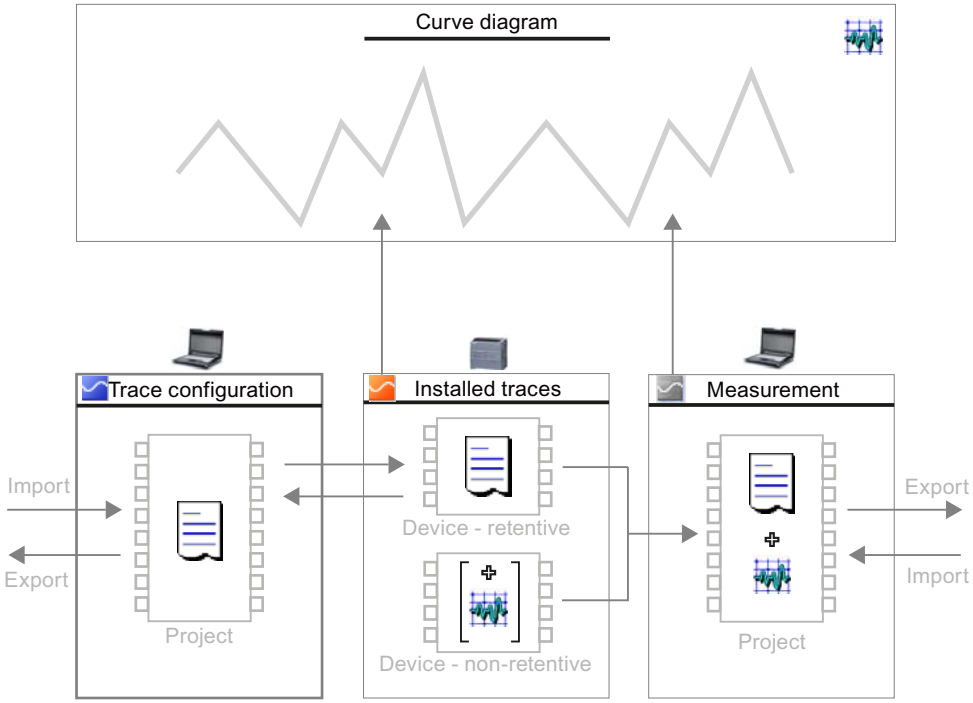
A measurement always consists of a trace configuration with an associated recording. If an installed trace contains a recording, it can be saved in the project as a measurement.

The recording of a measurement can be viewed offline.

1.4 Data storage

The trace handling and the curve diagram also enable the transfer of the trace configuration and the viewing of the recording.

The following figure is a schematic diagram of the data storage:



Note

Saving the trace configuration and measurement

You save the trace configuration and measurement with the project in the TIA Portal.

If you close the project without saving, the trace configurations and the measurements transferred to the project are discarded. The trace editor can be closed and reopened without loss of data until the project is closed.

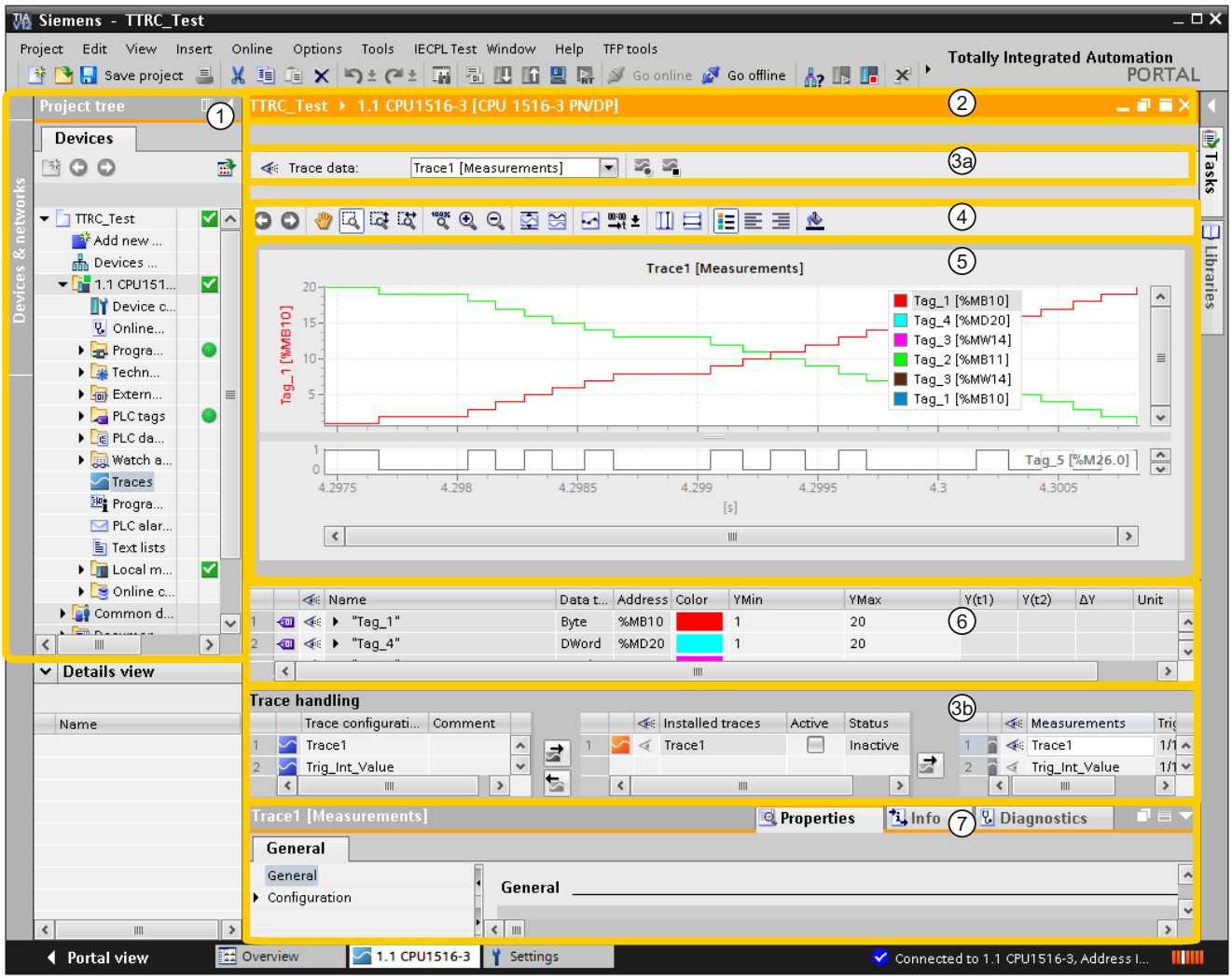
Software user interface

2

Display areas

The user interface of the trace and logic analyzer function consists of several areas.

The example in the figure below shows the division of the user interface in the TIA Portal:



1	Project navigator	
	Working area	
2		Title bar of the working area Shows the device to which the current display belongs.
3a		Toolbar of the trace handling (Page 16) Selection of recordings for display in the curve diagram and buttons for activation/deactivation of installed traces.
4		Toolbar of the curve diagram (Page 13) Tools for editing the measurement and for adapting the display in the curve diagram
5		Curve diagram (Page 13) Display of the recorded values
6		Signal table (Page 15) Signals of the measurement
3b		Trace handling (Page 16) Creation of new trace configurations and the handling of the measurements.
	Device-specific area (see Devices (Page 37))	
7		Properties area in the Inspector window Configuration dialog boxes for the recording duration, trigger condition and signal selection.

2.1 Project navigator

If a device supports the trace and logic analyzer function, "Traces" is offered for selection in the project navigator below the device.

Double-clicking "Traces" opens the trace editor.

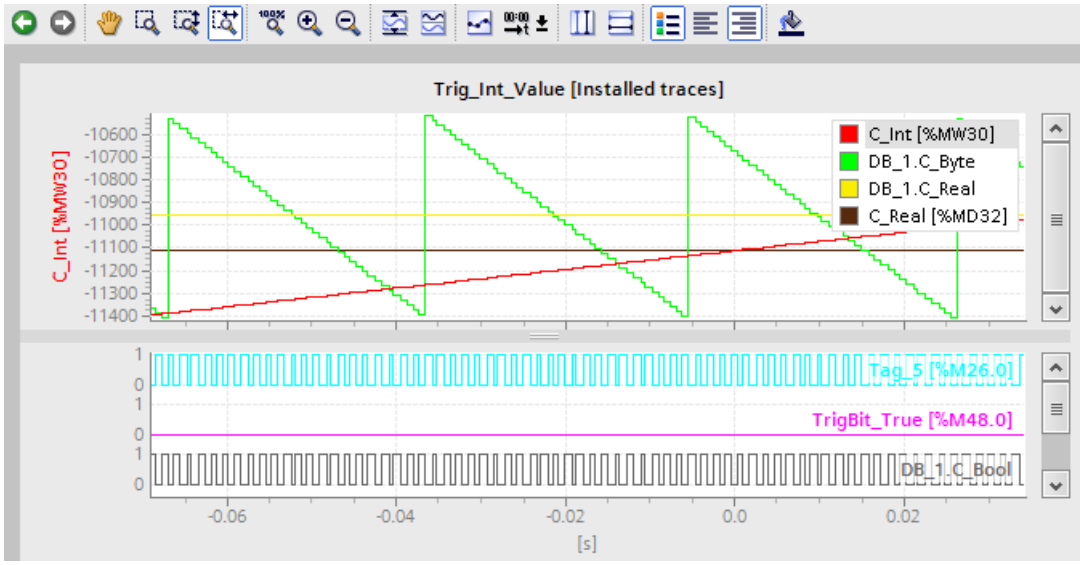
2.2 Working area

2.2.1 User interface - curve diagram

The curve diagram displays the selected signals of a recording. Bits are shown in the lower diagram as a bit track. Adjust the display of the signals in the signal table (Page 15) and with the aid of the toolbar of the curve diagram.

Setting options and displays in the curve diagram

The following figure shows an example of the display in the TIA Portal:



The scale in the diagram applies to the selected (highlighted in gray) signal in the legend. The legend can be moved laterally with the mouse.

Shortcut menu commands

The following table shows the shortcut menu commands in the curve diagram:

Shortcut menu command	Description
"Save diagram as image"	Exports the current display as a bitmap.
"Copy image to clipboard"	Copies the current display to the clipboard.
"Center measurement cursors"	Positions the activated measurement cursors at a central point in the current display.

Toolbar of the curve diagram

Tools are available for adapting the display via buttons.

The following table shows the functions of the buttons:

Icon	Function	Description
	Undo zoom	Undoes the zoom function executed last. If several zoom functions have been executed, they can be undone step-by-step.
	Redo zoom	Redoes the last undone zoom function. If several zoom functions have been undone, they can be redone step-by-step.
	Move view	Moves the display with the mouse button pressed.
	Zoom selection	Selection of an arbitrary range with the mouse button pressed. The display is scaled to the range selection.
	Vertical zoom selection	Selection of a vertical range with the mouse button pressed. The display is scaled to the range selection.
	Horizontal zoom selection	Selection of a horizontal range with the mouse button pressed. The display is scaled to the range selection.
	Display all	Scaling of the display so that the entire time range and all values are displayed.
	Zoom in	Enlargement of the display. The ranges of the time axis and value axis are reduced every time the button is clicked. The curves are displayed larger.
	Zoom out	Reduction of the display. The ranges of the time axis and value axis are increased every time the button is clicked. The curves are displayed smaller.
	Scale automatically	Scaling of the display so that all values are displayed for the currently displayed time range.
	Arrange in tracks	Arranges signals one beneath the other without overlaps.
	Display samples	The samples are displayed as small circles on the curves.
	Unit changeover of the time axis	Changeover of the unit between time and cycles.
	Display vertical measurement cursors	Display of the vertical measurement cursors. The vertical position of the two measurement cursors can be moved with the mouse. The associated measured values and the difference of the measurement cursors corresponding to the position are shown in the signal table.
	Display horizontal measurement cursors	Display of the horizontal measurement cursors.
	Display chart legend	Display of the chart legend in the curve diagram.
	Align the chart legend to the left	Display of the chart legend on the left side of the curve diagram.

Icon	Function	Description
	Align the chart legend to the right	Display of the chart legend on the right side of the curve diagram.
	Change background color	Changeover between various background colors.

2.2.2 User interface - signal table

The signal table lists the signals of the selected measurement and provides setting options for some properties. If recording data of "Installed traces" is displayed and the settings are changed in the signal table, these settings are retained until there is a change to the offline mode.

Setting options and displays in the signal table

The following figure shows an example of the display in the TIA Portal:

			Name	Data type	Address	Color	YMin	YMax	Y(t1)	Y(t2)	ΔY	Unit	Comment
1			"C_Int"	Int	%MW30	...	-11410	-10513	-11257	-11113	144		
2			"Tag_5"	Bool	%M26.0	...	0	1	1	1	0		
3			"TrigBit_True"	Bool	%M48.0	...	0	1	0	0	0		

The following table shows the settings and displays of the recorded signals:

Column		Description
		Static display of the signal icon
		Selection for the display in the curve diagram
"Name"		Display of the signal name A click on the name of a displayed signal updates the scale in the curve diagram.
		Open bit selection Individual bits can also be selected for the following data types for display as a bit track in the lower curve diagram. • Byte, Word, DWord, LWord • SInt, USInt, Int, UInt, DInt, UDInt, LInt, ULInt Example of an opened bit selection for the DWORD data type: 1 "Tag_1" Byte %MB10 2 "Tag_4" DWord %MD20 3 Bool %M20.0 4 Bool %M20.1 5 Bool %M20.2 Select or deselect the relevant bit for display by clicking the icon.
"Data type"		Display of the data type
"Address"		Display of the address (not for symbolic tags)
"Color"		Display and setting option for the color of the signal

Column	Description
"YMin"	Enter the minimum value for the scaling of the signal
"YMax"	Enter the maximum value for the scaling of the signal
"Y(t1)"	Display of the value at the position of the first measurement cursor
"Y(t2)"	Display of the value at the position of the second measurement cursor
"ΔY"	Display of the value difference between the first and the second measurement cursor
"Unit"	Display of the unit (e.g. for technology objects)
"Comment"	Display and input option for a comment about the signal

Shortcut menu commands

The following table shows the shortcut menu commands of the signal table:

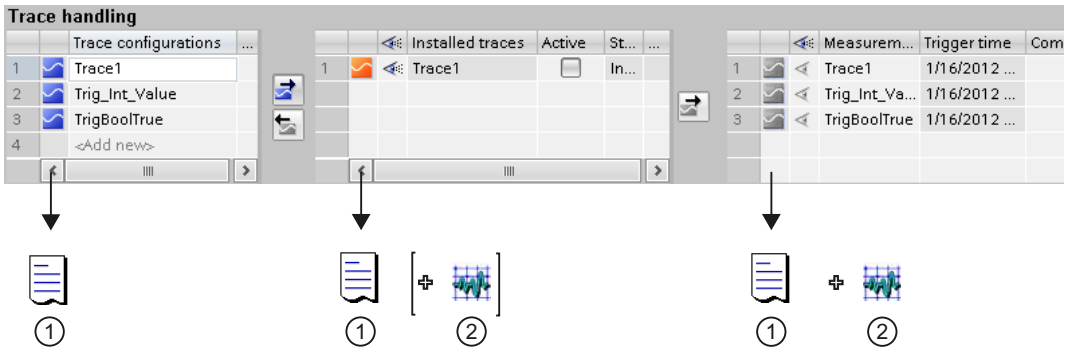
Shortcut menu command	Description
"Cut"	Cannot be selected.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected.
"Show/hide signal"	Shows/hides the signal in the curve diagram.
"Bring to foreground"	Displays the selected signal in the foreground. The other signals are hidden.

2.2.3 User interface - trace management

The trace handling enables the configuration and handling of trace configurations.

Setting options and displays in the trace handling

The following figure shows an example of the display in the TIA Portal:



① Trace configuration
② Recording (recorded values)

Toolbar of the trace handling

A recording can be selected for display via a drop-down list and buttons, and activated or deactivated.

The example in the figure below shows the toolbar of the trace handling

The following table describes the functions of the buttons:

Icon	Description
	Selection for the display in the curve diagram A click on the icon shows/hides the recording in the curve diagram.
	Selection of an "Installed trace" or a "Measurement" for display in the curve diagram
	Activation of the recording The button is available for "Installed traces".
	Deactivation of the recording The button is available for "Installed traces".

"Trace configurations" table

The table contains all the trace configurations of the project that can be transferred to the device. Each trace configuration contains the tags to be recorded and the required recording settings. The data is displayed in offline and online mode.

The following table shows the settings and displays:

Column	Icon	Description
-		Display of the icon for the trace configuration Incorrect trace configurations are shown with an additional red icon and cannot be transferred to the device. Check the device-specific configuration in the Inspector window. Double-clicking the icon brings the Inspector window with the device-specific properties to the foreground.
"Trace configuration"	-	Name of the trace configuration. The name can be changed after double-clicking the field.
"Comment"	-	Input field for a comment.

Shortcut menu commands

The following table shows the shortcut menu commands of the "Trace configurations" table:

Shortcut menu command	Description
"Cut"	Removes the selected lines and moves them to the clipboard.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Pastes the contents of the clipboard to the selected line. The existing contents are overwritten.
"Delete"	Deletes the selected lines from the table.
"Rename"	Switches the selected cell to the editing mode.
"Transfer trace configuration to device"	Transfers the trace configuration selected in the "Trace configurations" table to the device. The button is active when all the required settings in the device-specific configuration have been configured correctly in the Inspector window and there is an online connection.
"Export trace configuration"	Exports a trace configuration as a file with the "*.ttcfg" file extension.
"Import trace configuration"	Imports a trace configuration from a file.
"Properties"	Brings the Inspector window with the device-specific properties to the foreground.

"Installed traces" table

The table contains the trace configurations already transferred to the device and their current operating mode. The data is displayed in the online mode.

The following table shows the settings and displays:

Column	Icon	Description
-		Static display of the online icon Double-clicking the icon brings the Inspector window with the device-specific properties to the foreground.
		Selection for the display in the curve diagram A click on the icon shows/hides the recording in the curve diagram.
"Installed traces"	-	Name of the trace configuration.
"Active"		Activation of the recording and feedback of the status. The checkbox is reset at the end of the recording.
"Status"	-	Status display of the trace configuration The following states are possible: • "Installing" • "Waiting for trigger" • "Recording" • "Recording finished" • "Aborted" • "Fault"
"Comment"	-	Display of the trace configuration comment

Shortcut menu commands

The following table shows the shortcut menu commands of the "Installed traces" table:

Shortcut menu command	Description
"Cut"	Removes the selected lines and moves them to the clipboard.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected.
"Delete"	Deletes the selected lines from the table.
"Rename"	Cannot be selected.
"Add to trace configurations"	Transfers the installed trace configuration to the "Trace configurations" table.
"Add to measurements"	Adds the selected "Installed trace" to the "Measurements" table.
"Activate"	Activates the recording and shows the state in the table
"Show/hide in curve diagram"	Shows/hides the recording in the curve diagram.
"Properties"	Brings the Inspector window with the device-specific properties to the foreground.

"Measurements" table

The table contains the trace configurations with recordings. The data is displayed in offline and online mode.

Measurements can also be exported and imported, see Exporting and importing measurements (Page 33).

The following table shows the settings and displays:

Column	Icon	Description
-		Static display of the icon for a measurement Double-clicking the icon brings the Inspector window with the device-specific properties to the foreground.
		Selection for the display in the curve diagram A click on the icon shows/hides the recording in the curve diagram.
"Measurements"	-	Name of the measurement The name can be changed after double-clicking the field.
"Trigger time"	-	The meaning of the trigger time depends on the device Examples: • SIMATIC S7-1200/1500 CPUs The absolute time of the controller is entered at the start of the recording. • SINAMICS G120 The transfer time is entered with the transfer of the trace configuration to the device.
"Comment"	-	Input field for a comment.

Shortcut menu commands

The following table shows the shortcut menu commands of the "Measurements" table:

Shortcut menu command	Description
"Cut"	Removes the selected lines and moves them to the clipboard.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected.
"Delete"	Deletes the selected lines from the table.
"Rename"	Switches the selected cell to the editing mode.
"Add to trace configurations"	Transfers the trace configuration of the measurement to the "Trace configurations" table.
"Show/hide in curve diagram"	Shows/hides the recording in the curve diagram.
"Export measurement"	Exports a measurement as a file with the "*.ttrec" or "*.csv" file extension.
"Import measurement"	Imports a measurement from a file with the "*.ttrec" file extension.
"Properties"	Brings the Inspector window with the device-specific properties to the foreground.

Buttons

The following table shows the functions available via buttons:

Icon	Description
	Button to transfer a selected trace configuration to the device The selected trace configuration in the "Trace configurations" table is transferred to the device. The button is active when all the required settings in the device-specific configuration have been correctly configured in the Inspector window and there is an online connection.
	Button to transfer a selected trace configuration from the device The trace configuration selected in the "Installed traces" table is transferred from the device to the "Trace configurations" table.
	Button to transfer a selected measurement from the device to the project. The selection in the "Installed traces" table is added to the "Measurements" table.

2.3 Device-specific area

The device-specific area enables the trace configuration.

The signals to be recorded and the trigger condition are specified here. These and other configuration options are described in the device-specific part (Page 37) for the individual devices.

Operation

3

3.1 Quick start

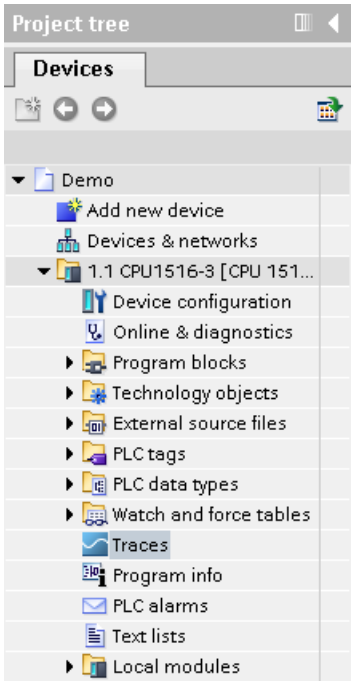
This description shows the steps for a recording of the S7-1500 CPU as an example. The displayed settings can differ depending on the device.

Requirement

A device is configured that supports the trace and logic analyzer function.

Calling the trace editor

The following figure shows the project navigator with "Traces" below the device:

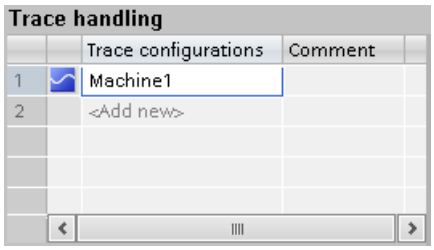


Procedure:

1. Open the trace editor by double-clicking the "Traces" entry.

Creating a trace configuration

The following figure shows the "Trace configurations" table:

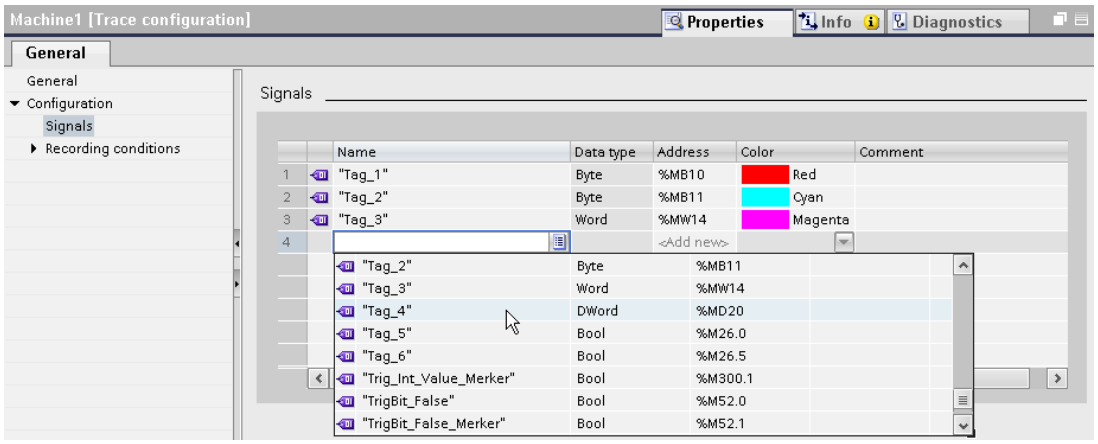


Procedure:

1. Enter the name of the trace configuration in the "Trace configurations" table.

Selecting signals

The following figure shows the configuration of the signals:

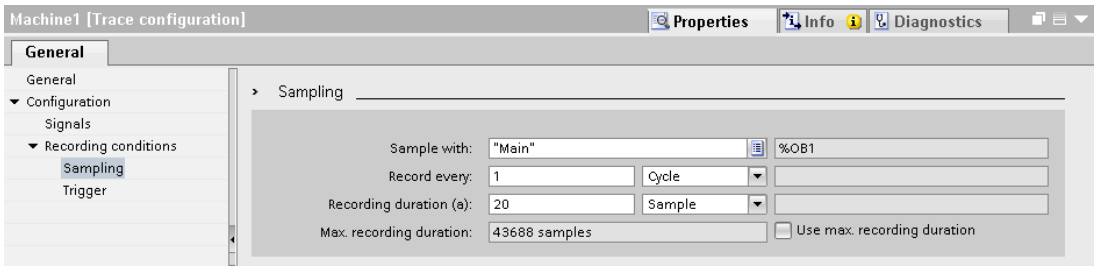


Procedure:

1. Select the signals to be recorded in the "Signals" area of the Inspector window.

Configuring the recording cycle

The following figure shows the configuration of the sampling:

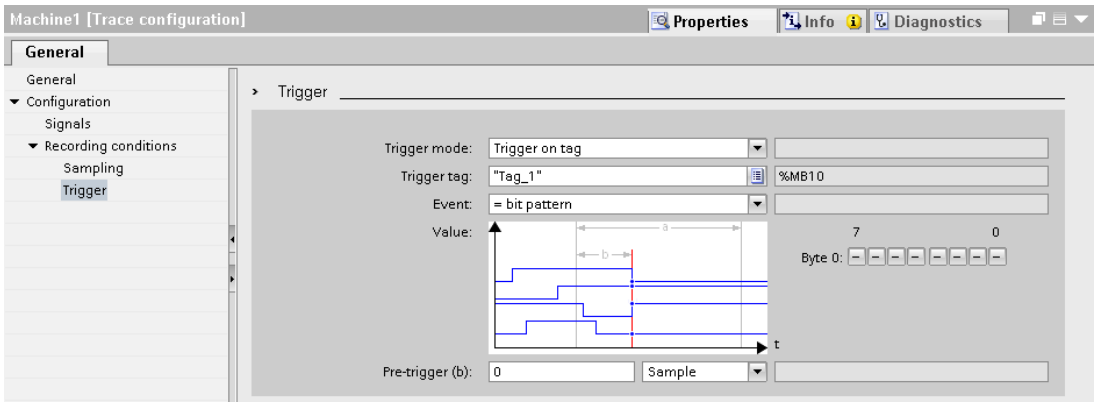


Procedure:

1. Configure the sampling.

Configuring the trigger

The following figure shows the configuration of the trigger:

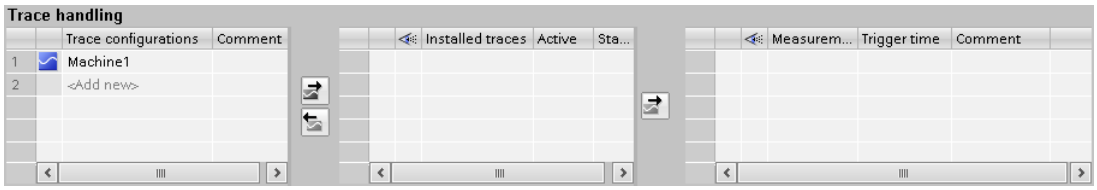


Procedure:

1. Configure the trigger mode and the condition for the selected trigger.

Transferring the trace configuration to the device

The following figure shows the trace handling in online mode:



Procedure:

1. Check whether the configuration is correct based on the icon in the "Trace configurations" table.

   The icon indicates a correct trace configuration.

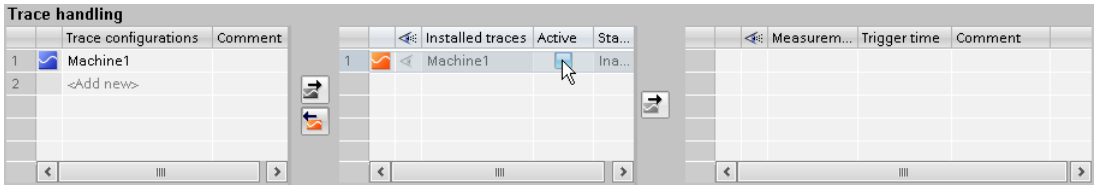
   The icon indicates a faulty trace configuration.

   Only correct trace configurations can be transferred to the device.

2. Establish an online connection to the device.
3. Select the trace configuration in the "Trace configurations" table and transfer it to the device with the button.

Activating a recording

The following figure shows the trace handling with an installed trace configuration:

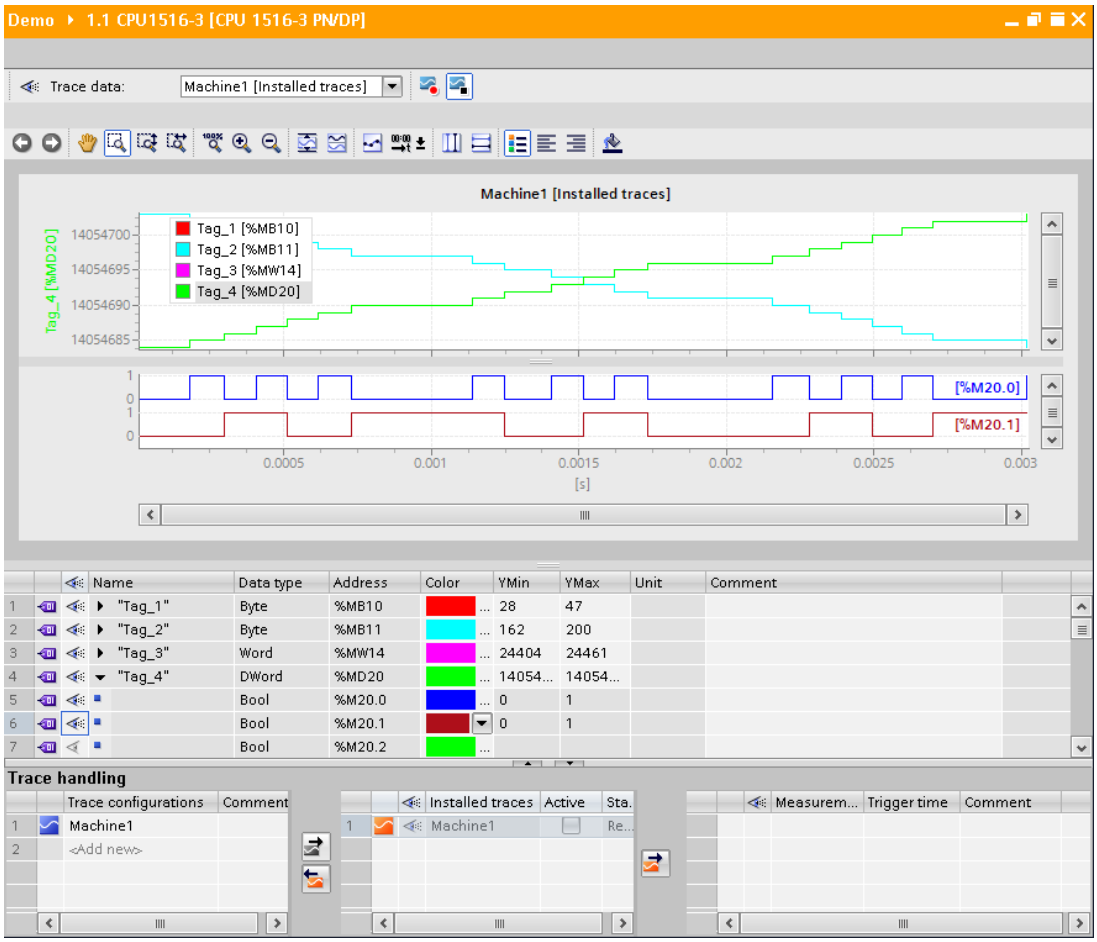


Procedure:

1. Click the checkbox in the "Active" column in the "Installed traces" table.

Displaying the recording

The following figure shows the curve diagram with the recording of the "Installed trace":



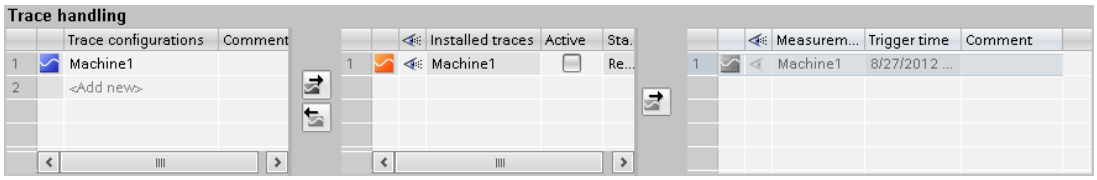
Procedure:

1. Wait until the "Recording" or "Recording completed" status is displayed in the "Installed traces" table.
2. Click the icon in the "Installed traces" table to display the recording in the curve diagram.
3. Click the ▸ icon of a signal in the signal table.

   The individual bits of the signal are offered for display as a bit track.
4. In the signal table, select or deselect the individual signals and bits for display with the icon.

Saving the measurement in the project

The following figure shows the measurement saved in the project:



Procedure:

1. Select the measurement in the "Installed traces" table and transfer it to the project with the button.

3.2 Using the trace function - overview

Requirement

A device is configured in the TIA Portal that supports the trace and logic analyzer function and to which an online connection has been established.

Procedure

The following table shows a procedural overview with typical steps when working with the trace and logic analyzer function.

Step	Description
1	Calling the trace editor (Page 29)
2	Configuring the trace (Page 29)
3	Transferring the trace configuration to the device (Page 30)
4	Activating/deactivating an installed trace (Page 31)
5	Monitoring the recording (Page 32)
6	Saving measurements in the project (Page 32)
7	Displaying the recording (Page 32)

3.3 Calling the trace editor

A trace editor can be opened for each device in the project navigator.

The following instructions describe how you call the trace editor in the work area of the TIA Portal.

Requirement

A device is configured that supports the trace and logic analyzer function.

Procedure

To call the trace editor, proceed as follows:

1. In the project navigator, double-click the device.

   The device folder opens.

2. Double-click "Traces".

3.4 Trace handling

3.4.1 Configuring the trace

Requirement

The trace editor is open.

Creating and deleting the trace configuration

To create a new trace configuration, proceed as follows:

1. Click the "<Add>" entry in the "Trace configurations" table in the Trace handling (Page 16).
2. Enter the name for the trace configuration.

   The new trace configuration is created.

To delete a trace configuration, proceed as follows:

1. Right-click a trace configuration in the "Trace configurations" table and select the shortcut menu command "Delete".

   The trace configuration is deleted.

Configuring the trace

In the configuration, you specify the recording and trigger conditions and select the signals to be recorded.

See Section "Configuration" below the respective device (Page 37).

Note

Saving the trace configuration

You save the trace configuration with the project in the TIA Portal.

If you close the project without saving, the configuration is discarded. The trace editor can be closed and reopened without loss of data until the project is closed.

3.4.2 Transferring the trace configuration to the device

Requirement

- A valid trace configuration is located in the "Trace configurations" table.
- The maximum number of "Installed traces" has not been reached yet.
- There is an online connection to the device.

Procedure

To transfer a trace configuration to the device, proceed as follows:

1. Select a trace configuration in the "Trace configurations" table.
2. Click the button to transfer the trace configuration to the device.

Result

The trace configuration is transferred to the device and displayed in the "Installed traces" table.

3.4.3 Activating/deactivating an installed trace

Requirement

A trace configuration is installed and there is an online connection to the device.

Activating an installed trace

To activate the recording for an installed trace, proceed as follows:

1. Activate the checkbox of the "Active" column in the "Installed traces" table.

   The installed trace is activated and starts the recording according to the configured trigger condition. The trigger condition is device-specific and described in Section "Configuration" below the respective device (Page 37).

   Note

   When a recording is restarted, the previously recorded values are lost.

   To save the recorded values, save the measurement in the project (Page 32) before you activate the recording again.

Deactivating an installed trace

To deactivate an activated installed trace, proceed as follows:

1. Deactivate the checkbox of the "Active" column in the "Installed traces" table.

   The installed trace is deactivated.

3.4.4 Displaying the recording

Requirement

A trace configuration with recording is in the device and there is an online connection to the device or there is an entry in the "Measurements" table.

Procedure

To display the recording, proceed as follows:

1. Select an entry in the "Installed traces" table.
2. Click in the column for the selected entry.

Or:

1. Select an entry in the "Measurements" table.
2. Click in the column for the selected entry.

Result

The recording is displayed in the curve diagram and the signal table.

3.4.5 Saving measurements in the project

Requirement

A trace configuration with recording is installed and there is an online connection to the device.

Procedure

To save a recording in the project, proceed as follows:

1. Click an entry in the "Installed traces" table in the trace handling.
2. Click the button to transfer the selected entry.

   The selected entry in the "Installed traces" table is added to the "Measurements" table.
3. Save the project in the TIA Portal.

3.4.6 Exporting and importing measurements

Requirement

There is at least one measurement in the "Measurements" table.

Exporting measurements

To export a measurement, proceed as follows:

1. Right-click an entry in the "Measurements" table and select the shortcut menu command "Export measurement".
2. Select a folder, a file name and a data type to save the measurement.
3. Click the "Save" button.

Importing measurements

To import a measurement, proceed as follows:

1. Right-click in the "Measurements" table and select the shortcut menu command "Import measurement".
2. Select the file of the "*.ttrec" file type with the measurement to be imported.
3. Click the "Open" button.

   The imported measurement is displayed with the file name in the "Measurements" table.

3.4.7 Transferring the trace configuration from the device to the project

Requirement

A trace configuration is installed and there is an online connection to the device.

Procedure

To transfer a trace configuration to the project, proceed as follows:

1. Select an entry in the "Installed traces" table.
2. Click the button to transfer the trace configuration from the device.

Result

The configuration of the "installed trace" is transferred to the "Trace configurations" table.

3.4.8 Deleting installed traces

Requirement

A trace is installed and there is an online connection to the device.

Deleting an installed trace

To delete an installed trace, proceed as follows:

1. Select one or more lines to be deleted in the "Installed traces" table.
2. Press <Del> to delete the "Installed traces".

3.5 Signal table

3.5.1 Use of the signal table

The signal table shows the recorded values of an installed trace or a measurement. You can show or hide individual signals for the display in the table and adapt the properties for the display.
Individual bits can be selected for some data types and displayed as a bit track.

The following operating instructions describe the operation of the signal table.

Requirement

- An entry is selected in the column in the "Installed traces" or "Measurements" table.
- For the display of individual bits as a bit track:
  At least one recorded signal supports the display as a bit track.

Selecting individual signals in the signal table and changing the format

To adapt the display to suit your requirements, proceed as follows:

1. Click the icon of the respective signal in the column to select or deselect it for the display.
2. Click in the "Color" column for the respective signal to change the default color of the signal.
3. Click the "Bring to foreground" entry in the shortcut menu of a signal to display it in the foreground.

Selecting individual bits in the signal table for display as a bit track

To display individual bits as a bit track in the lower curve diagram, proceed as follows:

1. Click the ▸ icon of a signal in the signal table.
2. Click the ◂ icon in the opened bit selection of the signal to select or deselect individual bits for the display.

3.6 Curve diagram

3.6.1 Use of the curve diagram

The curve diagram shows the signals of a recording selected in the signal table. Select the recording in the "Installed traces" or "Measurements" table of the trace handling.

The display area can be zoomed as required. Measurement cursors can be used to select individual values for display in the signal table.

The following operating instructions describe the use of the measurement cursors.

Requirement

A recording has been selected for display.

Evaluation of a certain instant of a recording

To display the values for a specific sample, proceed as follows:

1. Display the vertical measurement cursors via the button.
2. Move a measurement cursor with the mouse to the required position in the recording.

   The values of the signals are displayed in the signal table. The time or sample for the measurement cursors is displayed in the lower area of the curve diagram.

Evaluation of the difference between two samples

To display the difference, proceed as follows:

1. Display the vertical measurement cursors via the button.
2. Move both measurement cursors with the mouse to the required samples in the recording.

   The values of the signals and the difference are displayed in the signal table. The time or sample for the measurement cursors is displayed in the lower area of the curve diagram.

Using horizontal measurement cursors

To check whether a certain value has been reached, proceed as follows:

1. Display the horizontal measurement cursors via the button.
2. Move a measurement cursor with the mouse to the required value of the recording.

   The values of the measurement cursor for the selected signal are displayed in the lower area of the curve diagram.

3.6.2 Printing a recording

The curve diagram supports the saving of the display as a bitmap and the copying of the display to the clipboard. Also use these functions (Page 13) for printing.

Devices 4

4.1 S7-1200/1500 CPUs

4.1.1 Recordable variables

Device-dependent recording of tags

The following list shows the operand areas from which tags can be recorded:

- Process image input
- Process image output
- Bit memory
- Data blocks

Data types

All elementary data types can be recorded.

The following table lists the elementary data types:

Data types	Note
Binary numbers	
BOOL	-
Bit strings	
BYTE	-
WORD	-
DWORD	-
LWORD	Symbolic name required
Integers	
SINT	-
USINT	-
INT	-
UINT	-
DINT	-
UDINT	-
LINT	Symbolic name required
ULINT	Symbolic name required
Floating-point numbers	
REAL	-
LREAL	Symbolic name required

4.1.2 Lifetime of the installed trace configuration and recorded values

Installed trace configurations are retained after POWER OFF. The recording is activated again after the restart of the CPU.

Recorded values are lost during the restart.

4.1.3 Recording levels

The following list shows the execution levels that can be selected for the recording cycle:

- Program cycle - OB 1
- Time-of-day interrupt - OB 1x
- Time-delay interrupt - OB 2x
- Watchdog interrupt - OB 3x
- Synchronized processing cycles - OB 6x, not OB 60
- Servo task - OB 91 (S7-1500)
- IPO - OB 92 (S7-1500)

Note

The measured values are recorded at the end of the OB after the processing of the user program.

4.1.4 Quantity structure

The following table shows the maximum quantity structure that can be recorded with the trace and logic analyzer function:

Device	Maximum number of "Installed traces"	Maximum number of signals per trace configuration
S7-1200 (as of firmware version V4.x)	2	16
S7-1500	4	16

4.1.5 CPU load through trace recording

A trace recording increases the runtime of the respective recording level that can result in an execution level overflow with high utilization of the CPU.

Remedy

- **Change the trace configuration**

  1) Configure fewer tags and signals.

  2) Then increase the number of tags and signals up to the maximum number of signals step-by-step without an execution level overflow.

- **Select a slower recording level**

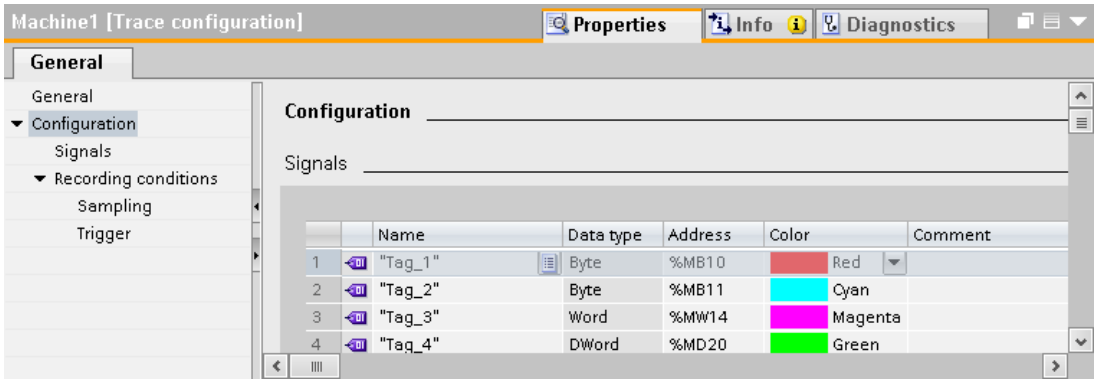
4.1.6 Software user interface of the device-specific area

4.1.6.1 Structure of the user interface

Display areas in the Properties window of the Inspector

The settings options differ depending on the configured device.

The following figure shows an example of the display in the TIA Portal:



The area navigation provides the following entries for selection:

- General
- Configuration
  - Signals (Page 41)
  - Recording conditions (Page 42)

Display of the properties of a trace configuration

The trace configuration is selected in the trace handling:

- Selection in the "Trace configurations" table

  The properties are displayed in the Inspector window and can be changed.
- Selection in the the "Installed traces" table or "Measurements" table

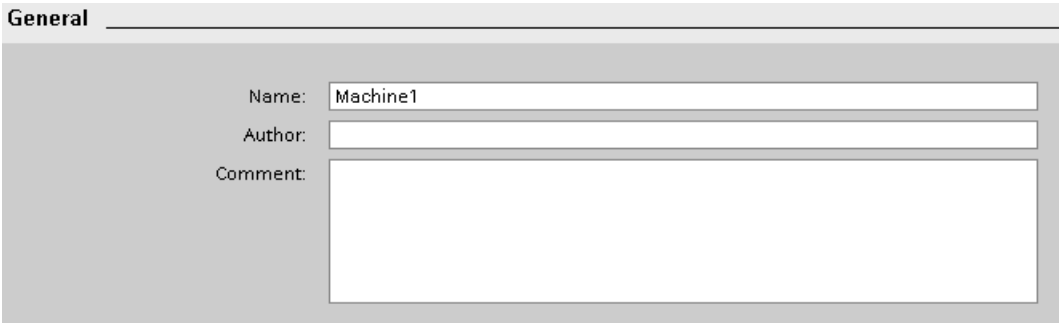
  The properties are displayed write-protected in the Inspector window.

4.1.6.2 User interface - General

The "General" area shows the name of the trace configuration and input fields for the author and a comment.

Input options and displays in General

The following figure shows an example of the display in the TIA Portal:



The following table shows the input fields and displays:

Column	Icon	Description
"Name"	-	Name of the trace configuration
"Author"	-	Author of the trace configuration
"Comment"	-	Input field for a comment

4.1.6.3 User interface - Signals

The "Signals" area shows a table in which the signals to be recorded are configured for the selected trace configuration.

Setting options and displays in "Signals"

The following figure shows an example of the display in the TIA Portal:

Signals

		Name	Data type	Address	Color	Comment
1		"Tag_1"	Byte	%MB10	Red	
2		"Tag_2"	Byte	%MB11	Cyan	
3		"Tag_3"	Word	%MW14	Magenta	
4		"Tag_4"	DWord	%MD20	Green	

The following table shows the settings and displays:

Column	Icon	Description
		Display of the signal icon for a selected signal.
"Name"	-	Input field for the name or address of the signal. **Examples:** • M0.0 • DB1.DBW3 • "Data_block_1".pressure
-		Button to open the signal selection table. The button is displayed when the table line is selected. Clicking the icon opens a table which offers possible signals for selection. The selected signal is displayed in the input field.
"Data type"	-	Text field with display of the data type for the signal.
"Address"	-	Input field for the address of the signal. With purely symbolic signals the field remains empty.
"Color"	-	Text field for display and selection of the color. Click the selected field to display the signal color. Click the signal color to open the color selection dialog.
"Comment"		Input field for a comment.

Shortcut menu commands

The following table shows the shortcut menu commands of the table:

Shortcut menu command	Description
"Cut"	Removes the selected lines and moves them to the clipboard.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Pastes the contents of the clipboard to the selected line. The existing contents are overwritten.
"Delete"	Deletes the selected lines from the table.
"Rename"	Switches the selected cell to the editing mode.

4.1.6.4 Recording conditions

Supported data types

The following table shows the supported data types for the trigger tag:

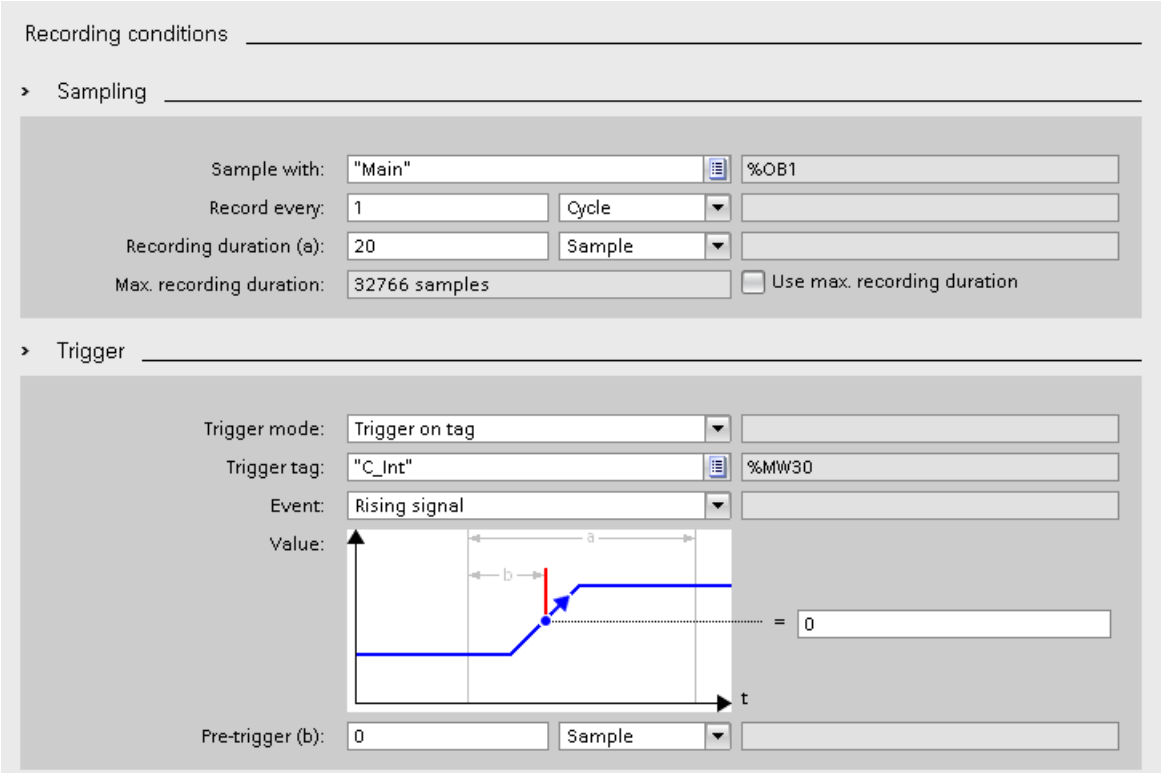
Memory requirement and format of the number	Data type
1 byte	BOOL
8-bit integers	SINT, USINT, BYTE
16-bit integers	INT, UINT, WORD
32-bit integers	DINT, UDINT, DWORD
64-bit integers	LINT, ULINT, LWORD
32-bit floating-point numbers	REAL
64-bit floating-point numbers	LREAL

User interface - Recording conditions

The "Recording conditions" area shows the trigger condition for the selected trace configuration and in which cycle, how fast and how long the recording is made.
The configuration is only possible if the trace configuration has been selected in the "Trace configurations" table of the trace handling.

Setting options and displays in "Recording conditions"

The following figure shows an example of the display in the TIA Portal:



Setting/display		Description
"Recording time"		
	Drop-down list	Selection of the recording time. See Recording levels (Page 38)
	Text field	Detailed information on the selected recording time.
"Record every"		
	Input field	Input of the reduction in relation to the cycles.
	Drop-down list	Selection of the reduction factor. The following settings are possible: • "Cycle"
	Text field	Display of the sampling time, taking into account the configured reduction.

Setting/display		Description
"Recording duration"		
	Input field	Input of the recording duration in relation to the samples. If the "Recording duration = max. recording duration" checkbox is activated, entries are overwritten by the value displayed in "Max. recording duration".
	Drop-down list	Select the time unit for the recording duration. The following settings are possible: • "Samples"
	Text field	Displays the calculated recording duration
"Max. recording duration"		
	Text field	Displays the calculated maximum recording duration The "Max. recording duration" depends on how many signals are recorded and the data type of these signals.
	"Use max. recording duration"	Set the recording duration to the maximum value. When the checkbox is activated, the recording duration is set to the maximum possible recording duration. The set reduction in the "Record every" input field is taken into account. The recording duration is also adapted when additional signals are added.
"Trigger mode"		Selection of the trigger mode.
	Drop-down list	The following settings are possible: • "Record immediately" The recording is made immediately after the device is activated. • "Trigger on tag" The recording is made as soon as the installed trace is activated and the configured trigger condition is fulfilled.
	Text field	Display of the trigger type.
"Trigger tag"		The "Trigger tag" specifies a signal that is used to trigger the recording.
	Input field	Enter a signal. **Examples:** • M0.0 • DB1.DBW3 • "DataBlock_1".Temperature
		Opens the signal selection table. Clicking the icon opens a table which offers possible signals for selection as trigger tag. The selected signal is displayed in the input field.
	Text field	Display of the trigger tag address.

Setting/display		Description
"Event"		The events that can be used on this trigger tag are offered for selection according to the data type of the trigger tag. The event can only be configured when a valid signal has been entered as trigger tag.
	Drop-down list	Event selection for which the trigger tag is checked. The entries in the drop-down list are described in Section Trigger event (Page 45).
	Text field	Display of the comparison type.
"Value"		Configuration of the selected event. The configuration options differ depending on the format of the trigger tag and the selected event. See Trigger event (Page 45).
"Pre-trigger"		"Pre-trigger" defines the time during which the signals are already recorded before the actual trigger condition is fulfilled. If the trigger event occurs immediately or shortly after the activation of the recording, this may result in a shorter recording duration. Example of "recording duration" = 20 samples and "pre-trigger" = 5 samples: • Trigger event occurs 50 samples after activation of the recording Actual recording duration = 20 samples • Trigger event occurs 2 samples after activation of the recording Actual recording duration = 17 samples
	Input field	Input of the duration in relation to the selection in the drop-down list.
	Drop-down list	Select the time unit The following settings are possible: • "Samples"
	Text field	Displays the calculated "pre-trigger" period

Trigger event

Depending on the selection in the drop-down list box, the further settings differ for the "event".

The individual events are described below.

"=TRUE"

Supported data types: Bit (Page 42)

The recording starts when the state of the trigger is TRUE.

"=FALSE"

Supported data types: Bit (Page 42)

The recording starts when the state of the trigger is FALSE.

"Rising edge"

Supported data types: Bit (Page 42)

The recording is started when the trigger state changes from FALSE to TRUE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Rising signal"

Supported data types: Integers and floating-point numbers (Page 42)

The recording is started when the rising value of the trigger reaches or exceeds the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling edge"

Supported data types: Bit (Page 42)

The recording is started when the trigger state changes from TRUE to FALSE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling signal"

Supported data types: Integers and floating-point numbers (Page 42)

The recording is started when the falling value of the trigger reaches or falls below the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"In the range"

Supported data types: Integers and floating-point numbers (Page 42)

The recording starts as soon as the value of the trigger is in the value range configured for this event.

"Outside of the range"

Supported data types: Integers and floating-point numbers (Page 42)

The recording starts as soon as the value of the trigger is outside the value range configured for this event.

"= value"

Supported data types: Integers (Page 42)

The recording starts when the value of the trigger is equal to the value configured for this event.

"<> value"

Supported data types: Integers (Page 42)

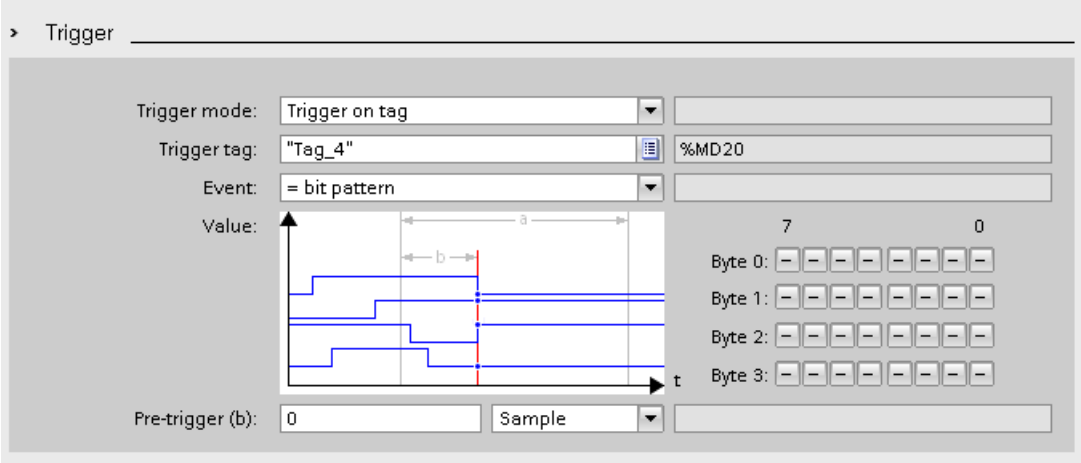
The recording starts when the value of the trigger is not equal to the value configured for this event.

"= bit pattern"

Supported data types: Integers (Page 42)

The recording starts when the value of the trigger matches the bit pattern configured for this event.

The following figure shows the setting options for a "bit pattern":



It is possible to switch between the icons by clicking the respective button.

The following table shows the icons:

Icon	Description
–	Bit is not evaluated
0	Bit is checked for FALSE
1	Bit is checked for TRUE

"<> bit pattern"

Supported data types: Integers (Page 42)

The recording starts when the value of the trigger does not match the bit pattern configured for this event.

See also

Configuring the trigger conditions (Page 51)

4.1.7 Configuration

4.1.7.1 Trace configuration - overview

The configuration of the recording conditions and the signals to be recorded is device-specific.

Requirement

A trace configuration has been created and selected in the "Trace configurations" table of the trace handling.

Procedure

The following table shows the procedure for configuring.

Step	Description
1	Documentation of the configuration (optional) Enter a comment and an author for the configuration.
2	Selecting signals (Page 49) Select the signals to be recorded in the "Signals" area.
3	Configuring the recording cycle and duration Select a recording time, a cycle and the duration in the "Recording conditions" area.
4	Configuring the trigger conditions (Page 51) In the "Recording conditions" area, select whether the recording is to be performed immediately or depending on a trigger condition.

4.1.7.2 Selecting signals

Requirement

- A trace configuration has been created and selected in the "Trace configurations" table of the trace handling.
- The "Signals" area is open in the Inspector window.

Procedure

To configure the signals to be recorded, proceed as follows:

1. Click in the first empty line of the table.
2. Click in the first empty line of the "Name" column
3. Select a signal. The following options are available:
   – In the "Name" column, click the button and select a tag.
   – Enter the symbolic tag name in the cell in the "Name" column.
   – Enter the address directly in the "Address" column.
4. Click in the "Display color" column and select a color for the display of the signal.
5. Click in the "Comment" column and enter a comment for the signal.
6. Repeat the procedure from step 1 until all the signals to be recorded have been entered in the table.

4.1.7.3 Configuring the recording cycle and duration

Requirement

- A trace configuration has been created and selected in the "Trace configurations" table of the trace handling.
- The "Recording conditions" area is open in the Inspector window.

Procedure

To configure the cycle and the duration of a recording, proceed as follows:

1. Click the button for the recording time.
2. Select an OB for the recording time (Page 38).
3. Select a unit for the reduction factor in the drop-down list box for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".
5. Select a unit in the drop-down list box for "Recording duration".
6. Specify the recording duration.
   The following options are available:
   – Enter a value for the duration in the input field for "Recording duration".
   – Activate the "Use max. recording duration" checkbox.

4.1.7.4 Configuring the trigger conditions

Requirement

- A trace configuration has been created and selected in the "Trace configurations" table of the trace handling.
- The "Recording conditions" area is open in the Inspector window.

"Record immediately" trigger condition

To start the recording immediately, proceed as follows:

1. Select the "Record immediately" entry in the drop-down list for "Trigger mode".

   The input fields for the trigger tag are hidden.

"Trigger on tag" trigger condition

To start the recording depending on a condition, proceed as follows:

1. Select the "Trigger on tag" entry in the drop-down list for "Trigger mode".
2. Select a trigger tag. The following options are available:
   - Click the button for the trigger tag and select a tag.
   - Enter the address or the symbolic name of the tag directly in the input field for the trigger tag.

   A drop-down list with events and input fields is displayed. The display depends on the data type of the tag.
3. Configure the event.
4. Select a unit for the pre-trigger in the drop-down list for "Pre-trigger".
5. In order to record a period before the trigger event, enter a value greater than 0 in the input field for the pre-trigger.

Note

The trigger condition is checked in every cycle irrespective of the setting in "Record every". To reliably identify the trigger, the trigger signal must be present for at least one full cycle.

Glossary

Curve diagram

Displays the selected signals of a recording.

Installed trace

Consists of a trace configuration and optionally a recording.

Measurement

Consists of a trace configuration with an associated recording.

Pre-trigger

Defines the time interval in which the signals are already recorded before the actual trigger condition is fulfilled.

Recording

Is performed in the device. There is only one recording for each installed trace configuration.

Recording condition

Sampling and trigger for a trace configuration.

Recording duration

Factor in number of samples. The factor of 100 means, for example, that 100 samples are recorded.

Reduction

Factor in number of cycles. A factor of 2 means, for example, that a recording is made every second cycle.

Sampling

Setting, in which cycle, how fast and how long the recording is to be made.

Signal table

Lists the signals of the selected measurement and provides setting options for some properties.

Trace configuration

Contains all the information required to record values in a device.

Trace handling

Enables the transfer of trace configurations and measurements to and from the device. Selection of an installed trace or a measurement displays recordings in the curve diagram.

Trigger

Specifies the trigger mode and the condition for the "Trigger on tag" mode.

Trigger mode

Specifies whether the recording should be started immediately or based on a trigger tag.

Trigger tag

Signal to trigger the recording.

Trigger time

The meaning of the measurement trigger time depends on the device.

For example, SIMATIC S7-1200/1500 CPUs: Specifies the absolute time of the control system at the start of recording.

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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP Designing interference-free controllers

Function Manual

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01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of the documentation

This documentation will support you in installing and commissioning programmable controllers.

Correct configuration is essential for fault-free operation of programmable controllers.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of VDE (German Association for Electrical, Electronic and Information Technologies) and EC regulations
- Knowledge of the rules for installing controllers and switchgear

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of validity of the documentation

This documentation is valid for all products of the product families SIMATIC S7-1500, ET 200MP and ET 200SP.

Additional support

Additional information on SIMATIC products is available to you on the Internet. The associated documentation is also available on the Internet.

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide 1

1.1 Documentation guide

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP and ET 200MP systems consists of the respective system manual, function manuals and device manuals.

Moreover, the STEP 7 information system (online help) supports you in configuring and programming your automation system.

Overview of documentation on the subject of designing interference-free controllers

The following table lists additional documentation which supplements this description of designing interference-free controllers.

Table 1- 1 Documentation on the subject of designing interference-free controllers

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	
	System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Basic information on electromagnetic compatibility 2

2.1 Overview of possible interference

Introduction

SIMATIC products and their components have been developed for use in industrial environment and meet the legal EMC requirements. However, you still need to conduct an EMC assessment before installing your controller in order to identify possible sources of interference and to include these in your considerations.

Electromagnetic compatibility

Electromagnetic compatibility (EMC) describes the ability of an electrical device to function properly in its particular electromagnetic environment. Neither the environment itself nor the electrical device are influenced in an unacceptable manner.

Possible interference

Electromagnetic interference can influence an automation system in various ways.
The most significant interferences and their causes are as follows:

- Electromagnetic fields having a direct influence on the system
- Interference coupling caused by bus signals (for example, PROFINET)
- Interference influencing the system via the process wiring
- Interference which reaches the system via the power supply and/or protective ground

The figure below shows the likely paths of electromagnetic interference.

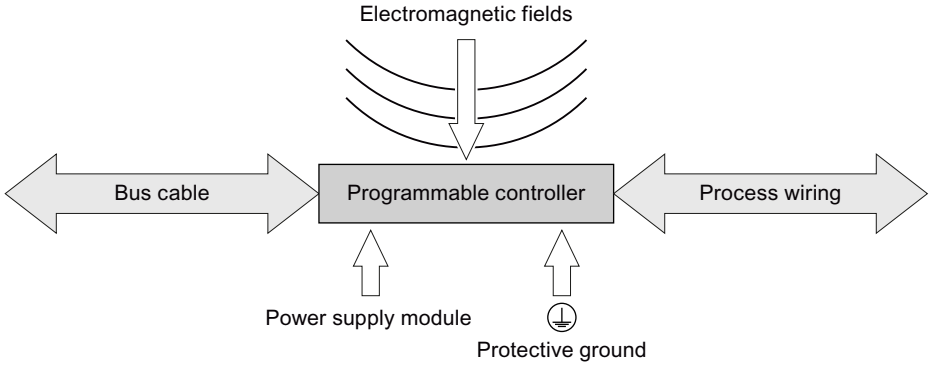


Figure 2-1 Electromagnetic interference

2.2 Coupling mechanisms

Depending on the emitting medium and the distance between the source of interference and the device, interference can reach the automation system via four different coupling mechanisms.

The following table shows possible causes and typical sources of interference for the various coupling mechanisms:

Table 2- 1 Coupling mechanisms

Coupling mechanism	Cause	Typical sources of interference
Galvanic coupling	two electric circuits share the same cable	• Clocked devices (influence on the network due to converters and third-party power supply units) • Starting motors • Potential differences on component enclosures with shared power supply
Capacitive coupling	Potential difference between conductors	• Interference coupling due to parallel routing of signal cables • Static discharge of the operator
Inductive coupling	Mutual influencing of current-carrying conductor loops. The magnetic fields caused by the current flow induce interference voltages.	• Transformers, motors, electrical welding equipment • Power supply cables routed in parallel • Cables whose currents are switched • High-frequency signal cables • Unwired coils
Radiation coupling	Effect of an electromagnetic wave on a cable configuration. This wave induces currents and voltages.	• Neighboring transmitters (for example, walkie-talkies) • Spark gaps (spark plugs, collectors of electrical motors, welding devices)

Interference-free cable routing 3

This chapter describes the EMC-compatible classification of cables and cable routing for bus, data, signal and supply lines.

3.1 Classifying cables into cable categories

Classify the cables into cable categories according to their sensitivity to interference coupling and interference emission. The further away from one another cables of different cable categories are installed, the lower the mutual influence by capacitive and inductive coupling.

The following table shows the cable categories into which you can classify your cables accordingly.

Table 3- 1 Cable categories

Category A	• Signal lines to I/O modules • Bus and data lines (for example, PROFIBUS, PROFINET) • Lines to HMI devices • Supply lines for extra-low voltages (< 24V DC or < 60V AC)
Category B	• Supply lines with safe electrical isolation (SELV) • Supply voltages < 400 V
Category C	• Supply voltages > 400 V

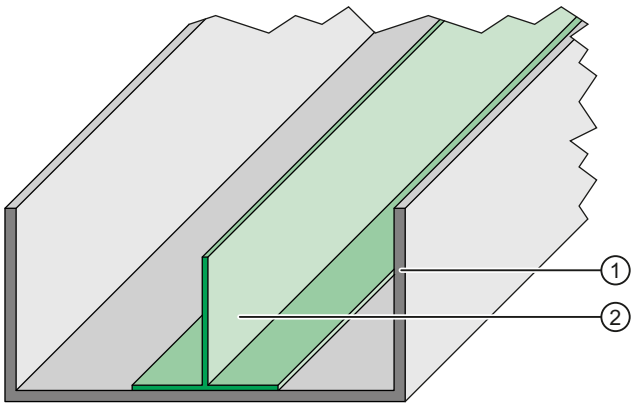
The following table shows the minimum clearance you must maintain when installing cables.

Table 3- 2 Combination of cable categories

	Category A	Category B	Category C
Category A	• In common bundles or cable channels	• In separate bundles or cable channels (no minimum clearance necessary)	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance
Category B	• In separate bundles or cable channels (no minimum clearance necessary)	• In common bundles or cable channels	
Category C	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance		• In common bundles or cable channels

If you install different cable categories in the same cable channel, use metallic cable channels with metallic partition.

The following figure show a schematic view of a cable channel with partition.



① Metallic cable channel
② Metallic partition

Figure 3-1 Cable channel with partition

3.2 Cable routing inside and outside of cabinets in buildings

Rule

Observe the following rules for proper cable routing inside of control cabinets:

- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Do not route cables coming into the cabinet from outside parallel to the shield supports.

3.3 Cable routing outside buildings

If possible, lay the cables outside buildings on metallic cable holders.
Connect the cable holder joints galvanically to each other and ground the cable holders.

Rule

Observe the following rules when laying cables outside of buildings:

- Use metallic auxiliary terminal boxes to connect cables coming from outside at the junction to cables inside the building. Ground these boxes.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Integrate bus cables installed outside of buildings into your lightning and overvoltage concept.

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 29).

3.4 Underground cable routing

Rule

Observe the following rules for underground cable routing:

- Lay the cable at least 60 cm below the ground surface.
- Install equipotential bonding approximately 20 cm above the cable. You can use a zinc-plated ground strip, for example. The ground strips also serve as protection against lightning strikes.
- Protect the cable against mechanical damage by, for example, using a plastic pipe and/or a cable warning tape in the ground, approximately 40 cm above the cable.
- Separate the various cable categories in the ground using cable channels, for example.

The following figure shows the arrangement of cable warning tape, equipotential bonding and a cable.

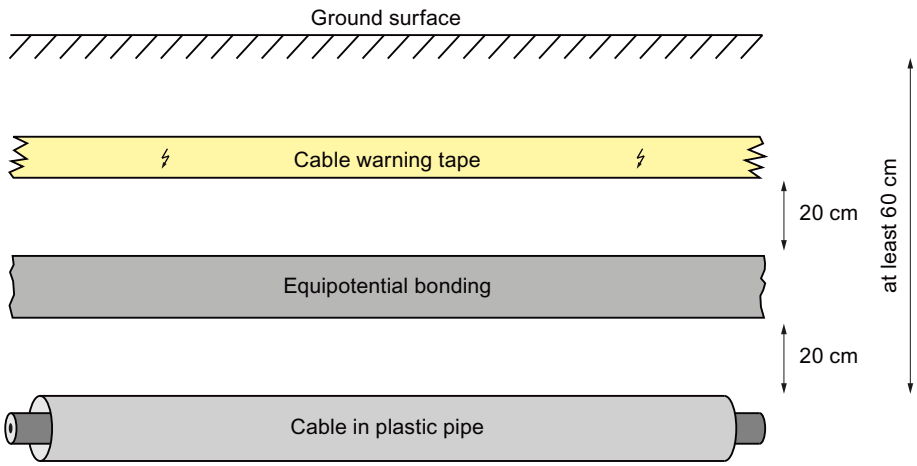


Figure 3-2 Arrangement underground

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 29).

3.5 Bending radii and tensile strength of cables

Tensile strain

Use the supplied cable ties to relieve the strain on the clamping points of the I/O module connectors.

A high strain on the cables due to tensile forces leads to conductor material flow. The tensile forces thus cause a change in the structure of the material and lower the conductor cross-section. This decrease of the conductor cross-section leads, in turn, to a heating of the conductor and premature wear of the conductor insulation.

Bending radius

If the bending radii selected when laying cables are too small, this causes the materials to stretch and compress and changes the mechanical structure of the cables. The electrical properties are impaired as a result.

Pay particular attention to the bending radii of fiber-optic cables. If the bending radii are too small, the optical properties of the fiber-optic cable are adversely affected. The result is that reliable transmission can no longer be guaranteed.

Cable shielding

4

Shielding is a measure to attenuate (dampen) magnetic, electrical or electromagnetic interference fields.

Interference currents on cable shields are diverted from the shield connection to ground. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the protective conductor.

Rules

Ideally, you should use cables equipped with a protective braided shield. The shield's contacting must be more than 80% at the contact point. Avoid tensile and compression strain on cables with a foil shield. This type of strain can damage the foil shield very slightly at the fastening point. The result is a reduced shielding effect.

Shield connection with grounding at both ends

Always connect the cable shields to the ground at both ends. Low and high frequency interference can be reduced only by connecting both ends of the shield to the ground.

Note

Laying an additional equipotential bonding cable

Whenever potential differences develop between the grounding points, an equalizing current flows on a shielding that is connected at both ends. In this case, lay an additional equipotential bonding cable. You can find more information on this topic in the chapter Equipotential bonding (Page 25).

Shield connection with capacitive grounding at one end

If you do not have the option of installing equipotential bonding (in plants covering a large area, for example), connect capacitive grounding to one end of your shield. In this case, only high-frequency interference will be reduced.

The following figure shows the capacitive grounding of a cable shield. The capacity (C <10 nF) diverts the high-frequency interference. This capacity provides high-impedance protection for the power frequency (50 or 60 Hz), thus preventing equalizing currents via the shield. A parallel switched high-impedance resistance prevents the capacity from loading a direct current.

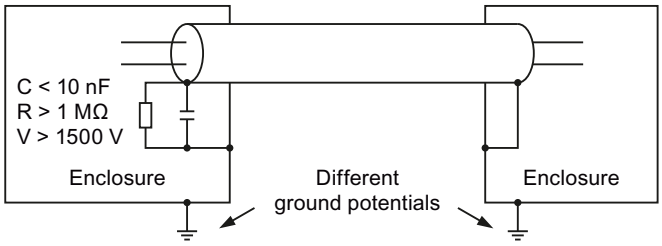


Figure 4-1 Capacitive grounding of the shield

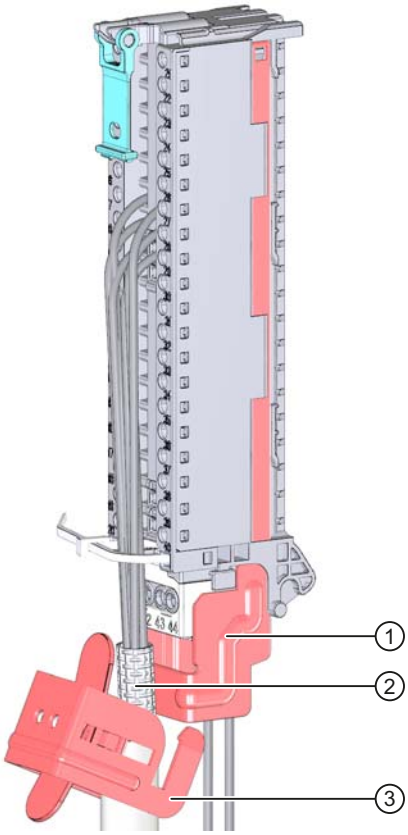
4.1 Connection of the cable shield for S7-1500 and ET 200MP

A special shield concept has been developed for the automation systems S7-1500 and ET 200MP for the shield connection of the signal lines. The connection element for the cable shield consists of a shield clamp and a shield terminal.

If the front connector is located in the module, the interference currents which occur are diverted by the connection element to the ground via the module and mounting rail.

The shield clamp is a pluggable mount for the analog and technology modules. The shield clamp allows the low-impedance application of cable shields with minimum installation times.

The following figure shows a front connector with mounted shield clamp and associated shield terminal.



① Shield clamp
② Stripped cable shield
③ Shield terminal

Figure 4-2 Shield clamp and shield terminal on front connector

The shield clamp is inserted from below onto the front connector until the shield clamp latches audibly. The shield terminal is fastened to the shield clamp.

Additional Information

For additional information on installing the shield clamp and shield terminal, refer to the "Wiring front connectors" chapter in the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) or ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

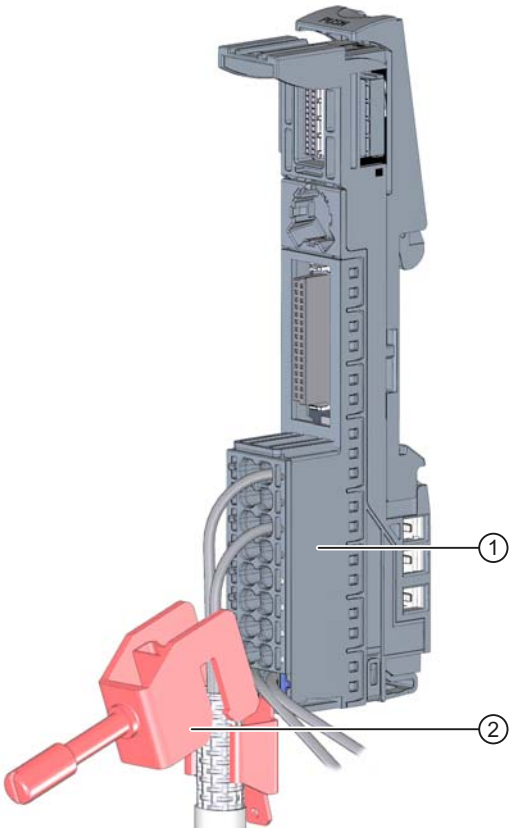
4.2 Connecting the cable shield for ET 200SP

A special shield concept has been developed for the shield connection of the ET 200SP signal lines. The connection element for the cable shield consists of a shield terminal.

If the front connector is located in the module, the interference currents that occur are diverted by the connection element via BaseUnit and mounting rail to the ground.

The shield terminal is plugged into a mount of the BaseUnit. The shield terminal allows the low-impedance application of cable shields with minimum installation times. There is no need for the otherwise standard connection of the cable shield at the cabinet entry.

The following figure shows a BaseUnit with shield terminal.



① BaseUnit of ET 200SP
② Shield terminal

Figure 4-3 BaseUnit with shield terminal

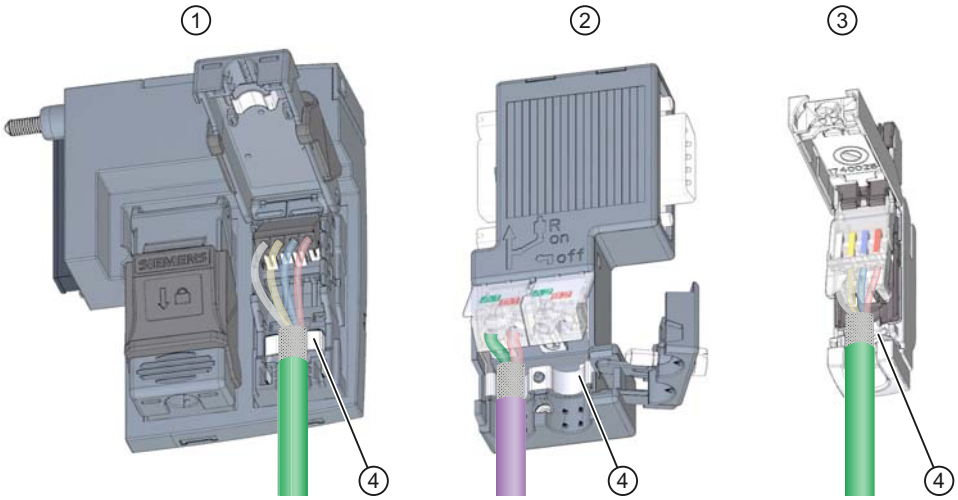
Additional Information

For more information on mounting the shield terminal, refer to the "Connecting cable shields" chapter of the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Connecting the cable shield for bus cables

In the S7-1500, ET 200MP and ET 200SP systems, the cable shields of PROFIBUS and PROFINET cables are connected to the existing bus connection elements. Cable shield and shield support are thus galvanically connected to each other. If the connector is plugged into the module, the coupled interferences are diverted via the module carrier to the ground. There is no need for the otherwise standard connection of the shield at the cabinet entry.

The following figure shows examples of the shield connection for various bus connection elements.



① BusAdapter BA 2xRJ45 for ET 200SP
② PROFIBUSconnector, 15-pin D-Sub
③ PROFINETconnector RJ45
④ Shield support of respective connector

Figure 4-4 Shield connection for bus connection elements

Reference

For more information on installing the connectors, refer to the "Connecting PROFINET IO BusAdapter BA 2xRJ45 to the interface module" chapter of the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and to the supplied product information.

4.4 Connecting the cable shield for other components

The following procedures for connecting the shield to devices that do not have any special shield terminals have proven themselves in practice.

Rule

Note the following points when handling the shield:

- Always use metal clamps to mount the protective braided shields of the cables.
  The clamps must cover a large area of the shield and provide appropriate contact force.
- Attach the shield to a shielding bus directly after the point where the cable enters the cabinet. If you route the shield further to the module, do not connect the shield again in front of the module, as this would create ground loops.

The following figure shows standard types of shield fastening.

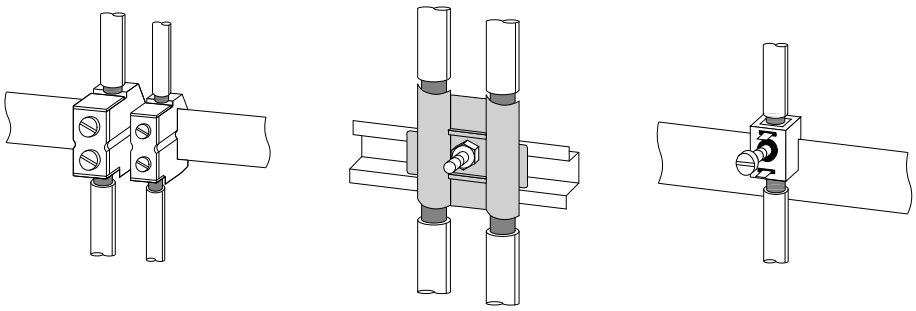


Figure 4-5 Cable shielding

Equipotential bonding

5

Definition according to DIN VDE 0100

Equipotential bonding is an electrical connection which brings the bodies of electrical equipment and external conductive parts to the same, or nearly the same, potential.

Equipotential bonding is divided into:

- Main equipotential bonding
- Additional local equipotential bonding

Both versions of equipotential bonding are of great importance not only for protection against electric shock, but also for EMC.

Main equipotential bonding

Main equipotential bonding is required by DIN VDE 0100 Part 410 as a protective measure and is mandatory, regardless of other measures for protection against direct and indirect contact.

Additional local equipotential bonding

Additional local equipotential bonding is required if:

- Unfavorable grounding conditions exist between plant parts due to different conductivity of the soil (for example, sandy or stony ground)
- Cables bridge a large distance
- Electrical energy is fed in from various power supplies (for example, in the case of multiple substations)
- Considerable electrical power is used (for example, welding robots, large drives)

Measures

In such cases, an additional equipotential bonding cable between the individual potentials can solve the problem. The equipotential bonding cable must also be able to divert large currents and carry lightning stroke current. The following equipotential bonding systems have proven themselves in practice:

- 16 mm^2 for copper equipotential bonding cables up to 200 m long
- 25 mm^2 for copper equipotential bonding cables over 200 m long

To prevent ground loops, equipotential bonding cables are installed in parallel and, whenever possible, near to the signal/bus cable. This allows the area between the two cables to be kept as small as possible.

The following figure shows a schematic view of the installation of an equipotential bonding cable.

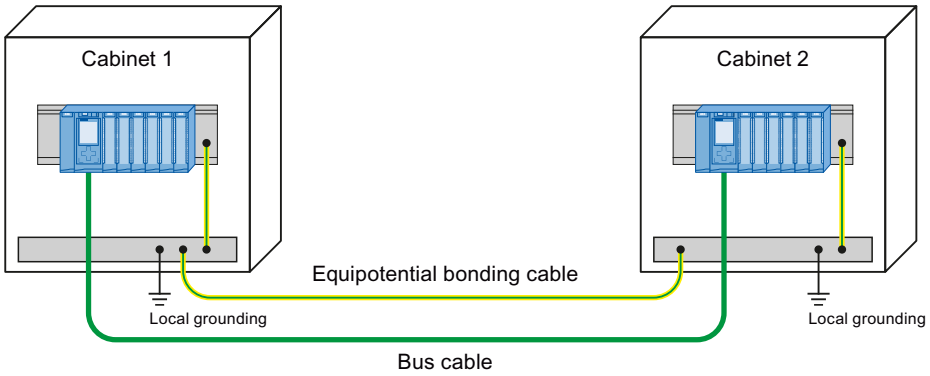


Figure 5-1 Installation of equipotential bonding cables

Rule

Note the following issues regarding equipotential bonding:

- The lower the impedance of an equipotential bonding cable, the more effective is equipotential bonding. The impedance of the additionally installed equipotential bonding cable should not exceed 10% of the shield impedance.
- Connect the equipotential bonding cables to a large area of the grounding system.
- Protect the connection points against corrosion.
- Avoid ground loops.
- Install the equipotential bonding cables in such a way as to minimize the areas enclosed between the equipotential bonding cables and signal lines.

Special measures for interference-free operation 6

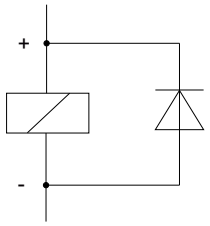
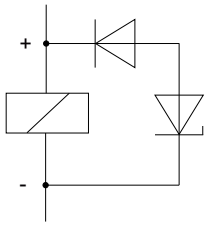
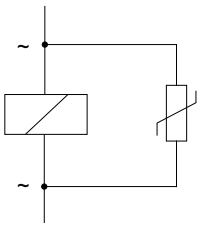
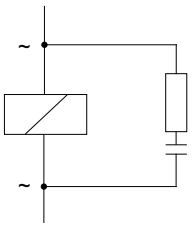
Connecting inductances to quenching elements

Ideally, the inductances (for example, contactor or relay coils) controlled by SIMATIC do not require any wiring to external quenching elements. The required quenching elements are already integrated into the modules.

If the SIMATIC output circuit can also be switched off by built-in contacts (such as relay contacts for EMERGENCY OFF), the module's integrated quenching elements are no longer effective. In this case, the inductances must be wired to quenching elements.

Wire inductances to freewheeling diodes, varistors or RC elements, for example.

Table 6- 1 Wiring inductances

Wiring DC-operated inductances		Wiring AC-operated inductances	
with diode	with Z diode	with varistor	with RC element
			

Programming devices

Provide a socket in each cabinet for the supply of the programming devices. The sockets are supplied from the distribution board to which the protective conductor for the cabinet is also connected.

Observe the following points during the installation of the socket in the control cabinet:

- Include the grounding of the socket in your consideration of the equipotential bonding.
- The common star point of the two ground potentials (cabinet and socket) must be close to the two end points.
- An equipotential bonding cable is not permitted as communication cable between programming device and controller.

Lightning protection and overvoltage protection 7

7.1 What is lightning and overvoltage protection?

Introduction

The term "Lightning and overvoltage protection" covers both the concept and system for the protection of structural systems (such as buildings or electrical equipment). This concept also includes the protection of people and animals.

Overvoltages are most frequently caused by lightning strikes.

Lightning protection system

The lightning protection system is the complete system used to reduce physical damage to a structural system as a result of direct lightning strikes and overvoltages. The lightning protection system is divided into external and internal lightning protection.

External lightning protection

External lightning protection is part of the lightning protection system and comprises an interception device, an arrester and a grounding system. In the event of a lightning strike, the external lightning protection serves to divert the lightning current safely to the ground. This measure most frequently prevents fire damage.

Internal lightning protection

Internal lightning protection is part of the lightning protection system and comprises lightning protection equipotential bonding and/or electrical isolation with respect to the external lightning protection. In the event of a lightning strike, the internal lightning protection reduces the damage caused by overvoltages resulting from the lightning.

Even at larger distances of up to 1.5 km, lightning strikes can sometimes still cause damage. You obtain effective lightning protection by expanding the external lightning protection into an overall protection system. This system includes equipotential bonding and surge protection devices.

7.2 Lightning protection zone concept

Introduction

Each building requires a coordinated protection zone concept. The grading of the protection is of key importance for this. Sufficient protection can only be guaranteed if this grading requirement is satisfied.

The lightning protection zone concept described in the standards IEC 62305-4 and DIN EN 62305-4 is used for this purpose. The lightning protection zone concept groups devices and areas that have the same risk potential and can be wired to arresters of the same type.

Depending on the requirements, surge protection devices are to be used at the transitions of the lightning protection zones and installed in an appropriate location, such as the main distribution or sub-distribution board.

Principle of the lightning protection zone concept

The principle behind the lightning protection zone concept is the division of the areas to be protected from overvoltages, for example buildings, into lightning protection zones based on EMC considerations.

Schematic diagram of the lightning protection zone concept

The lightning protection zone concept for a structural system is shown in schematic form in the following figure.

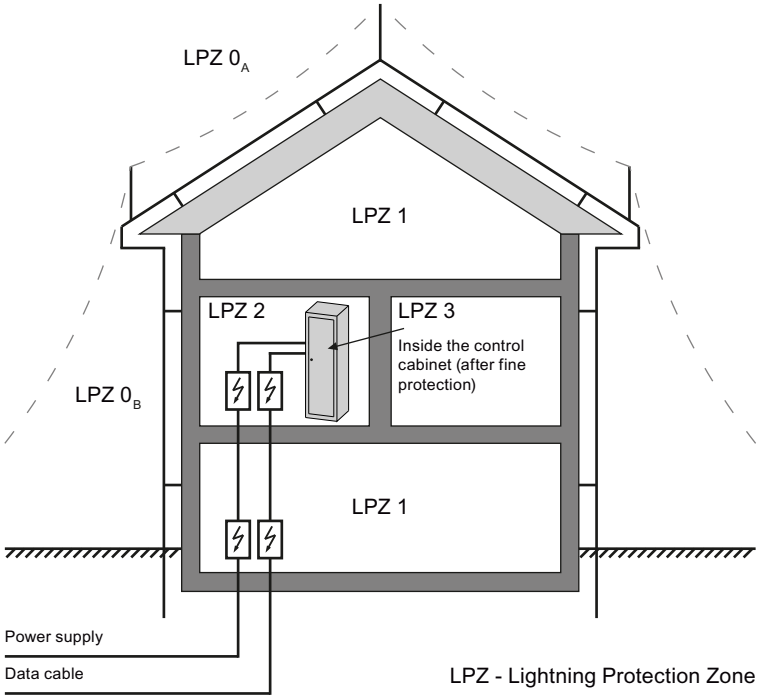


Figure 7-1 Division of a structural system into lightning protection zones

Division of lightning protection zones

The various lightning protection zones (LPZ - Lightning Protection Zone) are limited spatially as follows and not necessarily by physical boundaries, such as walls or floors.

The following table explains the division into various lightning protection zones.

Table 7- 1 External and internal lightning protection zones

Lightning protection zones	
External lightning protection zones:	
LPZ 0_A	• Risk from direct lightning strikes • Risk from the full electromagnetic field of the lightning
LPZ 0_B	• Protected against direct lightning strike • Risk from the full electromagnetic field of the lightning
Internal lightning protection zones:	
LPZ 1	• Protected against direct lightning strike • Attenuated electromagnetic field of the lightning
LPZ 2	• Protected against direct lightning strike • Reduced leakage currents and electromagnetic fields compared to LPZ 1 • Protected terminal devices
LPZ 3	• Protected against direct lightning strike • Protected area inside the terminal device • Local equipotential bonding

Effects of the lightning strike

Direct lightning strikes occur in the lightning protection zone LPZ 0_A. Effects of the lightning strike are high-energy lightning currents and strong electromagnetic fields. These effects are reduced from one lightning protection zone to the next through suitable lightning current or overvoltage arrester/shielding measures.

Frequent damage caused by lightning strikes includes:

- Injury to people and animals, which may in worst cases lead to death
- Damage to buildings
- Fire caused by strong heat development of a lightning strike

Overvoltages

Electromagnetic fields of the lightning channel can be reduced with appropriate shielding measures. Overvoltages due to inductions can be reduced to a safe level starting in lightning protection zone LPZ 0_B with overvoltage arresters.

7.3 Rules and components for the transitions between lightning protection zones

Introduction

This chapter provides you with information on the rules for transitions between lightning protection zones. Measures must be taken to reduce the surge current load and the magnetic fields at the transitions between the lightning protection zones.

Each zone-penetrating metallic/electrical system is incorporated into the equipotential bonding at the zone transition.

The metallic systems include channels, structural parts, and pipes (for water, gas, and heat, for example).

Electrical systems include power and IT cables and wires (for example, power cables and bus cables).

Transitions between lightning protection zones

Overvoltage protection must be provided at the transitions between lightning protection zones (LPZ - Lightning Protection Zone) in accordance with DIN EN 62305. The protection levels are defined at the transitions and implemented by means of surge protection devices (SPD - Surge Protective Device).

- SPD Type 1 - Coarse protection for the transition from LPZ 0 to LPZ 1
- SPD Type 2 - Medium protection for the transition from LPZ 1 to LPZ 2
- SPD Type 3 - Fine protection for the transition from LPZ 2 to LPZ 3

The following figure illustrates the lightning protection zones and the type classes from the supply line to the consumer.

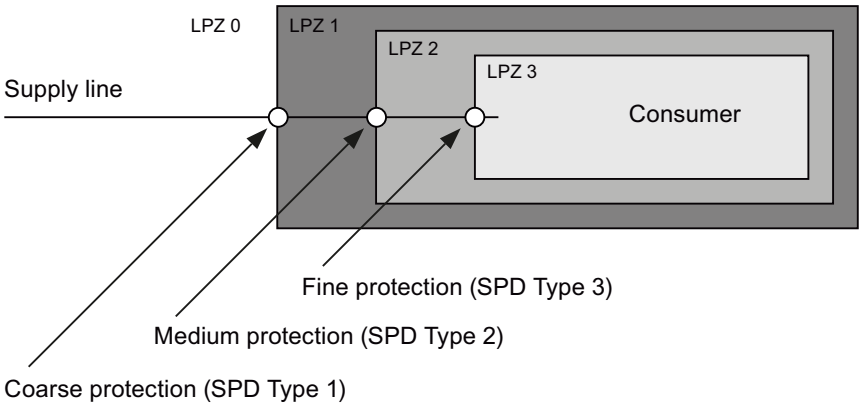


Figure 7-2 Lightning protection zone transitions

Rule for transition from lightning protection zone 0_A to 1

Lightning protection equipotential bonding is required at the transition from lightning protection zone 0_A to 1. The following applies to the transition at the interface of lightning protection zone 0_A to 1:

- Use of lightning arresters prevents introduction of partial lightning currents into structural systems
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Components for lightning protection equipotential bonding from lightning protection zone 0_A to 1

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_A to 1.

Table 7- 2 Components for lightning protection equipotential bonding from lightning protection zone 0_A to 1

Seq. no.	Cables for ...	Connection at the 0_A interface to 1 with:	Item number
1	Three-phase TN-C system	DEHNventil® DV M TNC 255 DEHNventil® DV M TNC 255 FM *	951 300 951 305 *
2	Three-phase TN-S system	DEHNventil® DV M TNS 255 DEHNventil® DV M TNS 255 FM *	951 400 951 405 *
3	Three-phase TT system	DEHNventil® DV M TT 255 DEHNventil® DV M TT 255 FM *	951 310 951 315 *
4	AC TN-S system	DEHNventil® DV M TN 255 DEHNventil® DV M TN 255 FM *	951 200 951 205 *
5	AC TT system	DEHNventil® DV M TT 2P 255 DEHNventil® DV M TT 2P 255 FM *	951 110 951 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 B 180 (I_L = 1.2 A) (2-wire)	920 300 920 211
7	Supply U_N = 24 V DC	DEHNbloc® M, DB M 1 150 DEHNbloc® M, DB M 1 150 FM * (2 units required)	961 110 961 115 *
8	MPI bus cable, RS 485, RS 232 (V.24)	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 B 180 (2-wire)	920 300 920 211
9	Inputs/outputs of digital modules U_N = 24 V DC	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML4 B 180 (I_L = 1.2 A) (4-wire)	920 300 920 310
10	Inputs/outputs of digital modules U_N = 230 V AC	DEHNbloc® M, DB M 1 255 DEHNbloc® M, DB M 1 255 * (2 units required)	961 120 961 125 *
11	Inputs/outputs of analog modules (for example, 4-20 mA, 1-10 V)	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML4 B 180 (I_L = 1.2 A) (4-wire)	920 300 920 310

* Version with remote indication contact

Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)

Components can be ordered directly from:
DEHN+SÖHNE GMBH+CO.KG.
Hans-Dehn-Straße 1
D-92318 Neumarkt

Rule for the transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3

The transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3 prevents strong electromagnetic coupling and serves as overvoltage protection. The following applies to the transition at the interface from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3:

- Use of power cables with surge current-carrying cable shields or twisted-pair IT cables
- Laying cables and lines
  - In continuous, surge current-carrying metal pipes that are grounded at both ends
  - In reinforced concrete channels capable of carrying surge current with grounding at both ends
  - On closed metal cable racks that are grounded at the beginning and end
- Use of fiber-optic cables without a metal shield if such a transmission is intended
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Additional measures

If the actions listed above cannot be implemented, protection by means of surge arresters must be provided. The following table contains surge arresters that are very suitable for protecting the plant.

Components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2.

Table 7- 3 Components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2

Seq. no.	Cables for ...	Connection at the 0_B interface to 1 with:	Item number
1	Three-phase TN-C system	DEHNguard® DG M TNC 275 DEHNguard® DG M TNC 275 FM *	952 300 952 305 *
2	Three-phase TN-S system	DEHNguard® DG M TNS 275 DEHNguard® DG M TNS 275 FM *	952 400 952 405 *
3	Three-phase TT system	DEHNguard® DG M TT 275 DEHNguard® DG M TT 275 FM *	952 310 952 315 *
4	AC TN-S system	DEHNguard® DG M TN 275 DEHNguard® DG M TN 275 FM *	952 200 952 205 *
5	AC TT system	DEHNguard® DG M TT 2P 275 DEHNguard® DG M TT 2P 275 FM *	952 110 952 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918422
7	MPI/DP RS 485 bus cable	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 300 920 271
8	RS 232 (V.24) bus cable	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 300 920 222
9	Industrial Ethernet	DEHNpatch DPA M CLE RJ45B 48	929 121
10	Inputs of digital modules U_N = 24 V DC	DEHNconnect RK, DCO RK E 60 (I_L = 0.5 A)	919 990
11	Outputs of digital modules U_N = 24 V DC	DEHNconnect RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986
12	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275 DEHNguard® DG S 275 FM * N-PE arrester in the TT system DEHNgap C S, DGP C S DEHNgap C S, DGP C S FM *	952 070 952 090 * 952 030 952 035 *
13	Inputs/outputs of analog modules (for example, 4-20 mA, 1-10 V)	DEHNconnect RK, DCO RK E 60 (I_L = 0.5 A)	919 990

* Version with remote indication contact

Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)

Components can be ordered directly from:
DEHN+SÖHNE GMBH+CO.KG.
Hans-Dehn-Straße 1
D-92318 Neumarkt

Components for lightning protection equipotential bonding from lightning protection zone 2 to 3

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3.

Table 7- 4 Components for lightning protection equipotential bonding from lightning protection zone 2 to 3

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:	Item number
1	Three-phase TN-S, TT system	DEHNrail® DR M 4P 255 DEHNrail® DR M 4P 255 FM * (I_L = 25.0 A)	953 400 953 405 *
2	AC TN-S, TT system	DEHNrail® DR M 2P 255 DEHNrail® DR M 2P 255 FM * (I_L = 25.0 A)	953 200 953 205 *
3	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918422
4	MPI/DP RS 485 bus cable	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 300 920 271
5	RS 232 (V.24) bus cable	BLITZDUCTOR® XT, basic unit BXT BAS BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 300 920 222
6	Industrial Ethernet	DEHNpatch DPA M CLE RJ45B 48	929 121
7	Inputs of digital modules U_N = 24 V DC	DEHNconnect RK, DCO RK E60 (I_L = 0.5 A)	919 990
8	Outputs of digital modules U_N = 24 V DC	DEHNconnect RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986
9	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275 DEHNguard® DG S 275 FM * N-PE arrester in the TT system DEHNgap C S, DGP C S DEHNgap C S, DGP C S FM *	952 070 952 090 * 952 030 952 035 *
10	Inputs/outputs of analog modules (for example, 4-20 mA, 1-10 V)	DEHNconnect RK, DCO RK E 60 (I_L = 0.5 A)	919 990

* Version with remote indication contact

Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)

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SIEMENS

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SIMATIC

S7-1500, ET 200MP, ET 200SP
Cycle and response times

Function Manual

01/2013
A5E03461504-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of the documentation

The control system offers various options for program processing with different run priorities. Cyclic and time-driven program processing have the largest share. The response times of a control system are therefore significantly determined by the processing cycles.

Additionally there is also the possibility of event-driven program processing. This is normally limited to a few selected events. Since each event is handled separately, this program processing is less efficient than cyclic or time-driven processing. At the same time the chronological behavior when many events are used is less predictable, since it depends strongly on how these events occur in time.

This manual provides information on the following topics:

- Types of program processing
- Run priorities
- Cycle and response times, and the influences to which they are subject
- Configuration options for the optimization of your user program

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge about the use of Windows-based computers
- Knowledge about how to use STEP 7/TIA Portal

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for all products from the S7-1500, ET 200MP, and ET 200SP product families.

Additional support

Additional information on SIMATIC products is available on the Internet.
The associated documentation is likewise available on the Internet.

- The range of technical documentation for the individual SIMATIC products and systems can be found on the internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP and ET 200MP systems consists of the respective system manual, function manuals and product manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the additional documentation on the topic of cycle and response times

The following table lists additional documentation which supplements this description of cycle and response times.

Table 1- 1 Documentation of cycle and response times

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	
	System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	
CPU	CPU 1511-1 PN (http://support.automation.siemens.com/WW/view/en/59402190) manual	• Block diagram • Wiring • Parameter assignment/addressing • Diagnostics alarms/interrupts • Technical specifications • Dimensional drawings
	CPU 1513-1 PN (http://support.automation.siemens.com/WW/view/en/59186494) manual	
	CPU 1516-3 PN/DP (http://support.automation.siemens.com/WW/view/en/59191914) manual	

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Program processing 2

Introduction

The CPU's control task is written in a program. This user program can be processed in various organization blocks with various run priorities.

The most frequent type of program processing is cyclic processing in OB 1. Here, after each run of the program, the CPU starts the program processing again at the beginning of the program. This is the so-called main cycle of the CPU.

In addition to program processing in the main cycle there is time-driven and event-driven program processing.

Program organization

For the processing of your user program, you can choose from the following types of program processing:

Program processing in the main cycle of the CPU:

In the simplest case you process the entire user program in the main cycle of the CPU. All tasks in the user program are then processed with equal rank. This also results in the same response times for all tasks.

Time-driven processing:

In a control program there are frequently portions with different response time requirements. You can optimize the response times by taking advantage of these differences in the requirements. For this purpose, you can assign the calls of the structured program parts to other OBs (e.g. time-driven cyclic interrupts) in addition to OB 1.

The processing of these parts can thus occur with different frequencies and priorities.

Event-driven processing:

Depending on the I/O modules used, you can plan hardware interrupts for specific process events, that lead to the call of the assigned hardware interrupt OBs.

Using process image partitions

If a program is distributed to various OBs, e.g., due to differing priority requirements, it is advisable and often necessary to assign separate process image partitions to these OBs.

Divide the I/O modules into corresponding process image partitions, which are used by the program parts. Then assign the process image partitions to the corresponding OBs. By means of this allocation you optimize the response times, because the update of the affected I/O module is directly synchronized with the processing in the program.

A process image partition of the inputs (PIPI) permits the associated input data for an OB program to be updated immediately before the OB program starts.

A process image partition of the outputs (PIPQ) permits the output data associated with an OB program to become effective on the outputs immediately after the OB program runs.

You have to configure this "system-side update of process image partitions". For additional information on "Configuring process image partitions", refer to the online help for STEP 7 under the keyword "Assign process image/process image partition".

Interruptability of program run

Each organization block that you use in your program has a priority, and you can assign the organization blocks a priority.

Organization block OB 1 always has the lowest priority, which is 1. The highest priority is 26. Communication tasks always have priority 15.

Organization blocks or system activities with higher priority interrupt those with lower priority, and thus extend their execution time. If two pending tasks have the same priority, these tasks are processed in the order in which the tasks occurred.

Note

Higher priority OBs

Communication functionality is strongly influenced by too many or runtime-intensive OBs with a priority > 15.

When using OBs with a priority > 15, you should consider the runtime load that they cause in order to keep communication functionality at a reasonable level.

Reference

You can find additional information on the subject of priorities in the system manual for the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792), in the Events and OBs chapter.

Cyclic program processing 3

3.1 Main cycle

Introduction

In this section you will learn about the concept of the "main cycle".

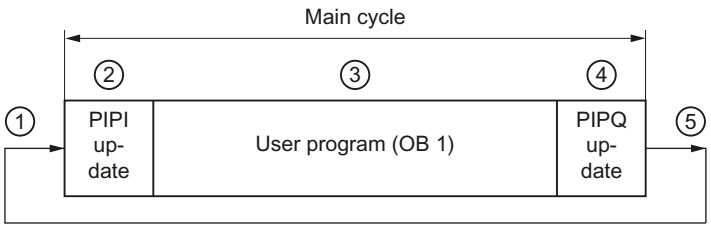
Definition of the main cycle

The main cycle is a CPU cycle, in which the user program of organization block OB 1 is processed once. A main cycle in the S7-1500 automation system encompasses the following:

- Update of process image partition 0 of the inputs (PIPI 0)
- Processing of the cyclic program
- Update of process image partition 0 of the outputs (PIPQ 0)

Cyclic program processing

The following figure illustrates the phases that are passed through during a cycle.



① The operating system starts the cycle monitoring time.

② The CPU reads the status of the inputs at the input module and updates the process image partition of the inputs.

③ The CPU processes the user program in time slices and executes the instructions specified in the program.

④ The CPU reads the status of the outputs at the output module and updates the process image partition of the outputs.

⑤ The operating system stops the cycle monitoring time and analyzes the calculated cycle time.

Figure 3-1 Cyclic program processing

Reference

You can find additional information on the subject of "organization blocks" in the Events and OBs chapter of the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

3.2 Cycle time

Introduction

In this section you will learn about the concept of "cycle time", and how to estimate the cycle time.

Definition of cycle time

The cycle time represents the time a CPU requires to process one program run of the main cycle. One program run encompasses the time that is required during the run to update the assigned process image partition (PIP 0) and the cyclic program (the main program in the OB 1), as well as all program parts and system activities that interrupt this run.

3.2.1 Different cycle times

Introduction

The cycle time (T_{cyc}) is not equally long for every cycle, because the processing times can vary. Causes for this are, for example:

- Different program runtimes

  (e.g. program loops, conditional commands, conditional block calls, or different program paths)

- Lengthening due to interruptions

  (e.g. time-driven interrupt processing, processing of hardware interrupts or communication)

The cycle time T_{cyc2} is longer than T_{cyc1}, because the cyclically working OB 1 is interrupted by a cyclic interrupt OB (e.g: OB 30). The cyclic interrupt OB in turn is interrupted by communication. The figure below shows the different cycle times T_{cyc1} and T_{cyc2}.

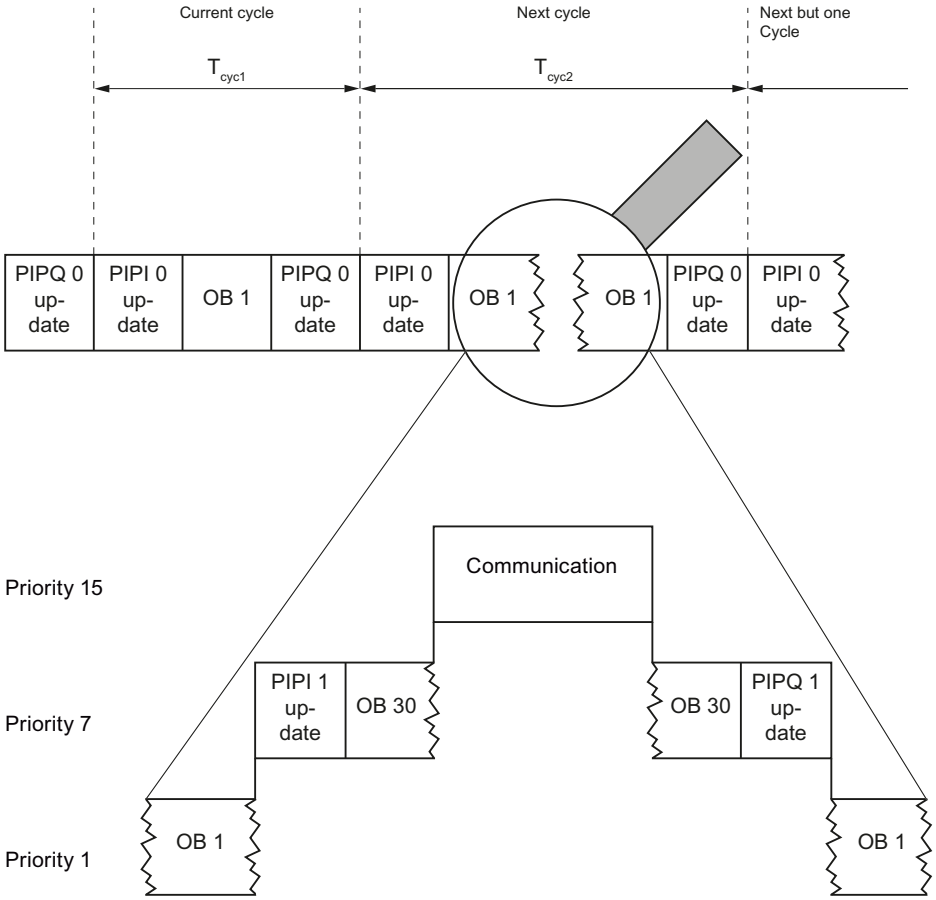


Figure 3-2 Possible causes of differing cycle times

Minimum cycle time

In STEP 7 you can set a minimum cycle time for a CPU. The default setting for a minimum cycle time is one millisecond. It may be advisable to increase this setting in the following cases:

- To reduce the cycle time's fluctuation range.
- To avoid updating the process images unnecessarily often when the cycle time is short.
- To make remaining computing time available for communication tasks.

Maximum cycle time

The maximum cycle time is monitored by the CPU By default, the scan cycle monitoring time is preset to 150 ms. This value can be changed by setting CPU parameters. When the cycle monitoring time has ended, the time error OB (OB 80) is called.

You have the option of restarting the cycle monitoring time using the "RE_TRIGR" instruction, and thus extending it.

With the user program in OB 80 you specify how the CPU responds to the time error. Under the following conditions the CPU goes to STOP.

- If you have not loaded an OB 80.
- If the cycle is still not completed after an additional cycle monitoring time.

The cycle monitoring time encompasses the entire processing time of the cyclic program. This time also includes the processing times for OBs with higher priority classes, which interrupt the main program in the current cycle. The operating system's communication processes likewise extend the runtime of the main program.

Cycle time statistics

In STEP 7 and in the TIA Portal you have the option of viewing the cycle time statistics, and of determining the minimum and maximum cycle time. You need this information in order to determine the response times of the user program in the main cycle.

The following figure shows an extract from the TIA Portal with the cycle time statistics. In this example, the cycle time ranges from 70 ms to 90 ms. The current cycle time is 80 ms.

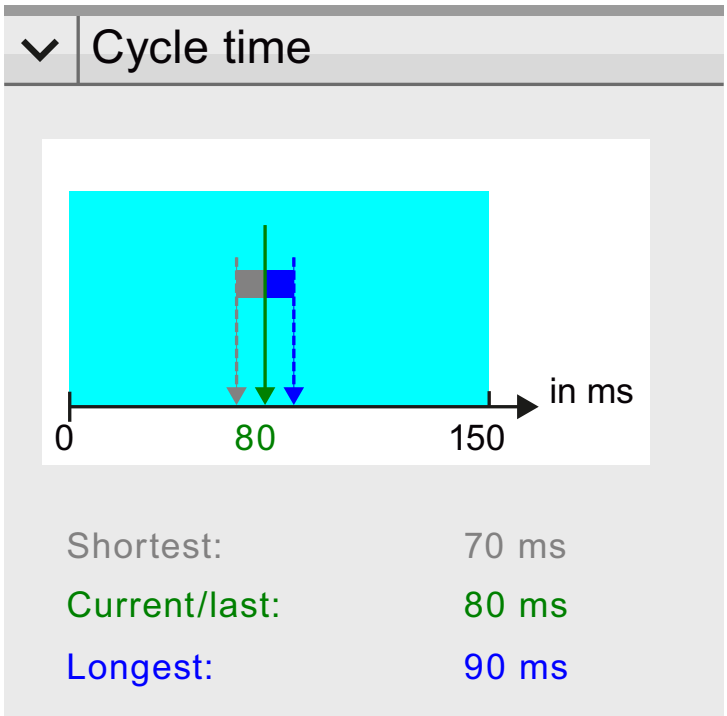


Figure 3-3 Cycle time statistics

3.2.2 Influences on the cycle time

3.2.2.1 Update time for process images

Introduction

You can divide the process image into 32 (0 to 31) process image partitions. The process image for OB 1 is always the process image partition 0 (PIP 0 or "Automatic update").

In this section, you will learn how you can estimate the update time of the process image partitions.

Update time for process image partitions

The process image or the process image partitions are always updated at the beginning and at the end of the associated OBs.

The update time of the process image partitions depends on the quantity of assigned central and distributed I/O module data.

You can estimate the update time using the following formula:

Base load for process image update
+ Number of words in the process image x update time for central I/O modules
+ Number of words in the process image via DP x update time via PROFIBUS
+ Number of words in the process image via PROFINET x update time via PROFINET

= **Update time of the process image partition**

The following table contains the times for estimating the typical update time of the process images.

Table 3- 1 Data for estimating the typical update time of the process image partition

Components	Update time of the		
	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Base load for process image partition update	35 µs/word	35 µs/word	30 µs/word
Update time for central I/O modules	9 µs/word	9 µs/word	8 µs/word
Update time for distributed I/O modules via PROFIBUS	0.5 µs/word	0.5 µs/word	0.5 µs/word
Update time for distributed I/O modules via PROFINET	0.5 µs/word	0.5 µs/word	0.5 µs/word

3.2.2.2 User program processing time

Introduction

In the ideal case, each cycle in the cyclically running user program is equally long. A cycle is prolonged by the occurrence of events or interrupts. As a result several recurring events (e.g. cyclic interrupts) can occur in this extended cycle. These events extend a cycle additionally.

Program processing time without interruptions

The user program has a certain runtime without interruptions. The length of the runtime depends on the number of operations that are executed in the user program.

The following table contains the times for how long an operation lasts.

Table 3- 2 Duration of an operation

	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Bit operations, typ.	60 ns	40 ns	10 ns
Word operations, typ.	72 ns	48 ns	12 ns
Fixed-point arithmetic, typ.	96 ns	64 ns	16 ns
Floating-point arithmetic, typ.	384 ns	256 ns	64 ns

Extension due to nesting of higher-priority OBs and/or interrupts

A cycle is not only extended by the direct program processing time of the event, but also by the time that is required in order to nest the OB for event processing into the running user program.

The interruption of a user program by a higher-priority OB causes a certain basic time expenditure. Take account of this basic time expenditure in addition to the update time of the assigned process image partitions and the processing time of the contained user program. The following tables show the corresponding times for the various interrupts and error events.

Table 3- 3 Times for interrupts

	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Hardware interrupt	90 µs	90 µs	80 µs
Time-of-day interrupt	90 µs	90 µs	80 µs
Time-delay interrupt	90 µs	90 µs	80 µs
Cyclic interrupt	90 µs	90 µs	80 µs

Table 3- 4 Times for error events

	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Programming errors	90 µs	90 µs	80 µs
I/O access error	90 µs	90 µs	80 µs
Time error	90 µs	90 µs	80 µs
Diagnostic interrupt	90 µs	90 µs	80 µs
Module failure/ recovery	90 µs	90 µs	80 µs
CPU stop/ recovery	90 µs	90 µs	80 µs

Reference

You can find additional information on the subject of error handling in the system manual for the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792), in the Events and OBs chapter.

3.2.2.3 Extension of cycle time due to communication load

Influence of communication on the cycle time

In the sequence model of the CPU, communication tasks are processed with priority 15. All program parts with priority > 15 are not influenced by communication.

Configured communication load

The CPU operating system continuously provides a specified percentage of total CPU processing power for communication tasks. If the processing power is not needed for communication, then the processing power is available to the operating system and the user program.

Communication is allocated the requisite processing time in 1-ms increments, with priority 15. With a 50% communication load, this corresponds to 500 µs per millisecond. Note that this time is also extended by higher-priority interruptions.

The following formula may be used to estimate the extension of the cycle time by communication.

$$\text{Actual cycle time} = \text{Cycle time without communication} \times \frac{100}{100 - \text{"configured communication load in \%"}}$$

Figure 3-4 Formula: Influence of communication load

With a communication load of 50% (default), the following value results:

Actual cycle time	=	Cycle time without communication	x	2

Figure 3-5 Extension of cycle time due to communication load

Dependency of maximum cycle time on the configured communication load

The diagram shows the nonlinear relationship between maximum cycle time and configured communication load with a pure cycle time of 10 ms.

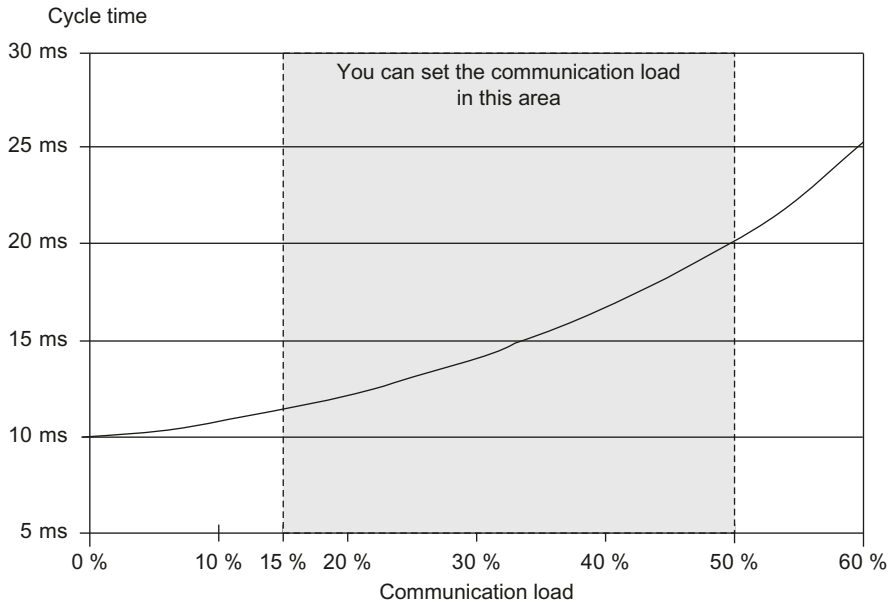


Figure 3-6 Maximum cycle time depending on the configured communication load

This representation of cycle time and communication load is valid for the main cycle and all other organization blocks with a priority ≤ 15.

Example: 20% communication load

You have specified a communication load of 20% in the hardware configuration.
Using the above formula, the cycle time is extended by the factor 1.25.

Example: 50% communication load

You have specified a communication load of 50% in the hardware configuration.
Using the above formula, the cycle time is extended by the factor 2.

Effect on the actual cycle time

Communication is only one cause for extension of the cycle time. All cycle time extending settings lead to the result that more asynchronous events can occur within a cycle, which additionally extend the OB 1 cycle. This extension depends on the number of events that occur per OB1 cycle and the time required to process these events.

Note

Checking parameter changes

- Check the effects of a value change on the "Cycle load due to communication" parameter during system operation.
- To prevent time errors, take account of the communication load when setting the maximum cycle time.

Tips

Whenever possible, use the default setting for the configured communication load.

If the cycle time of the CPU is critical, decrease the value.

3.3 Time-driven program processing in cyclic interrupts

With a cyclic interrupt you have the option of having a specific program repeatedly processed at a given time interval. This program is processed at a configurable higher priority, and is thus independent of the processing time of the cyclic main program.
By moving program parts to cyclic interrupts, the corresponding response times are shortened, and/or the response times are better adapted to the requirements.

In STEP 7, the organization blocks OB 30 to OB 38 are provided for the processing of cyclic interrupts. You can create additional cyclic interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Definition

A cyclic interrupt is an interrupt that is triggered at repeated regular time intervals and triggers the processing of a cyclic interrupt OB.

Cycle of a cyclic interrupt

The cycle of a cyclic interrupt is defined as the time from the call of a cyclic interrupt OB to the next call of a cyclic interrupt OB.

The following figure shows an example of the cycle of a cyclic interrupt.

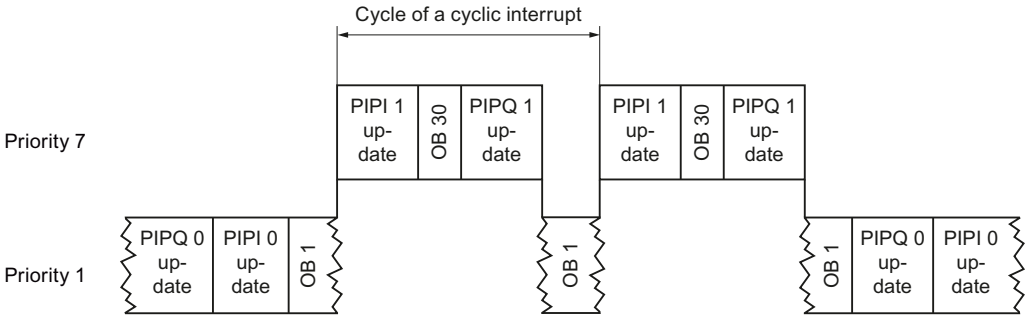


Figure 3-7 Call interval of a cyclic interrupt

Accuracy of a cyclic interrupt

If a cyclic interrupt is not delayed by a higher-priority OB or communication activities, the accuracy with which it is started is nevertheless subject to system-dependent fluctuations.

The following table shows the accuracy with which a cyclic interrupt is triggered:

Table 3- 5 Accuracy of cyclic interrupts

	CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Cyclic interrupt	±90 µs	±90 µs	±80 µs

3.4 Response time for cyclic and time-driven program processing

Introduction

In this section you will learn about the concept of "response time", and how to calculate the response time.

Definition

The response time in cyclic program processing is the time between the detection of an input signal and the change of a linked output signal.

Fluctuation width

The following considerations apply generally for processing in the main cycle and for time-driven processing in cyclic interrupts. That is, they apply both to the user program in the main cycle, and to cyclic interrupts. In each case, simply replace the cycle time with the cycle of a cyclic interrupt. You must always reckon with the longest response time when configuring your system.

The actual response time of the CPU is between one and two cycle times, or cyclic interrupt cycles if cyclic interrupts are used.

The following figure shows the shortest and longest response time when an event occurs.

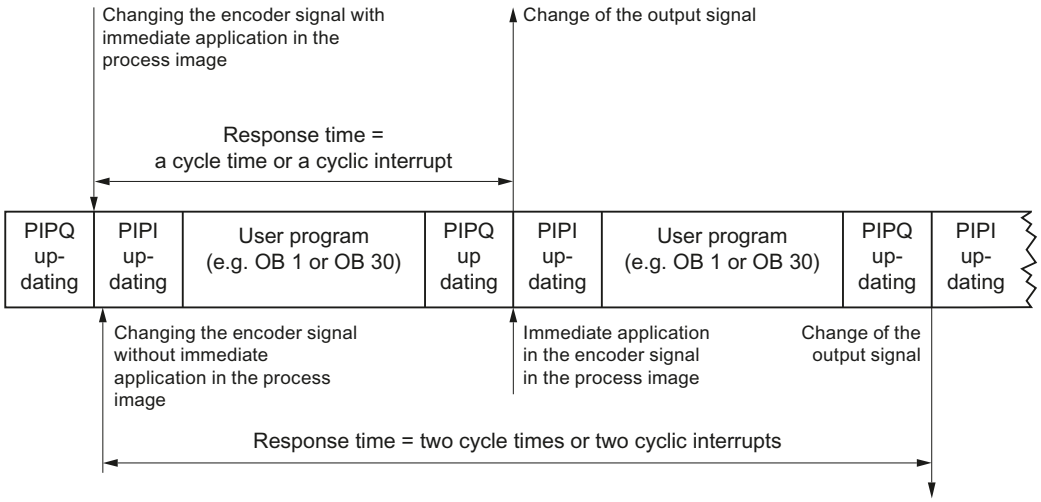


Figure 3-8 Shortest and longest response time

Factors

To determine the process response time, you must take account of the following factors in addition to the CPU response time described above:

- Delay of the inputs and outputs at the I/O module
- Update times for PROFINET IO or DP cycle times on PROFIBUS DP
- Switching times of the sensors and actuators used

Delay at the inputs and outputs of the modules

Delays in the response time arise at the inputs and outputs of the modules.

The delay times and cycle times can be found in the technical specifications for the I/O modules of the S7-1500 automation system.

Update time with distributed I/O

When distributed I/O is used, the maximum response time is additionally extended by the bus transmission times of PROFIBUS or PROFINET. These bus transmission times occur during both the reading and output of the process image partitions. The bus transmission times correspond to the bus update cycle of the distributed station.

PROFINET IO

If you configure your PROFINET IO system using STEP 7, STEP 7 calculates the update time. Select the PROFINET interface of the I/O module. In the General tab, select "Advanced options > Real time settings > I/O cycle". The update time is displayed in the field "Update time".

PROFIBUS-DP

If you configure your PROFIBUS DP master system using STEP 7, STEP 7 calculates the DP cycle time. Select the PROFIBUS subnet from the network view. In the Inspector window, navigate to the bus parameter in the General tab. The DP cycle time is typically displayed in the "Parameters" field at "Ttr typical".

The following figure illustrates the additional bus runtimes using distributed I/O.

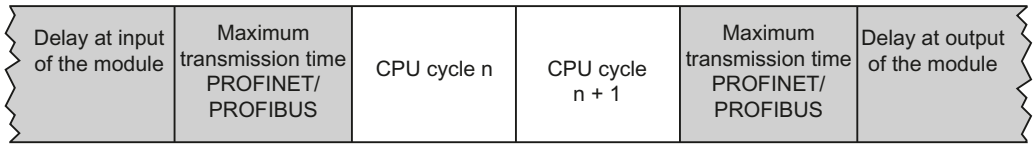


Figure 3-9 Additional bus runtimes with distributed I/O:

You can achieve a further optimization of the response times using isochronous mode.

Reference

You can find additional information on the topic of "Isochronous mode" in the function manual PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856) or function manual PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579), in each case in the "Isochronous mode" chapter.

3.5 Summary of response time with cyclic program processing

Estimation of the shortest and longest response time

The following formulas may be used to estimate the shortest and longest response time:

Estimation of the shortest response time

The shortest response time is the sum of:

1 x delay in the I/O module for inputs
+ 1 x update PROFINET IO or PROFIBUS DP
+ 1 x transfer time of the process image inputs
+ 1 x processing of the user program
+ 1 x transfer time of the process image outputs
+ 1 x update PROFINET IO or PROFIBUS DP
+ 1 x delay in the I/O module for outputs

= **Shortest response time**

The shortest response time is equivalent to the sum of the cycle time plus the input and output delay times.

Estimation of the longest response time

The longest response time is comprised of:

	1 x delay in the I/O module for inputs
+	2 x update PROFINET IO or PROFIBUS DP
+	2 x transfer time of the process image inputs
+	2 x processing of the user program
+	2 x transfer time of the process image outputs
+	2 x update PROFINET IO or PROFIBUS DP
+	1 x delay in the I/O module for outputs
=	**Longest response time**

The longest response time is equivalent to the sum of twice the cycle time plus the delay times of the inputs and outputs. The longest reaction time includes twice the update time for PROFINET IO or twice the DP cycle time on PROFIBUS DP.

Event-driven program processing 4

4.1 Hardware interrupts

Introduction

Use hardware interrupts in the user program in order to immediately detect process events and react to them with a corresponding program. In STEP 7, the organization blocks OB 40 to OB 47 are provided for the processing of a hardware interrupt. You can create additional hardware interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Definition

A hardware interrupt is an interrupt that occurs during the running program processing, due to an interrupt-triggering process event. The operating system calls the assigned interrupt OB; as a result, the processing of the program cycle or of lower priority program parts is interrupted.

Hardware interrupt response times of the CPU

The hardware interrupt response times of the CPU start with the occurrence of the hardware interrupt event in the CPU and end with application of the assigned hardware interrupt OB.

This time is subject to system-dependent fluctuations, which are expressed as a minimum and maximum hardware interrupt response time.

The following table contains the length of the interruption times for hardware interrupts.

Table 4- 1 Response times for hardware interrupts

		CPU 1511-1 PN	CPU 1513-1 PN	CPU 1516-3 PN/DP
Hardware interrupt response times of the CPU	Min.	100 µs	100 µs	90 µs
	Max.	400 µs	400 µs	360 µs

Note that the times are extended if higher-priority interrupts are queued up for processing, and if the hardware interrupt OB is assigned to a process image partition. You can find these times in the table Times for interrupts (Page 17).

Impact of communication on interrupts

Communication tasks are always processed by the CPU with priority 15. If the interrupt processing may neither be delayed nor interrupted by communication, configure the interrupt processing with a priority > 15. Interrupt processing is pre-configured with a priority > 15 by default.

Reference

You can find additional information on the number of available organization blocks in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual, in the Events and OBs chapter.

You can find additional information on the topic of "Configuring hardware interrupts" in the STEP 7 online help.

See also

User program processing time (Page 17)

4.2 Response time with event-driven program processing

Event-driven program processing is determined by processing times internal to the modules.

The response time of the event-driven program processing is the sum of the runtimes of several processing steps.

The following figure shows the individual processing steps for event-driven program processing.

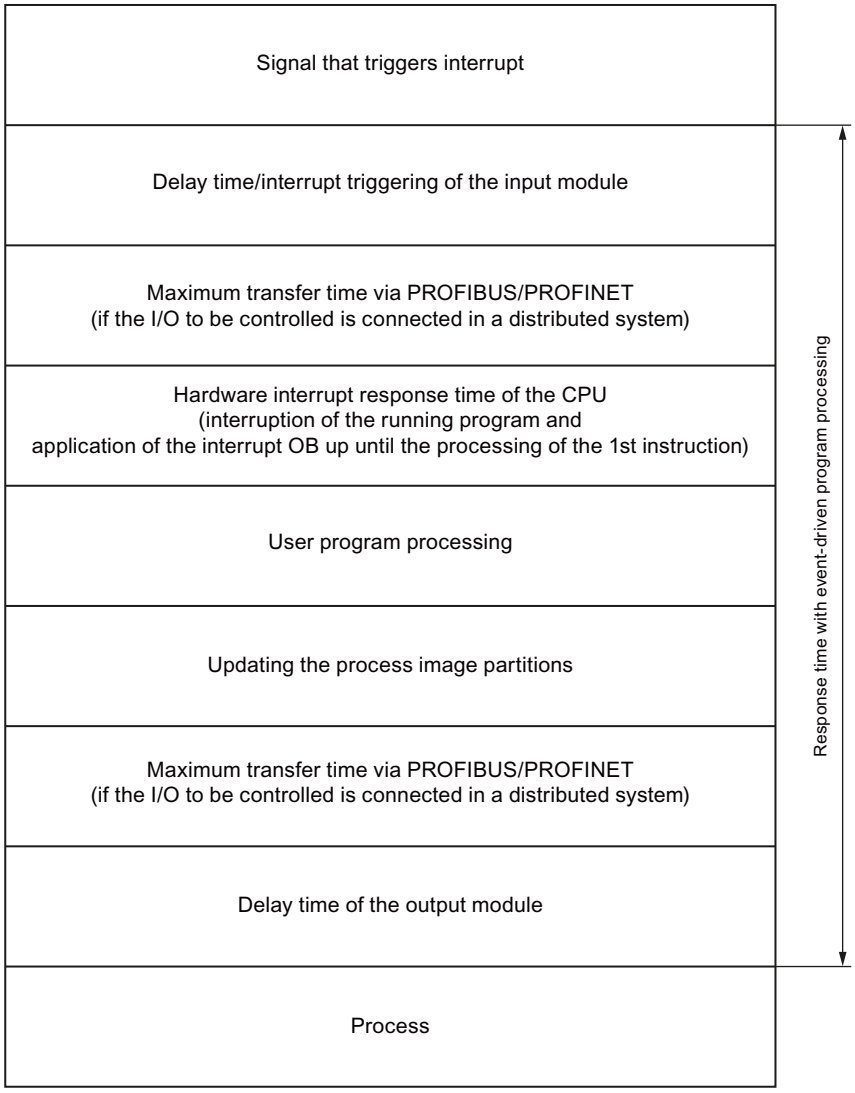


Figure 4-1 Schematic representation of event-driven program processing

Glossary

Automation system

An automation system in the context of SIMATIC S7 is a programmable logic controller.

Cycle time

The cycle time represents the time a CPU requires to process the user program once.

Cyclic interrupt

A cyclic interrupt is generated periodically by the CPU in a configurable time pattern. At this point in time the corresponding organization block is processed.

Diagnostic interrupt

Modules capable of diagnostics operations report detected system errors to the CPU by means of diagnostic interrupts.

Hardware interrupt

A hardware interrupt is started by interrupt-triggering modules when a specific event occurs in the process. The hardware interrupt is reported to the CPU. The assigned organization block will be processed according to interrupt priority.

Interrupt

The CPU's operating system distinguishes between various priority classes that control the processing of the user program. These priority classes include interrupts, e.g. hardware interrupts. When an interrupt occurs, the operating system automatically calls an assigned organization block, in which the user programs the desired response.

Process image

The process image is part of CPU system memory. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. At the end of the cyclic program the process image of the outputs is transmitted as signal state to the output modules.

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SIEMENS

SIMATIC

S7-1500
CPU 1511-1 PN
(6ES7511-1AK00-0AB0)

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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Preface

Purpose of the documentation

This device manual supplements the system manual of the S7-1500 automation system and the function manuals. All cross-system functions are described in the system manual.

The information provided in this device manual and the system manual enables you to commission the CPU 1511-1 PN.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers a range of topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Overview of the documentation for CPU 1511-1 PN

The following table lists additional documents which supplement this description of CPU 1511-1 PN and are available on the Internet.

Table 1- 1 Documentation for CPU 1511-1 PN

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual	• Application planning • Installation • Wiring • Commissioning
Properties of the modules	Power supplies (http://support.automation.siemens.com/WW/view/en/57251228) device manual Signal modules (http://support.automation.siemens.com/WW/view/en/59174020) device manual	• Wiring • Parameter assignment/ addressing • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimensional drawing
System diagnostics	System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual	• Overview • Hardware/software diagnostic evaluation

Topic	Documentation	Most important contents
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925) function manual	• Overview
	PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• PROFINET basics • PROFINET functions • PROFINET diagnostics
	Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual	• Function • Operation
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Memory concept	Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) function manual	• Setup • Function principle • Use
Cycle and response times	Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193566) function manual	• Basics • Calculations
Analog value processing	Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559) function manual	• Wiring options • Tables of measured values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7511-1AK00-0AB0

View of the module

The following figure shows a CPU 1511-1 PN.

Figure 2-1 CPU 1511-1 PN

Properties

The module has the following technical properties:

- Communication:
  - Interfaces

    The CPU 1511-1 PN has a PROFINET interface with two ports. The two ports have the same IP address and form the interface to the fieldbus level (switch functionality).
  - Integrated Web server

    The CPU status query is independent of a software installation. Graphically visualized process variables and user-defined websites facilitate information acquisition.
- Trace functionality
  - All CPUs of the S7-1500 automation system support trace functionality.
    Trace functionality is independent of the technology and supports you in debugging/optimizing the user program. It is particularly useful for Motion Control and control applications.
- Integrated technology:
  - Standard Motion Control

    PLC Open blocks for programming motion functionality by means of PROFINET IO IRT and PROFIdrive interface.

    The functionality supports speed-controlled axes, positioning axes and external encoders.
  - Integrated control functionality

    Universal PID controllers or 3-point controllers with integrated tuning.

    Integrated temperature controller
- Integrated system diagnostics:
  - System diagnostics is automatically generated and consistently displayed.
- Integrated security:
  - Know-how protection

    User programs can be securely protected against unauthorized access and modification.
  - Copy protection

    User program blocks are linked to the serial number of the SIMATIC memory card or of the module. User programs cannot run without the corresponding SIMATIC memory card or module.
  - Access protection

    Extended access protection provides comprehensive protection against unauthorized configuration changes. Authorization levels can be used to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU from unauthorized manipulation. Altered or external transmission of engineering data is reliably detected by the CPU.

- Other special features:
  - Color display
  - Short OB cycles (≤500 µs)

The module supports the following functions:

- Firmware update
- Integrated system diagnostics
- PROFINET IO RT
- PROFINET IO IRT
- PROFIenergy
- Media redundancy
- I-device
- IO controller
- Web server
- Trace
- Isochronous mode
- Integrated controller
- Standard Motion Control

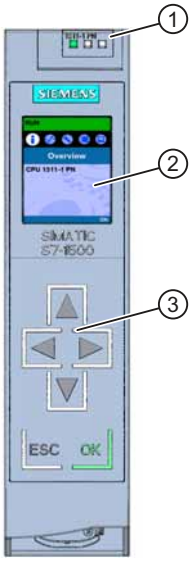
Reference

You can find additional information on "Integrated security/access protection" under "Protection" in the S7-1500 Automation System system manual (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Operating and display elements

2.2.1 Front view of the module with front panel

The following figure shows the front panel of CPU 1511-1 PN with integrated display.



① LED displays for the current operating mode and diagnostic status of the CPU
② Display
③ Operator control buttons

Figure 2-2 View of the CPU 1511-1 PN (with front panel) - front

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Note

Removing and fitting the front panel

The front panel can be removed and replaced during runtime without affecting operation.

Note

Temperature range for display

To increase the service life of the display, the display switches itself off before the permitted operating temperature is reached. When the display cools down again it automatically switches itself on again. The status of the CPU continues to be indicated by the LEDs when the display is switched off.

For more information on temperatures at which the display switches itself on and off, refer to the Technical Specifications (Page 29).

Reference

For more information about "Displays" refer to the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual, CPU display chapter. Removing and replacing the front cover is described in the section on handling the front cover.

Locking the front cover

You can lock the front cover to protect your CPU against unauthorized access.

You can attach a security seal or a padlock with a diameter of 3 mm to the front cover.

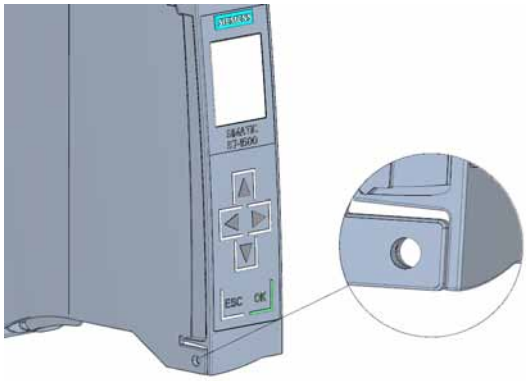
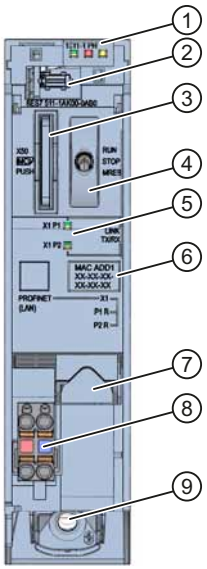


Figure 2-3 Locking latch on the CPU

2.2.2 Front view of the module without front panel

The following figure shows the operator control and connection elements of the CPU 1511-1 PN behind the front panel.

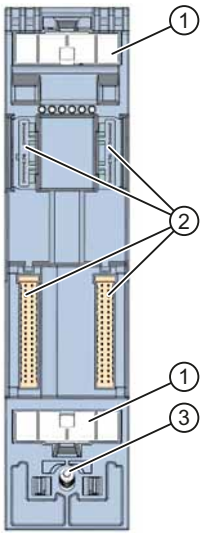


① LEDs for the current operating mode and diagnostic status of the CPU
② Display connection
③ Slot for the SIMATIC memory card
④ Mode selector switch
⑤ LEDs for the 2 ports of the PROFINET interface X1
⑥ MAC address
⑦ PROFINET interface (X1) with 2-port switch
⑧ Connection for power supply
⑨ Fixing screw

Figure 2-4 View of the CPU 1511-1 PN (without front panel) - front

2.2.3 Rear view of the module

The following figure shows the connection elements on the back of the CPU 1511-1 PN.



① Shield contact surface
② Backplane bus connector
③ Fixing screw

Figure 2-5 View of the CPU 1511-1 PN - back

2.3 Mode selector switch

Use the mode selector to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2- 1 Mode selector switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU is executing the user program.
STOP	STOP mode	The CPU is not executing the user program.
MRES	Memory reset	Position for CPU memory reset.

2.4 Functions

2.4.1 PROFINET IO

PROFINET is a fieldbus standard of the PROFIBUS user organization that defines a cross-vendor communication and engineering model.

Within the context of PROFINET, PROFINET IO is a communication concept for the implementation of modular, distributed applications. PROFINET IO IRT enables defined response times and high-precision system behavior.

The PROFINET IO controller operating mode enables direct access to IO devices via Industrial Ethernet.

The PROFINET IO device operating mode enables the operation of S7 stations as "intelligent" PROFINET IO devices on Industrial Ethernet.

UDP and RT or IRT are used to configure the cyclic IO data traffic for PROFINET IO communication.

General properties of PROFINET IO

PROFINET IO has the following properties and functions:

- Real-time communication
- Isochronous real-time communication
- Media redundancy
- Prioritized startup
- Device replacement without exchangeable medium
- I-device
- IO controller
- Isochronous mode

Reference

You will find additional information on "PROFINET IO" in the STEP 7 online help and in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) manual.

2.4.2 PROFIenergy

PROFIenergy

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during the production-free time.

Additional information

- System manual: PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
- Additional information on PROFIenergy is available on the Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order no: 3.802.

2.4.3 Memory reset

Apart from a few exceptions, a "memory reset" involves clearing all internal memories and then reading the data from the SIMATIC memory card.

Options

You have the following options for resetting the memory of the CPU:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

Proceed as follows to reset the CPU memory using the mode sselector switch:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.
2. Set the mode selector switch to the MRES position. Hold the switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, return the mode selector switch to the MRES position, and then back to STOP again.

Result: The CPU executes a memory reset, during which time the RUN/STOP LED flashes yellow. The RUN/STOP LED switches to yellow when the CPU has completed the memory reset.

Procedure using the display

You can reach the "Memory reset" menu command by successively selecting the following menu command and confirming each step with "OK".

- Settings → Reset → Memory reset

Result: The CPU performs a memory reset.

Procedure using STEP 7

Proceed as follows to reset the CPU memory in STEP 7:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" to confirm the security prompt.

Result: The CPU is set to STOP mode and the CPU memory reset is performed.

Memory object response to memory reset

The following table gives an overview of which memory objects are retained and which are initialized upon memory reset.

Table 2- 2 Retentive characteristics of the memory objects

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Retained
Diagnostic buffer entries (retentive area)	Retained
Diagnostic buffer entries (non-retentive area)	Initialized
Operating hours counter	Retained
Time	Retained

Reference

For more information about "Memory reset", refer to the Memory reset chapter in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual.

2.4.4 Restoring the factory settings of the CPU

The "Reset to factory settings" function restores the CPU to the "delivery state". This means that all data that was stored in internal CPU memory is deleted.

Recommendation:

Always reset a PROFINET CPU to the factory state if you want to store it or remove it for use at a different location with a different program. Make sure that the Reset to factory settings also deletes the IP address parameters.

Options

There are three ways to reset the CPU to the factory state:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (RUN/STOP LED lights up yellow).

Perform a reset to factory settings when there is no SIMATIC memory card inserted, as follows:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.
2. Set the mode selector switch to the MRES position. Hold the mode selector switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, return the mode selector switch to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings"; the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Note

Make sure to set the CPU to factory state when you remove a PROFINET CPU and use it elsewhere or put it in storage. Make sure that the Reset to factory settings also deletes the IP address parameters.

Procedure using the display

Make sure that the CPU is in STOP mode (RUN/STOP LED lights up yellow).
If a SIMATIC memory card is plugged in, make sure to remove this.

You can reach the "Factory settings" menu command by successively selecting the following menu commands and confirming each step with "OK".

- Settings → Reset → Factory settings

Result: The CPU executes the "Reset to factory settings"; the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Procedure using STEP 7

Make sure there is an online connection to the CPU that is to be reset to the factory settings.

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button to retain the IP address, or the "Reset IP address" option button to delete the IP address.
4. Click "Reset".
5. Click "OK" to confirm the security prompt.

Result: The CPU is set to STOP mode and is reset to factory settings.

Retentive characteristics of the memory objects

The properties of the CPU are set to the following values:

Table 2- 3 Properties of the CPU objects in the delivery state

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Initialized
Diagnostics buffer entries (retentive area)	Initialized
Diagnostics buffer entries (non-retentive area)	Initialized
Operating hours counter	Initialized
Time	Initialized

Reference

For more information about "Reset to factory settings", refer to the Structure and use of CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) Function Manual in the Memory areas and retentivity chapter, as well as to the STEP 7 Online Help.

Wiring

3

This section provides information on the terminal assignment of the individual interfaces and the block diagram of the CPU 1511-1 PN.

24 V DC power supply(X80)

The connector for the power supply is inserted in the factory state of the CPU.

The following table shows the terminal assignment for a 24 V DC power supply.

Table 3- 1 Terminal assignment 24 V DC power supply

View	Signal name*	Pin assignment
	1L+	24 V DC
	2L+	24 V DC **
	1M	Ground
	2M	Ground **
* 1L+ and 2L+ and 1M and 2M are jumpered internally.		
** Make sure that the current is limited to 10 A.		

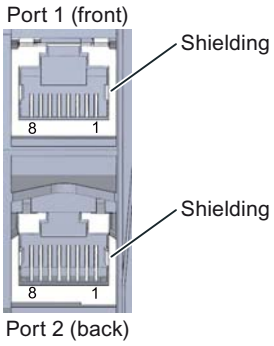
If the CPU is supplied by a system power supply, the 24 V supply connection is not required.

The 2L+ and 2M connections can be used to loop-through the 24 V supply.

PROFINET interface (X1) with 2-port switch (X1 P1 and X1 P2)

The following table shows the terminal assignment for the PROFINET interface with 2-port switch. The assignment corresponds to the Ethernet standard for a RJ45 plug.

Table 3- 2 Terminal assignment of PROFINET interface with 2-port switch

View	Signal name		Pin assignment
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

Reference

You can find additional information on the topics of "Connecting the CPU" and "Accessories (RJ45 plug)" in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Assignment of MAC addresses

The CPU 1511-1 PN has a PROFINET interface with two ports. The PROFINET interface itself has a MAC address, and each of the two PROFINET ports has its own MAC address. There are therefore three MAC addresses in total for the CPU 1511-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the proximity detection function.

The number range of the MAC addresses is sequential. The first and last MAC address is lasered on the right of each CPU 1511-1 PN.

The table below sets out the MAC address assignment.

Table 3- 3 Assignment of MAC addresses

	Assignment	Labeling
MAC address 1	PROFINET interface X1 (visible in STEP 7 for accessible devices)	• Front, lasered • Right-hand side, lasered (start of number range)
MAC address 2	X1 P1 port (needed for LLDP, for example)	• Front and right-hand side, not lasered
MAC address 3	X1 P2 port (needed for LLDP, for example)	• Front, not lasered • Right-hand side, lasered (end of number range)

Block diagram

Below is the block diagram of CPU 1511-1 PN.

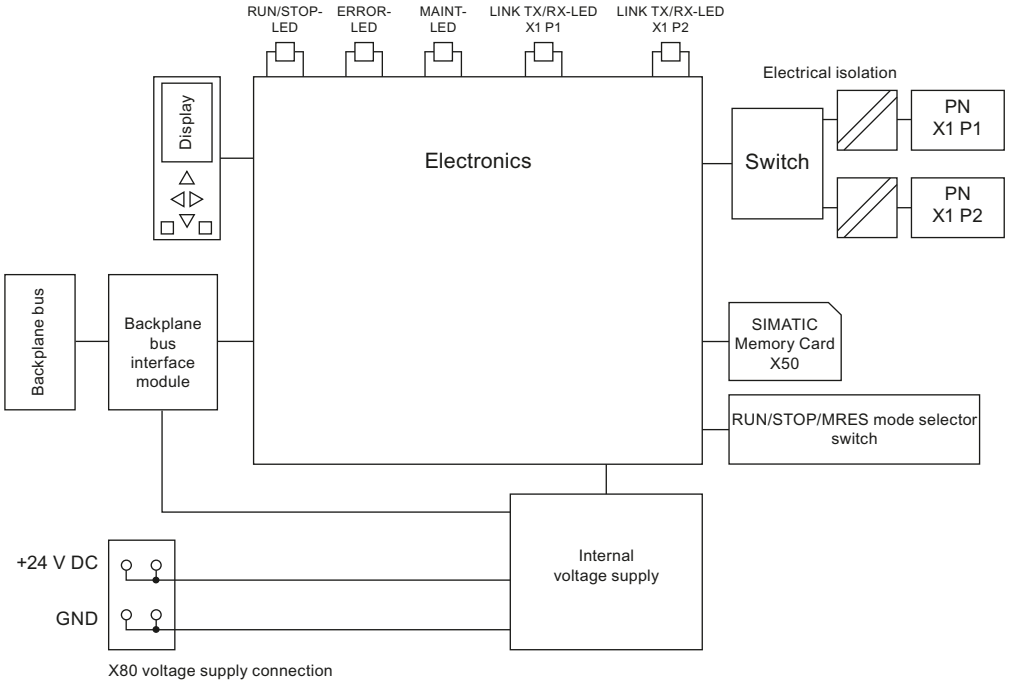


Figure 3-1 Block diagram CPU 1511-1 PN

Interrupts, diagnostics, error, and system messages 4

The status and error displays of the CPU 1511-1 PN are described below.

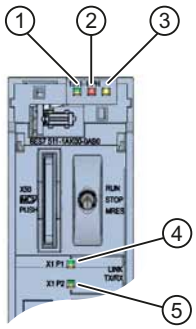
You will find additional information on "Interrupts" in the STEP 7 online help.

You will find additional information on "Diagnostics" and "System messages" in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

4.1 Status and error display of the CPU

LED display

The figure below shows the CPU 1511-1 PN LEDs.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX-LED for X1 P1 port (yellow/green LED)
⑤ LINK RX/TX-LED for X1 P2 port (yellow/green LED)

Figure 4-1 CPU 1511-1 PN LEDs (without front panel)

Meaning of the RUN/STOP, ERROR and MAINT LED

CPU 1511-1 PN has three LEDs to signal the current operating status and diagnostic status. The following table shows the meaning of the various combinations of colors for the RUN/STOP, ERROR and MAINT LEDs.

Table 4- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	Missing or insufficient power supply on the CPU.
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	CPU is in RUN mode.
LED green	LED flashes red	LED off	A diagnostic event is pending.
LED green	LED off	LED yellow	Maintenance demanded for the plant. The affected hardware must be replaced within a short period of time.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be replaced within a reasonable time period.
			Firmware update successfully completed.
LED yellow	LED off	LED off	CPU is in STOP mode.
LED yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

Meaning of LINK RX/TX-LED

Each port has a LINK RX/TX-LED. The table below shows the various "LED scenarios" of ports for the CPU 1511-1 PN.

Table 4- 2 Meaning of the LED

LINK TX/RX-LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is performed.
LED green	There is no Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.
LED flickers yellow	Data is currently being received from a communication partner on Ethernet via the PROFINET interface of the PROFINET device.

Technical specifications

5

	6ES7511-1AK00-0AB0
Product type designation	CPU 1511-1 PN
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0
Display	
• Screen diagonal (cm)	3.45 cm
Control and display elements	
• Number of buttons	6
• Mode selector switch	1
Installation type/mounting	
• Rail mounting possible	Yes
• Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
• Low limit of permitted range (DC)	19.2 V
• High limit of permitted range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption (rated value)	0.7 A
• Inrush current, max.	1.9 A; rated value
• I^2t	0.34 A^2s
Power	
• Power consumption from the backplane bus (balanced)	5.5 W
• Incoming power to the backplane bus	10 W
Power loss	
• Power loss, typ.	5.7 W

	6ES7511-1AK00-0AB0
Memory	
Work memory	
• Integrated (for program)	150 KB
• Integrated (for data)	1 MB
Load memory	
• Plug-in (SIMATIC memory card), max.	2 GB
Buffering	
• Maintenance-free	Yes
CPU processing time	
• For bit operations, typ.	60 ns
• For word operations, typ.	72 ns
• For fixed-point arithmetic, typ.	96 ns
• For floating-point arithmetic, typ.	384 ns
CPU blocks	
• Number of blocks (total)	2000
DB	
• Number, max.	2000; number range: 1 to 65535
• Size, max.	1 MB
FB	
• Number, max.	1998; number range: 1 to 65535
• Size, max.	150 KB
FC	
• Number, max.	1999; number range: 1 to 65535
• Size, max.	150 KB
OB	
• Size, max.	150 KB
• Number of free-cycle OBs	100
• Number of time-of-day interrupt OBs	20
• Number of time-delay interrupt OBs	20
• Number of cyclic interrupt OBs	20
• Number of hardware interrupt OBs	50
• Number of DPV1 interrupt OBs	3
• Number of isochronous mode OBs	1
• Number of technology synchronization interrupt OBs	2
• Number of restart OBs	100

	6ES7511-1AK00-0AB0
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic interrupt OBs	1
Nesting depth	
• Per priority class	24
Timers/counters and their retentivity	
S7 counters	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC counters	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
S7 timers	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC timers	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
Data areas and their retentivity	
• Total retentive data area (including timers, counters, bit memories), max.	128 KB; for bit memories, timers, counters, DBs and technological data (axes), usable retentive memory: 88 KB
Bit memory	
• Number, max.	16 KB
• Number of clock memories	8; 8 clock memory bits, summarized in one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
Retentivity preset	No
Local data	
• Per priority class, max.	64 KB max. 16 KB per block
Address area	
• Number of I/O modules	1024

	6ES7511-1AK00-0AB0
I/O address area	
• Inputs	32 KB; all inputs are in the process image
• Outputs	32 KB; all outputs are in the process image
Of which per IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Of which per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
• Number of process image partitions, max.	32
Address space per module	
• Number of I/O submodules	5
Hardware configuration	
• Modules per rack, max.	32; CPU + 31 modules
• Rack, number of rows, max.	1
Number of DP masters	
• Via CM	4; a maximum of 4 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted in total
Number of IO controllers	
• Integrated	1
PtP CM	
• Number of PtP CMs	The number of PtP CMs you can connect is only limited by the available slots
Time	
Clock	
Type	Hardware clock
• Deviation per day, max.	10 s; typ.: 2 s
• Buffered period	6 wk; at 40 °C ambient temperature, typ.
Time synchronization	
• Supported	Yes
• in AS, Master	Yes
• in AS, Slave	Yes
• On Ethernet via NTP	Yes

	6ES7511-1AK00-0AB0
Interfaces	
• Number of PROFINET interfaces	1
1. Interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ 45 (Ethernet)	Yes
Protocols	
• PROFINET IO controller	Yes
• PROFINET IO device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes
• Web server	Yes
• Media redundancy	Yes
Interface hardware	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
Number of connections	
• Number of connections, max.	96
• Number of connections reserved for ES/HMI/Web	10
• Number of connections via integrated interfaces	64
Protocols	
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50

	6ES7511-1AK00-0AB0
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PN devices
• Number of connectable IO devices, max.	128; a maximum of 256 distributed I/O devices can be connected by means of CPs/CMs via PROFIBUS or PROFINET.
• Number of IO devices that you can connect for RT, max.	128
• Of which are in line, max.	128
• Number of IO devices with IRT and the "high performance" option, max.	64
• Number of IO devices that can be activated/deactivated simultaneously, max.	8
• Number of IO devices per tool, max.	8
Update times	The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data.
with RT	
• for send cycle of 250 µs	250 µs to 128 ms
• for send cycle of 500 µs	500 µs to 256 ms
• for send cycle of 1 ms	1 ms to 512 ms
• for send cycle of 2 ms	2 ms to 512 ms
• for send cycle of 4 ms	4 ms to 512 ms
with IRT and "high performance" option	
• for send cycle of 250 µs	250 µs to 4 ms
• for send cycle of 500 µs	500 µs to 8 ms
• for send cycle of 1 ms	1 ms to 16 ms
• for send cycle of 2 ms	2 ms to 32 ms
• for send cycle of 4 ms	4 ms to 64 ms
For IRT with the "high performance" option and parameter assignment for so-called "odd-numbered" send cycles	Update time = set "odd-numbered" send cycle (any multiple of 125 µs: 375 µs, 625 µs to 3.875 µs)
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT, supported	Yes

	6ES7511-1AK00-0AB0
• MRP, supported	Yes
• PROFIenergy	Yes
SIMATIC communication	
• S7 communication as server	Yes
• S7 communication as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
• Data length, max.	64 KB
• ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
• UDP	Yes
• Data length, max.	1472 bytes
• DHCP	No
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
Web server	
• HTTP	Yes; standard and user-defined pages
• HTTPS	Yes; standard and user-defined pages
Media redundancy	
• Changeover time on line interruption, typ.	200 ms
• Number of ring nodes, max.	50
Slots	
• SIMATIC Memory Card required	Yes
Isochronous mode	
• Isochronous mode (application synchronized up to terminal)	Yes
• Constant bus cycle time	Yes
S7 signaling functions	
• Number of stations that can be logged in for message functions, max.	32
• Block-related alarms	Yes
• Number of configurable interrupts, max.	5000
• Number of simultaneously active interrupts	500

	6ES7511-1AK00-0AB0
Test/commissioning functions	
Status/modify	
• Status/modify tag	Yes
Tags	Inputs, outputs, memory bits, DBs, timers, counters
• Of which are status tags, max.	200; per job
• Of which are modify tags, max.	200; per job
Force	
Forcing, tags	Inputs, outputs
• Number of tags, max.	200
• Status block	Yes; up to 8 at the same time
• Single-step	No
Diagnostic buffer	
• Available	Yes
• No. of entries, max.	1000
• Of which are power failure-proof	250
Interrupts/diagnostics/status information	
Diagnostic indicator LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
• Motion	Yes
• Speed-controlled axis	
• Number of speed-controlled axes, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Positioning axis	
• Number of positioning axes, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• External encoder	
• Number of external encoders, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Controller	
• PID_Compact	Yes; universal PID controller with integrated optimization

	6ES7511-1AK00-0AB0
• PID_3Step	Yes; PID controller with integrated optimization for valves
• Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C; display: 50 °C, the display is switched off at an operating temperature of typically 50 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C; display: 40 °C, the display is switched off at an operating temperature of typically 40 °C
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
Know-how protection	
• User program protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• Password for display	Yes
• Protection level: Read-only	Yes
• Protection level: Read/write protection	Yes
• Protection level: Complete protection	Yes
Cycle-time monitoring	
• Low limit	Adjustable minimum cycle time
• High limit	Adjustable maximum cycle time
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	430 g

Dimensional drawing

A

This section includes a dimensional drawing of the module on a mounting rail and a dimensional drawing with the front panel open. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimensional drawings for CPU 1511-1 PN

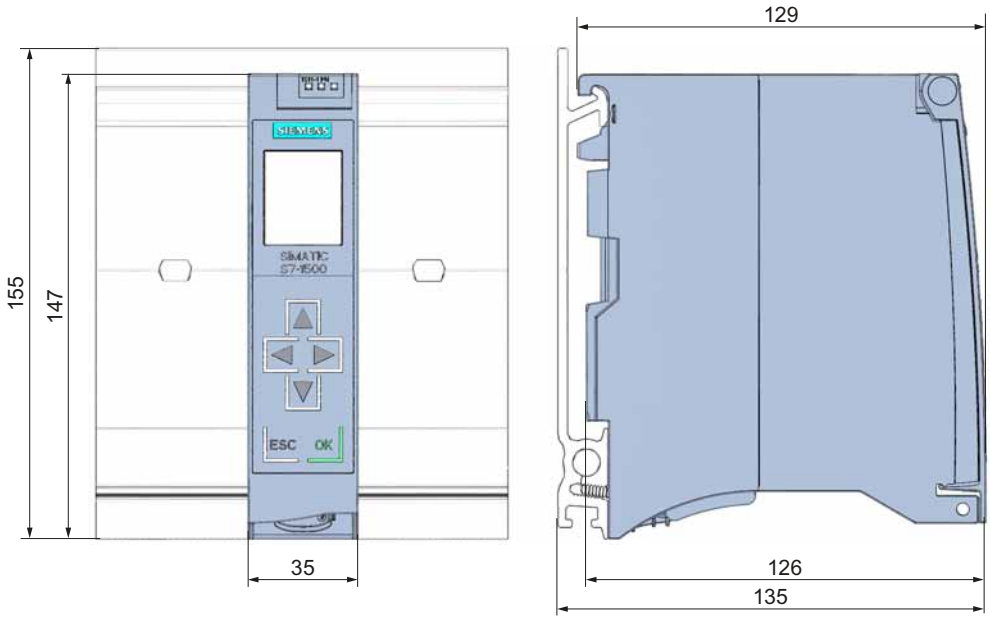


Figure A-1 Dimensional drawing of CPU 1511-1 PN, front and side views

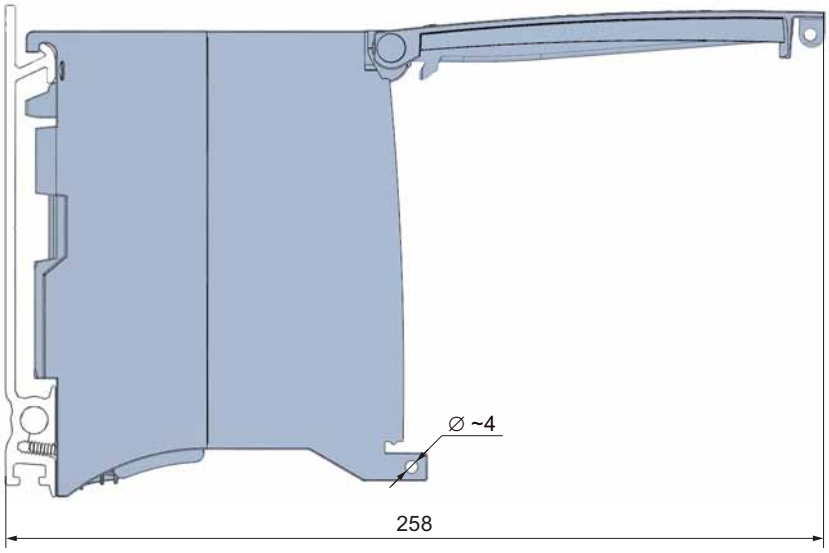


Figure A-2 Dimensional drawing of CPU 1511-1 PN, side view with front panel open

SIEMENS

SIMATIC

S7-1500
CPU 1513-1 PN
(6ES7513-1AL00-0AB0)

Manual

Preface

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Product overview 2

Wiring 3

Interrupts, diagnostics, error, and system messages 4

Technical specifications 5

Dimensional drawing A

01/2013

A5E03506268-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E03506268-01
Ⓟ 01/2013 Technical data subject to change

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Preface

Purpose of the documentation

This device manual supplements the system manual of the S7-1500 automation system and the function manuals. All cross-system functions are described in the system manual.

The information provided in this device manual and the system manual enables you to commission the CPU 1513-1 PN.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers a range of topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (Online Help) also helps you to configure and program your automation system.

Overview of the documentation for CPU 1513-1 PN

The following table lists additional documents which supplement this description of CPU 1513-1 PN and are available on the Internet.

Table 1- 1 Documentation for CPU 1513-1 PN

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual	• Application planning • Installation • Wiring • Commissioning
Properties of the modules	Power supplies (http://support.automation.siemens.com/WW/view/en/59174020) device manual Signal modules (http://support.automation.siemens.com/WW/view/en/57251228) device manual	• Wiring • Parameter assignment/ addressing • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimensional drawing
System diagnostics	System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual	• Overview • Hardware/software diagnostic evaluation

Topic	Documentation	Most important contents
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925) function manual	• Overview
	PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• PROFINET basics • PROFINET functions • PROFINET diagnostics
	Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual	• Function • Operation
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Memory concept	Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) function manual	• Setup • Function principle • Use
Cycle and response times	Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193566) function manual	• Basics • Calculations
Analog value processing	Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559) function manual	• Wiring options • Tables of measured values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview 2

2.1 Properties

Order number

6ES7513-1AL00-0AB0

View of the module

The following figure shows the CPU 1513-1 PN.

Figure 2-1 CPU 1513-1 PN

Properties

The module has the following technical properties:

- Communication:
  - Interfaces

    The CPU 1513-1 PN has a PROFINET interface with two ports. The two ports have the same IP address and form the interface to the fieldbus level (switch functionality).
  - Integrated Web server

    The CPU status query is independent of a software installation. Graphically visualized process variables and user-defined websites facilitate information acquisition.
- Trace functionality
  - All CPUs of the S7-1500 automation system support trace functionality.
    Trace functionality is independent of the technology and supports you in debugging/optimizing the user program. It is particularly useful for Motion Control and control applications.
- Integrated technology:
  - Standard Motion Control

    PLC Open blocks for programming motion functionality by means of PROFINET IO IRT and PROFIdrive interface.

    The functionality supports speed-controlled axes, positioning axes and external encoders.
  - Integrated control functionality

    Universal PID controllers or 3-point controllers with integrated tuning.

    Integrated temperature controller
- Integrated system diagnostics:
  - System diagnostics is automatically generated and consistently displayed.
- Integrated security:
  - Know-how protection

    Algorithms can be securely protected against unauthorized access and modification.
  - Copy protection

    User program blocks are linked to the serial number of the SIMATIC memory card or of the module. User programs cannot run without the corresponding SIMATIC memory card or module.
  - Access protection

    Extended access protection provides comprehensive protection against unauthorized configuration changes. Authorization levels can be used to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU from unauthorized manipulation. Altered or external transmission of engineering data is reliably detected by the CPU.

- Other special features:
  - Color display
  - Short OB cycles (≤500 µs)

The module supports the following functions:

- Firmware update
- Integrated system diagnostics
- PROFINET IO RT
- PROFINET IO IRT
- PROFIenergy
- Media redundancy
- I-device
- IO controller
- Web server
- Trace
- Isochronous mode
- Integrated controller
- Standard Motion Control

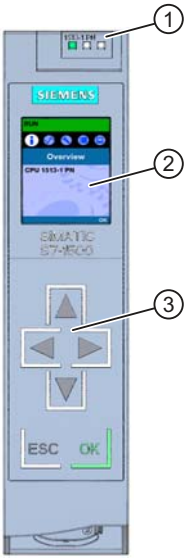
Reference

You can find additional information on "Integrated security/access protection" under "Protection" in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

2.2 Operating and display elements

2.2.1 Front view of the module with front panel

The following figure shows the front panel of CPU 1513-1 PN with integrated display.



① LED displays for the current operating mode and diagnostic status of the CPU
② Display
③ Operator control buttons

Figure 2-2 View of the CPU 1513-1 PN (with front panel) - front

---

Note

Removing and fitting the front panel

The front panel can be removed and replaced during runtime without affecting operation.

Note

Temperature range for display

To increase the service life of the display, the display switches itself off before the permitted operating temperature is reached. When the display cools down again it automatically switches itself on again. The status of the CPU continues to be indicated by the LEDs when the display is switched off.

For more information on temperatures at which the display switches itself on and off, refer to the Technical Specifications (Page 29).

Reference

For more information about "Displays" refer to the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual, CPU display chapter. Removing and replacing the front cover is described in the section on handling the front cover.

Locking the front cover

You can lock the front cover to protect your CPU against unauthorized access.

You can attach a security seal or a padlock with a diameter of 3 mm to the front cover.

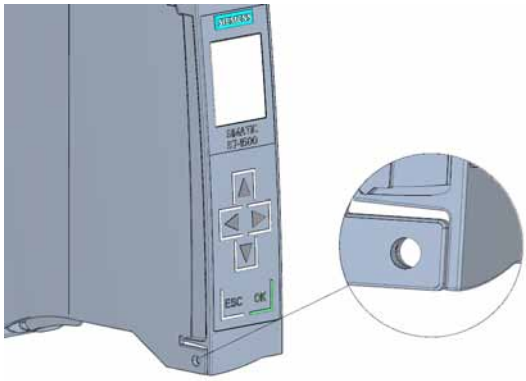
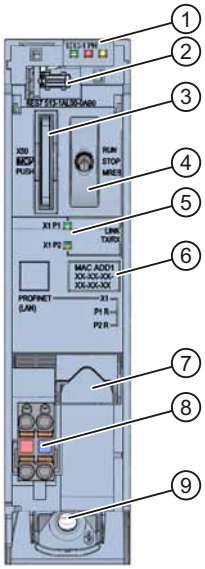


Figure 2-3 Locking latch on the CPU

2.2.2 Front view of the module without front panel

The following figure shows the operator control and connection elements of the CPU 1513-1 PN behind the front panel.

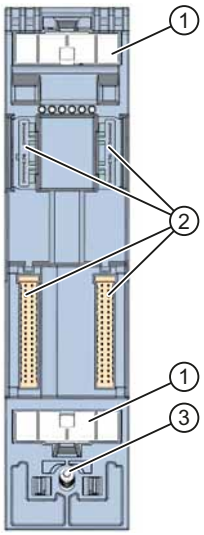


① LEDs for the current operating mode and diagnostic status of the CPU
② Display connection
③ Slot for the SIMATIC memory card
④ Mode selector switch
⑤ LEDs for the 2 ports of the PROFINET interface X1
⑥ MAC address
⑦ PROFINET interface (X1) with 2-port switch
⑧ Connection for power supply
⑨ Fixing screw

Figure 2-4 View of the CPU 1513-1 PN (without front panel) - front

2.2.3 Rear view of the module

The following figure shows the connection elements on the back of the CPU 1513-1 PN.



① Shield contact surface
② Backplane bus connector
③ Fixing screw

Figure 2-5 View of the CPU 1513-1 PN - back

2.3 Mode selector switch

Use the mode selector to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2- 1 Mode selector switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU is executing the user program.
STOP	STOP mode	The CPU is not executing the user program.
MRES	Memory reset	Position for CPU memory reset.

2.4 Functions

2.4.1 PROFINET IO

PROFINET is a fieldbus standard of the PROFIBUS user organization that defines a cross-vendor communication and engineering model.

Within the context of PROFINET, PROFINET IO is a communication concept for the implementation of modular, distributed applications. PROFINET IO IRT enables defined response times and high-precision system behavior.

The PROFINET IO controller operating mode enables direct access to IO devices via Industrial Ethernet.

The PROFINET IO device operating mode enables the operation of S7 stations as "intelligent" PROFINET IO devices on Industrial Ethernet.

UDP and RT or IRT are used to configure the cyclic IO data traffic for PROFINET IO communication.

PROFINET IO properties

PROFINET IO has the following properties and functions:

- Real-time communication
- Isochronous real-time communication
- Media redundancy
- Prioritized startup
- Device replacement without exchangeable medium
- I-device
- IO controller
- Isochronous mode

Reference

You can find additional information on the "PROFINET IO" topic in the STEP 7 online help and in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) manual.

2.4.2 PROFIenergy

PROFIenergy

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during the production-free time.

Additional information

- System manual: PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
- Additional information on PROFIenergy is available on the Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order no: 3.802.

2.4.3 Memory reset

Apart from a few exceptions, a "memory reset" involves clearing all internal memories and then reading the data from the SIMATIC memory card.

Options

You have the following options for resetting the memory of the CPU:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

Proceed as follows to reset the CPU memory using the mode sselector switch:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.
2. Set the mode selector switch to the MRES position. Hold the switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, return the mode selector switch to the MRES position, and then back to STOP again.

Result: The CPU executes a memory reset, during which time the RUN/STOP LED flashes yellow. The RUN/STOP LED switches to yellow when the CPU has completed the memory reset.

Procedure using the display

To navigate to the desired "Memory reset" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Memory reset

Result: The CPU performs a memory reset.

Procedure using STEP 7

Proceed as follows to reset the CPU memory in STEP 7:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" to confirm the security prompt.

Result: The CPU is set to STOP mode and the CPU memory reset is performed.

Memory object response to memory reset

The following table gives an overview of which memory objects are retained and which are initialized upon memory reset.

Table 2- 2 Retentive characteristics of the memory objects

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Retained
Diagnostic buffer entries (retentive area)	Retained
Diagnostic buffer entries (non-retentive area)	Initialized
Operating hours counter	Retained
Time	Retained

Reference

For more information about "Memory reset", refer to the Memory reset chapter in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual.

2.4.4 Restoring the factory settings of the CPU

The "Reset to factory settings" function restores the CPU to "factory state".
This means that all data that was stored in internal CPU memory is deleted.

Recommendation:

Always reset a PROFINET CPU to the factory state if you want to store it or remove it for use at a different location with a different program. Make sure that the Reset to factory settings also deletes the IP address parameters.

Options

There are three ways to reset the CPU to the factory state:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (RUN/STOP LED is lit up in yellow).

Perform a reset to factory settings without inserted SIMATIC memory card as follows:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.

2. Set the mode selector switch to the MRES position. Hold the mode selector switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.

3. Within the next three seconds, return the mode selector switch to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings"; the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostic buffer.

Note

Make sure to set the CPU to factory state when you remove a PROFINET CPU and use it elsewhere or put it in storage. Make sure that the Reset to factory settings also deletes the IP address parameters.

Procedure using the display

Make sure that the CPU is in STOP mode (RUN/STOP LED lights up yellow).
Always remove a SIMATIC memory card, if installed.

You can reach the "Factory settings" menu command by successively selecting the following menu command and confirming each step with "OK".

- Settings → Reset → Factory settings

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostic buffer.

Procedure using STEP 7

Make sure there is an online connection to the CPU that is to be reset to the factory settings.

1. Open the online and diagnostic view of the CPU.
2. Go to the "Functions" folder and select the "Reset to factory settings" group.
3. Activate the "Retain IP address" check box to retain the IP address, or activate the "Reset IP address" check box to delete the IP address.
4. Click "Reset".
5. Click "OK" to confirm the security prompt.

Result: The CPU is set to STOP mode and is reset to factory settings.

Retentive characteristics of the memory objects

The properties of the CPU are set to the following values:

Table 2- 3 Properties of the CPU objects in the factory state

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Initialized
Diagnostic buffer entries (retentive area)	Initialized
Diagnostic buffer entries (non-retentive area)	Initialized
Operating hours counter	Initialized
Time	Initialized

Reference

For more information about "Reset to factory settings", refer to the Structure and use of CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) Function Manual in the Memory areas and retentivity chapter, as well as to the STEP 7 Online Help.

Wiring

3

This section provides information on the terminal assignment of the individual interfaces and the block diagram of the CPU 1513-1 PN.

24 V DC power supply(X80)

The connector for the power supply is inserted in the factory state of the CPU.

The following table shows the terminal assignment for a 24 V DC power supply.

Table 3- 1 Terminal assignment 24 V DC power supply

View	Signal name*	Designation
	1L+	24 V DC
	2L+	24 V DC **
	1M	Ground
	2M	Ground **
* 1L+ and 2L+ and 1M and 2M are jumpered internally.		
** Make sure that the current is limited to 10 A.		

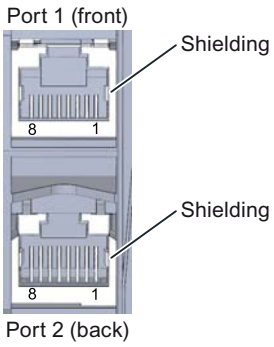
If the CPU is supplied by a system power supply, the 24 V supply connection is not required.

The 2L+ and 2M connections can be used to loop-through the 24 V supply.

PROFINET interface (X1) with 2-port switch (X1 P1 and X1 P2)

The following table shows the terminal assignment for the PROFINET interface with 2-port switch. The assignment corresponds to the Ethernet standard for a RJ45 plug.

Table 3- 2 Terminal assignment of PROFINET interface with 2-port switch

View	Signal name		Designation
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

Reference

You can find additional information on the topics of "Connecting the CPU" and "Accessories (RJ45 plug)" in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Assignment of MAC addresses

The CPU 1513-1 PN has a PROFINET interface with two ports. The PROFINET interface itself has a MAC address, and each of the two PROFINET ports has its own MAC address. There are therefore three MAC addresses in total for the CPU 1513-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the proximity detection function.

The number range of the MAC addresses is sequential. The first and last MAC address is lasered on the right of each CPU 1513-1 PN.

The table below sets out the MAC address assignment.

Table 3- 3 Assignment of MAC addresses

	Assignment	Labeling
MAC address 1	PROFINET interface X1 (visible in STEP 7 for accessible devices)	• Front, lasered • Right-hand side, lasered (start of number range)
MAC address 2	X1 P1 port (needed for LLDP, for example)	• Front and right-hand side, not lasered
MAC address 3	X1 P2 port (needed for LLDP, for example)	• Front, not lasered • Right-hand side, lasered (end of number range)

Block diagram

Below is the block diagram of CPU 1513-1 PN.

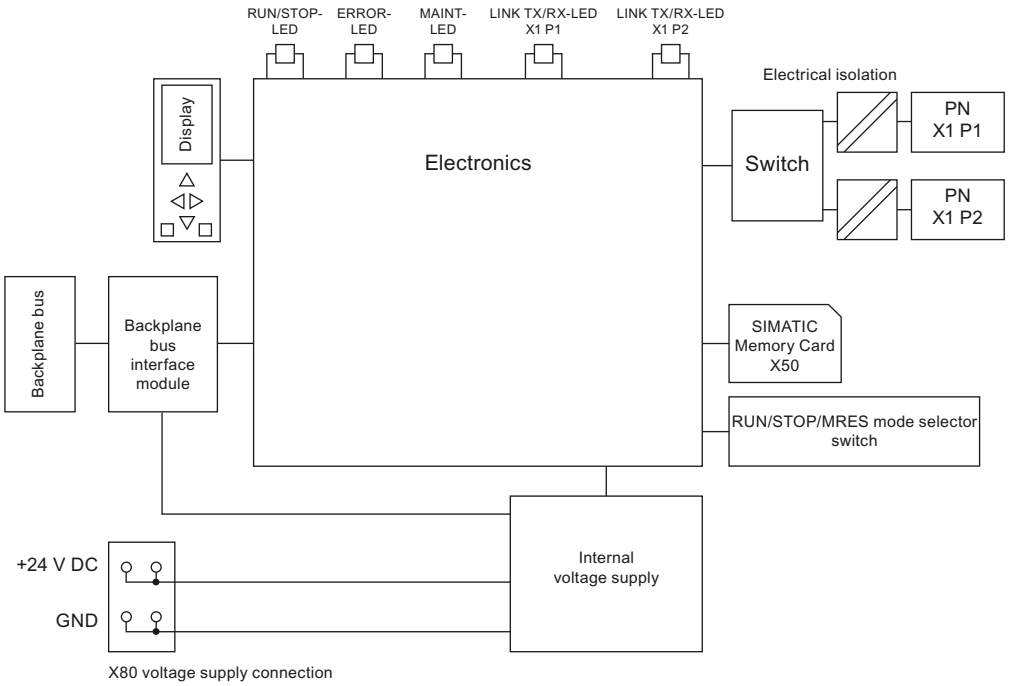


Figure 3-1 Block diagram CPU 1513-1 PN

Interrupts, diagnostics, error, and system messages 4

The status and error displays of the CPU 1513-1 PN are described below.

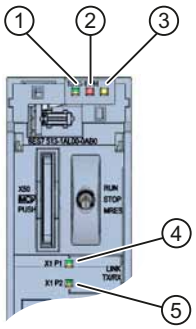
You will find additional information on "Interrupts" in the STEP 7 online help.

You will find additional information on "Diagnostics" and "System messages" in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

4.1 Status and error display of the CPU

LED display

The figure below shows the CPU 1513-1 PN LEDs.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX-LED for X1 P1 port (yellow/green LED)
⑤ LINK RX/TX-LED for X1 P2 port (yellow/green LED)

Figure 4-1 CPU 1513-1 PN LEDs (without front panel)

Meaning of the LED displays

CPU 1513-1 PN has three LEDs to signal the current operating status and diagnostic status. The following table shows the meaning of the various combinations of colors for the RUN/STOP, ERROR and MAINT LEDs.

Table 4- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	Missing or insufficient power supply on the CPU.
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	CPU is in RUN mode.
LED green	LED flashes red	LED off	A diagnostic event is pending.
LED green	LED off	LED yellow	Maintenance demanded for the plant. The affected hardware must be replaced within a short period of time.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be replaced within a reasonable time period.
			Firmware update successfully completed.
LED yellow	LED off	LED off	CPU is in STOP mode.
LED yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

Meaning of the LEDs of the interfaces: X1 P1 and X1 P2

Each port has a LINK RX/TX-LED. The table below shows the various "LED scenarios" of ports for the CPU 1513-1 PN.

Table 4- 2 Meaning of the LED

LINK TX/RX-LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is performed.
LED green	There is no Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.
LED flickers yellow	Data is currently being received from a communication partner on Ethernet via the PROFINET interface of the PROFINET device.

Technical specifications

5

	6ES7513-1AL00-0AB0
Product type designation	CPU 1513-1 PN
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0
Display	
• Screen diagonal (cm)	3.45 cm
Control and display elements	
• Number of buttons	6
• Mode selector switch	1
Installation type/mounting	
• Rail mounting possible	Yes
• Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
• Low limit of permitted range (DC)	19.2 V
• High limit of permitted range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption (rated value)	0.7 A
• Inrush current, max.	1.9 A; rated value
• I^2t	0.34 A^2s
Power	
• Power consumption from the backplane bus (balanced)	5.5 W
• Incoming power to the backplane bus	10 W
Power loss	
• Power loss, typ.	5.7 W

	6ES7513-1AL00-0AB0
Memory	
Work memory	
• Integrated (for program)	300 KB
• Integrated (for data)	1.5 MB
Load memory	
• Plug-in (SIMATIC memory card), max.	2 GB
Buffering	
• Maintenance-free	Yes
CPU processing time	
• For bit operations, typ.	40 ns
• For word operations, typ.	48 ns
• For fixed-point arithmetic, typ.	64 ns
• For floating-point arithmetic, typ.	256 ns
CPU blocks	
• Number of blocks (total)	2000
DB	
• Number, max.	2000; number range: 1 to 65535
• Size, max.	1.5 MB
FB	
• Number, max.	1998; number range: 1 to 65535
• Size, max.	300 KB
FC	
• Number, max.	1999; number range: 1 to 65535
• Size, max.	300 KB
OB	
• Size, max.	300 KB
• Number of free-cycle OBs	100
• Number of time-of-day interrupt OBs	20
• Number of time-delay interrupt OBs	20
• Number of cyclic interrupt OBs	20
• Number of hardware interrupt OBs	50
• Number of DPV1 interrupt OBs	3
• Number of isochronous mode OBs	1
• Number of technology synchronization interrupt OBs	2
• Number of restart OBs	100

	6ES7513-1AL00-0AB0
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic interrupt OBs	1
Nesting depth	
• Per priority class	24
Timers/counters and their retentivity	
S7 counters	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC counters	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
S7 timers	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC timers	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
Data areas and their retentivity	
• Total retentive data area (including timers, counters, bit memories), max.	128 KB; for bit memories, timers, counters, DBs and technological data (axes), usable retentive memory: 88 KB
Bit memory	
• Number, max.	16 KB
• Number of clock memories	8; 8 clock memory bits, summarized in one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
Retentivity preset	No
Local data	
• Per priority class, max.	64 KB max. 16 KB per block
Address area	
• Number of I/O modules	2048

	6ES7513-1AL00-0AB0
I/O address area	
• Inputs	32 KB; all inputs are in the process image
• Outputs	32 KB; all outputs are in the process image
Of which per IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Of which per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
• Number of process image partitions, max.	32
Address space per module	
• Number of I/O submodules	7
Hardware configuration	
• Modules per rack, max.	32; CPU + 31 modules
• Rack, number of rows, max.	1
Number of DP masters	
• Via CM	6; a maximum of 6 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted in total
Number of IO controllers	
• Integrated	1
PtP CM	
• Number of PtP CMs	The number of PtP CMs you can connect is only limited by the available slots
Time	
Clock	
Type	Hardware clock
• Deviation per day, max.	10 s; typ.: 2 s
• Buffered period	6 wk; at 40 °C ambient temperature, typ.
Time synchronization	
• Supported	Yes
• in AS, Master	Yes
• in AS, Slave	Yes
• On Ethernet via NTP	Yes

	6ES7513-1AL00-0AB0
Interfaces	
• Number of PROFINET interfaces	1
1. Interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ 45 (Ethernet)	Yes
Protocols	
• PROFINET IO controller	Yes
• PROFINET IO device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes
• Web server	Yes
• Media redundancy	Yes
Interface hardware	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
Number of connections	
• Number of connections, max.	128
• Number of connections reserved for ES/HMI/Web	10
• Number of connections via integrated interfaces	88
Protocols	
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50

	6ES7513-1AL00-0AB0
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PN devices
• Number of connectable IO devices, max.	128; a maximum of 256 distributed I/O devices can be connected by means of CPs/CMs via PROFIBUS or PROFINET.
• Number of IO devices that you can connect for RT, max.	128
• Of which are in line, max.	128
• Number of IO devices with IRT and the "high performance" option, max.	64
• Number of IO devices that can be activated/deactivated simultaneously, max.	8
• Number of IO devices per tool, max.	8
Update times	The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data.
with RT	
• for send cycle of 250 µs	250 µs to 128 ms
• for send cycle of 500 µs	500 µs to 256 ms
• for send cycle of 1 ms	1 ms to 512 ms
• for send cycle of 2 ms	2 ms to 512 ms
• for send cycle of 4 ms	4 ms to 512 ms
with IRT and "high performance" option	
• for send cycle of 250 µs	250 µs to 4 ms
• for send cycle of 500 µs	500 µs to 8 ms
• for send cycle of 1 ms	1 ms to 16 ms
• for send cycle of 2 ms	2 ms to 32 ms
• for send cycle of 4 ms	4 ms to 64 ms
For IRT with the "high performance" option and parameter assignment for so-called "odd-numbered" send cycles	Update time = set "odd-numbered" send cycle (any multiple of 125 µs: 375 µs, 625 µs to 3.875 µs)
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT, supported	Yes

	6ES7513-1AL00-0AB0
• MRP, supported	Yes
• PROFIenergy	Yes
SIMATIC communication	
• S7 communication as server	Yes
• S7 communication as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
• Data length, max.	64 KB
• ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
• UDP	Yes
• Data length, max.	1472 bytes
• DHCP	No
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
Web server	
• HTTP	Yes; standard and user-defined pages
• HTTPS	Yes; standard and user-defined pages
Media redundancy	
• Changeover time on line interruption, typ.	200 ms
• Number of ring nodes, max.	50
Slots	
• SIMATIC Memory Card required	Yes
Isochronous mode	
• Isochronous mode (application synchronized up to terminal)	Yes
• Constant bus cycle time	Yes
S7 signaling functions	
• Number of stations that can be logged in for message functions, max.	32
• Block-related alarms	Yes
• Number of configurable interrupts, max.	5000
• Number of simultaneously active interrupts	500

	6ES7513-1AL00-0AB0
Test/commissioning functions	
Status/modify	
• Status/modify tag	Yes
Tags	Inputs, outputs, memory bits, DBs, timers, counters
• Of which are status tags, max.	200; per job
• Of which are modify tags, max.	200; per job
Force	
Forcing, tags	Inputs, outputs
• Number of tags, max.	200
• Status block	Yes; up to 8 at the same time
• Single-step	No
Diagnostic buffer	
• Available	Yes
• No. of entries, max.	1000
• Of which are power failure-proof	250
Interrupts/diagnostics/status information	
Diagnostic indicator LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
• Motion	Yes
• Speed-controlled axis	
• Number of speed-controlled axes, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Positioning axis	
• Number of positioning axes, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• External encoder	
• Number of external encoders, max.	6; a total of up to 6 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Controller	
• PID_Compact	Yes; universal PID controller with integrated optimization

	6ES7513-1AL00-0AB0
• PID_3Step	Yes; PID controller with integrated optimization for valves
• Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C; display: 50 °C, the display is switched off at an operating temperature of typically 50 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C; display: 40 °C, the display is switched off at an operating temperature of typically 40 °C
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
Know-how protection	
• User program protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• Password for display	Yes
• Protection level: Read-only	Yes
• Protection level: Read/write protection	Yes
• Protection level: Complete protection	Yes
Cycle-time monitoring	
• Low limit	Adjustable minimum cycle time
• High limit	Adjustable maximum cycle time
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	430 g

Dimensional drawing

A

This section includes a dimensional drawing of the module on a mounting rail and a dimensional drawing with the front panel open. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimensional drawings for CPU 1513-1 PN

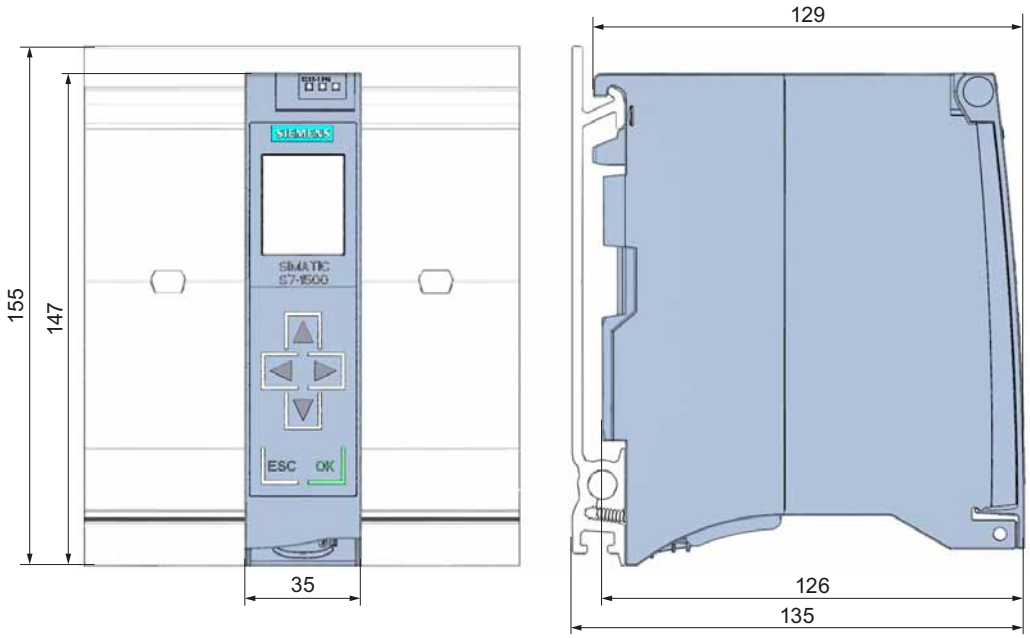


Figure A-1 Dimensional drawing of CPU 1513-1 PN, front and side views

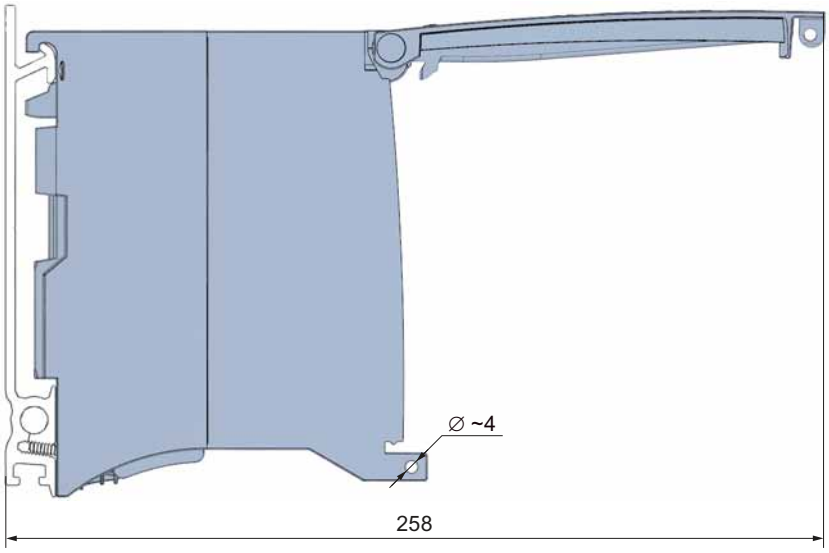


Figure A-2 Dimensional drawing of CPU 1513-1 PN, side view with front panel open

SIEMENS

SIMATIC

S7-1500
CPU 1516-3 PN/DP
(6ES7516-3AN00-0AB0)

Manual

Preface

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Product overview 2

Connecting 3

Interrupts, error messages, diagnostics and system alarms 4

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Dimensional drawing A

01/2013

A5E03461313-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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Ⓟ 01/2013 Technical data subject to change

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Preface

Purpose of the documentation

This device manual supplements the system manual of the S7-1500 automation system and the function manuals. All cross-system functions are described in the system manual.

The information provided in this device manual and the system manual enables you to commission the CPU 1516-3 PN/DP.

Conventions

Please also observe notes labeled as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

Moreover, the STEP 7 information system (online help) supports you in configuring and programming your automation system.

Overview of the documentation for CPU 1516-3 PN/DP

The following table lists additional documents, which supplement this description of CPU 1516-3 PN/DP and are available in the Internet.

Table 1- 1 Documentation for CPU 1516-3 PN/DP

Topic	Documentation	Most important contents
System description	System manual: S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
Module properties	Device manual: Power supplies (http://support.automation.siemens.com/WW/view/en/57251228) Device manual: Signal modules (http://support.automation.siemens.com/WW/view/en/59174020)	• Connecting • Parameter assignment/ addressing • Interrupts, error messages, diagnostics and system alarms • Technical specifications • Dimensional drawing
System diagnostics	Function manual: System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation for hardware/software

Topic	Documentation	Most important contents
Communication	Function manual: Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Overview
	Function manual: PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)	• PROFINET basics • PROFINET functions • PROFINET diagnostics
	Function manual: PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579)	• PROFIBUS basics • PROFIBUS functions • PROFIBUS diagnostics
	Function manual: Web Server (http://support.automation.siemens.com/WW/view/en/59193560)	• Function • Operation
Interference-free installation of control systems	Function Manual: Interference-free installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Memory concept	Function manual: Structure and Use of the CPU Memory (http://support.automation.siemens.com/WW/view/en/59193101)	• Design • Principle of operation • Use
Cycle and response times	Function manual: Cycle and Response Times (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Calculations
Analog value processing	Function manual: Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559)	• Wiring options • Tables of measured values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7516-3AN00-0AB0

View of the module

The following figure shows the CPU 1516-3 PN/DP.

Figure 2-1 CPU 1516-3 PN/DP

Properties

The module has the following technical properties:

- Communication:
  - Interfaces

    CPU 1516-3 PN/DP has three interfaces. Two interfaces for PROFINET and one for PROFIBUS.

    The 1st PROFINET interface has two ports. The two ports have the same IP address and form the interface to the fieldbus level (switch functionality).

    The 2nd PROFINET interface has a port with its own IP address for integration into your company network.

    The 3rd interface is used to connect to a PROFIBUS network.
  - Integrated Web server

    The CPU status query is independent of a software installation. Graphically visualized process variables and user-defined websites facilitate information acquisition.
- Trace functionality
  - All CPUs of the S7-1500 automation system support trace functionality. Trace functionality is independent of the technology and supports you in debugging/optimizing the user program. It is particularly useful for Motion Control and control applications.
- Integrated technology:
  - Standard Motion Control

    PLC Open blocks for programming motion functionality by means of PROFINET IO IRT and PROFIdrive interface.

    The functionality supports speed-controlled axes, positioning axes and external encoders.
  - Integrated control functionality

    Universal PID controllers or 3-point controllers with integrated tuning.

    Integrated temperature controller
- Integrated system diagnostics:
  - System diagnostics is automatically generated and consistently displayed.

- Integrated security:
  - Know-how protection

    Algorithms can be securely protected against unauthorized access and modification.
  - Copy protection

    User program blocks are linked to the serial number of the SIMATIC memory card or of the module. User programs cannot run without the corresponding SIMATIC memory card or module.
  - Access protection

    Extended access protection provides comprehensive protection against unauthorized configuration changes. Authorization levels can be used to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU from unauthorized manipulation. Altered or external transmission of engineering data is reliably detected by the CPU.
- Other special features:
  - Color display
  - Short OB cycles (≤500 µs)

The module supports the following functions:

- Firmware update
- Integrated system diagnostics
- PROFINET IO RT
- PROFINET IO IRT
- PROFIenergy
- PROFIBUS
- Media redundancy
- I-device
- IO controller
- Web server
- Trace
- Isochronous mode
- Integrated controller
- Standard Motion Control

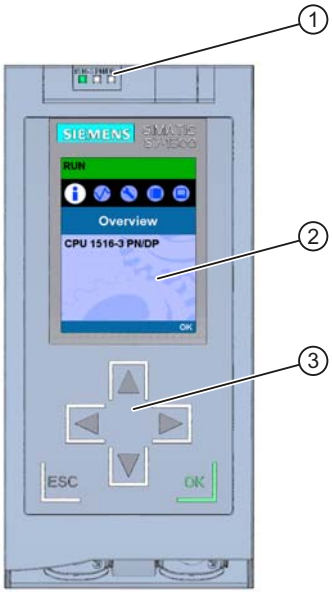
Reference

You can find additional information on "Integrated security/access protection" under "Protection" in the S7-1500 Automation System system manual (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Operating and display elements

2.2.1 Front view of the module with front cover

The following figure shows the front panel of CPU 1516-3 PN/DP with integrated display.



① LED displays for the current operating mode and diagnostic status of the CPU
② Display
③ Operator control buttons

Figure 2-2 View of the CPU 1516-3 PN/DP (with front panel) - front

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Note

Removing and fitting the front panel

The front panel can be removed and replaced during runtime without affecting operation.

Note

Temperature range for display

To increase the service life of the display, the display switches itself off before the permitted operating temperature is reached. When the display cools down again it automatically switches itself on again. The status of the CPU continues to be indicated by the LEDs when the display is switched off.

For more information on temperatures at which the display switches itself on and off, refer to the Technical Specifications (Page 31).

Reference

For more information about "Displays" refer to the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual, CPU display chapter. Removing and replacing the front cover is described in the section on handling the front cover.

Locking the front cover

You can lock the front cover to protect your CPU against unauthorized access.

You can attach a security seal or a padlock with a diameter of 3 mm to the front cover.

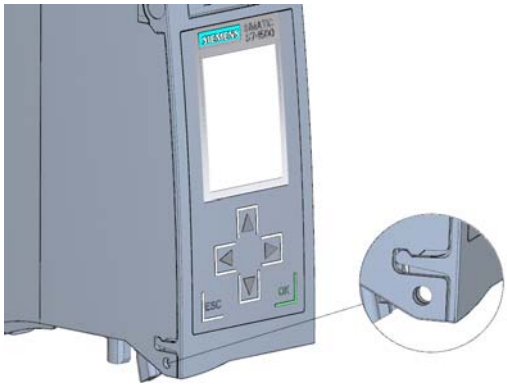
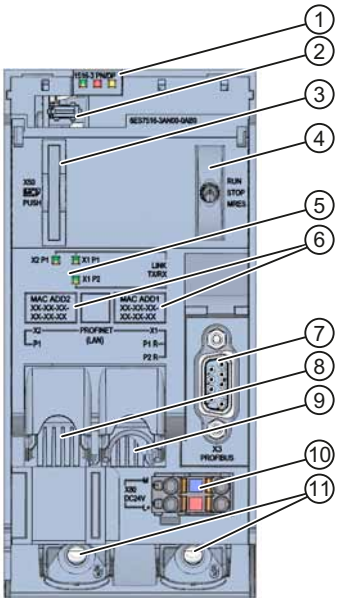


Figure 2-3 Locking latch on the CPU

2.2.2 Front view of the module without front cover

The following figure shows the operator control and connection elements of the CPU 1516-3 PN/DP behind the front cover.

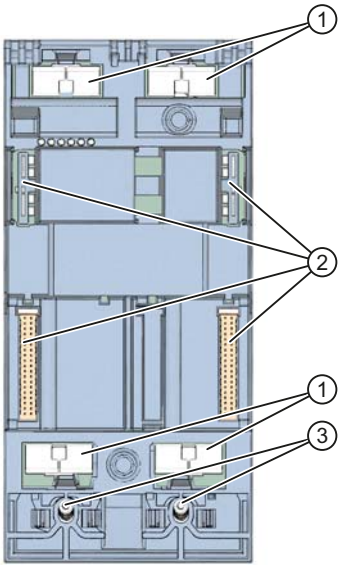


① LED displays for the current operating mode and diagnostics status of the CPU
② Display connection
③ Slot for the SIMATIC memory card
④ Mode selector switch
⑤ LEDs for the 3 ports of the PROFINET interfaces X1 and X2
⑥ MAC addresses of the interfaces
⑦ PROFIBUS interface (X3)
⑧ PROFINET interface (X2) with 1 port
⑨ PROFINET interface (X1) with 2-port switch
⑩ Connection for power supply
⑪ Fixing screws

Figure 2-4 View of the CPU 1516-3 PN/DP (without front cover) - front

2.2.3 Rear view of the module

The following figure shows the connection elements on the rear of the CPU 1516-3 PN/DP.



① Shield contact surfaces
② Backplane bus connector
③ Fixing screws

Figure 2-5 View of the CPU 1516-3 PN/DP - rear

2.3 Mode selector switch

Use the mode selector to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2- 1 Mode selector switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU is executing the user program.
STOP	STOP mode	The CPU is not executing the user program.
MRES	Memory reset	Position for CPU memory reset.

2.4 Functions

2.4.1 PROFINET IO

PROFINET is a fieldbus standard of the PROFIBUS user organization that defines a cross-vendor communication and engineering model.

Within the context of PROFINET, PROFINET IO is a communication concept for the implementation of modular, distributed applications. PROFINET IO IRT enables defined response times and high-precision system behavior.

The PROFINET IO controller operating mode enables direct access to IO devices via Industrial Ethernet.

The PROFINET IO device operating mode enables the operation of S7 stations as "intelligent" PROFINET IO devices on Industrial Ethernet.

UDP and RT or IRT are used to configure the cyclic IO data traffic for PROFINET IO communication.

PROFINET IO general properties

PROFINET IO provides the following properties and functions:

- Real-time communication
- Isochronous real-time communication
- Media redundancy
- Prioritized startup
- Device replacement without exchangeable medium
- I-device
- IO controller
- Isochronous mode

Note

The two PROFINET interfaces of the CPU 1516-3 PN/DP have separate IP addresses and must be configured on separate IP subnets.

Reference

You can find additional information on the "PROFINET IO" topic in the STEP 7 online help and in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) manual.

2.4.2 PROFIenergy

PROFIenergy

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during the production-free time.

Additional information

- System manual: PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
- Additional information on PROFIenergy is available on the Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order no: 3.802.

2.4.3 PROFIBUS DP

The PROFIBUS DP interface is used to connect distributed I/O. PROFIBUS DP allows you to create extensive subnets, for example.

PROFIBUS represents the network at the cell and field level in the open, multi-vendor SIMATIC NET communication system. PROFIBUS is physically implemented either as an electrical network based on shielded twisted-pair cables, or as an optical network based on fiber optic cable.

Data transmission via PROFIBUS-DP provides a standardized interface (EN 50170 Vol. 2) for the transfer of process input and process output data between SIMATIC S7 and field devices (DP slaves).

Cyclic data communication between a DP master and DP slaves is a characteristic of transmission via PROFIBUS-DP.

A DP system based on the PROFIBUS-DP standard (EN 50170 Vol. 2) consists of the following devices:

- DP master

  A device of this function class handles the actual control task.

  The device sends and receives process input and process output signals.

- DP slave

  This is a device in the field area, which reads or outputs the process signals. The devices can be modular or compact.

The PROFIBUS DP interface can be configured as a master and supports transmission rates up to 12 Mbps.

When master mode is set, the CPU sends its configured bus parameters to the PROFIBUS DP interface. This functionality automatically provides the correct parameters for online operation of a programming device, for example.

PROFIBUS DP properties

PROFBUS DP provides the following properties and functions:

- Time synchronization
- Line diagnostics
- Configuration limits
- S7 services
- Isochronous mode
- PROFIBUS DP master

Reference

You can find additional information on the "PROFIBUS DP" topic in the STEP 7 online help and in the PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579) function manual.

2.4.4 Memory reset

Apart from a few exceptions, a "memory reset" involves clearing all internal memories and then reading in the data on the SIMATIC memory card.

Options

You have the following options for resetting the memory of the CPU:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

To perform a memory reset of the CPU using the mode selector, follow these steps:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.

2. Set the operating mode switch to the MRES position. Hold the switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, switch the operating mode switch back to MRES position, and then back to STOP again.

Result: The CPU executes a memory reset, during which time the RUN/STOP LED flashes yellow. The RUN/STOP LED lights yellow when the CPU has completed the memory reset.

Procedure using the display

To navigate to the desired "Memory reset" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Memory reset

Result: The CPU executes memory reset.

Procedure using STEP 7

To perform a memory reset of the CPU using STEP 7, follow these steps:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU is set to STOP mode and the CPU memory reset is performed.

Memory object response to memory reset

The following table gives an overview of which memory objects are retained and which are initialized upon memory reset.

Table 2- 2 Retentive characteristics of the memory objects

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Retained
Diagnostics buffer entries (retentive area)	Retained
Diagnostics buffer entries (non-retentive area)	Initialized
Operating hours counter	Retained
Time	Retained

Reference

You can find additional information on the "Memory reset" topic in the Memory reset section of the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

2.4.5 Resetting the CPU to factory settings

The "Reset to factory settings" function restores the CPU to the "delivery state". This means that all data that was stored in internal CPU memory is deleted.

Recommendation:

Always reset a PROFINET CPU to the factory state if you want to store it or remove it for use at a different location with a different program. Make sure that the Reset to factory settings also deletes the IP address parameters.

Options

There are three options for resetting the CPU to the factory state:

- Using the mode selector switch
- Using the display
- Using STEP 7 V12

Procedure using the mode selector switch

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (RUN/STOP LED lights up yellow).

Perform a reset to factory settings when there is no SIMATIC memory card inserted, as follows:

1. Set the mode selector switch to STOP.

   Initial result: The RUN/STOP LED lights up yellow.
2. Set the mode selector switch to the MRES position. Hold the mode selector switch in this position until the RUN/STOP LED lights up in yellow for the 2nd time and remains lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, return the mode selector switch to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings"; the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Note

Make sure to set the CPU to factory state when you remove a PROFINET CPU and use it elsewhere or put it in storage. Make sure that the Reset to factory settings also deletes the IP address parameters.

Procedure using the display

Make sure that the CPU is in STOP mode (RUN/STOP LED lights up yellow). If a SIMATIC memory card is plugged in, make sure to remove this.

You can reach the "Factory settings" menu command by successively selecting the following menu commands and confirming each step with "OK".

- Settings → Reset → Factory settings

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. The yellow state of the RUN/STOP LED indicates that the CPU is reset to factory settings and in STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Procedure using STEP 7

Make sure there is an online connection to the CPU that is to be reset to the factory settings.

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button to retain the IP address, or the "Reset IP address" option button to delete the IP address.
4. Click "Reset".
5. Click "OK" to confirm the security prompt.

Result: The CPU is set to STOP mode and is reset to factory settings.

Retentive characteristics of the memory objects

The properties of the CPU are set to the following values:

Table 2- 3 Properties of the CPU objects in the delivery state

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Initialized
Diagnostics buffer entries (retentive area)	Initialized
Diagnostics buffer entries (non-retentive area)	Initialized
Operating hours counter	Initialized
Time	Initialized

Reference

For more information about "Reset to factory settings", refer to the Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) Function Manual, in the Memory areas and retentivity chapter, as well as to the STEP 7 Online Help.

Connecting

3

This section provides information on the terminal assignment of the individual interfaces and the block diagram of the CPU 1516-3 PN/DP.

24 V DC power supply (X80)

The connector for the power supply is plugged in the factory state of the CPU.

The following table shows the terminal assignment for a 24 V DC power supply.

Table 3- 1 Terminal assignment 24 V DC power supply

View	Signal name*	Designation
	1L+	24 V DC
	2L+	24 V DC **
	1M	Ground
	2M	Ground **
* 1L+ and 2L+ and 1M and 2M are jumpered internally.		
** Make sure that the current is limited to 10 A.		

Note

PROFIBUS interface

The CPU 1516-3 PN/DP provides no 24 V DC power supply on the PROFIBUS interface. I/O devices (for example, PC adapter 6ES7972-0CB20-0XA0) are therefore not operational on the interface).

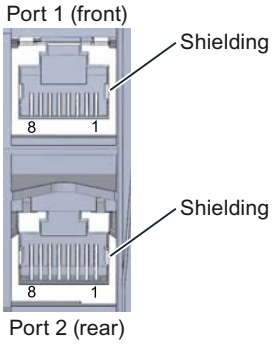
If the CPU is supplied by a system power supply, the 24 V supply connection is not required.

The 2L+ and 2M connections can be used to loop-through the 24 V supply.

PROFINET interface (X1) with 2-port switch (X1 P1 and X1 P2)

The following table shows the terminal assignment for the PROFINET interface with 2-port switch. The assignment corresponds to the Ethernet standard for an RJ45 plug.

Table 3- 2 Terminal assignment of PROFINET interface with 2-port switch

View	Signal name		Designation
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

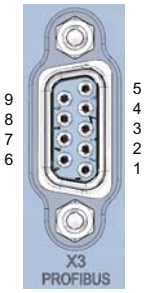
PROFINET interface (X2) with 1 port (X2 P1)

With the PROFINET interface X2, the pin assignments 1 to 8 are identical to the pin assignments for the PROFINET interface X1.

PROFIBUS interface X3

The table below shows the terminal assignment of the PROFIBUS interface. The assignment corresponds to the standard assignment of RS485 interface.

Table 3- 3 Terminal assignment PROFIBUS interface

View	Signal name		Designation
	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	Data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

Reference

You can find additional information on the topics of "Connecting the CPU" and "Accessories (RJ45 plug)" in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Assignment of MAC addresses

The CPU 1516-3 PN/DP has two PROFINET interfaces, with the first having two ports. The PROFINET interfaces each have a MAC address, and each of the PROFINET ports has its own MAC address. There are therefore five MAC addresses in total for the CPU 1516-3 PN/DP.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the proximity detection function.

The number series of the MAC addresses is sequential. The first and last MAC address is lasered on the right of each CPU 1516-3 PN/DP.

The table below sets out the MAC address assignment.

Table 3- 4 Assignment of MAC addresses

	Assignment	Labeling
MAC address 1	PROFINET interface X1 (visible in STEP 7 for accessible devices)	• Front, lasered • right side, lasered (start of number series)
MAC address 2	X1 P1 port (needed for LLDP, for example)	• Front and right side, not lasered
MAC address 3	X1 P2 port (needed for LLDP, for example)	• Front and right side, not lasered
MAC address 4	PROFINET interface X2 (visible in STEP 7 for accessible devices)	• Front, lasered • Right side, not lasered
MAC address 5	X2 P1 port (needed for LLDP, for example)	• Front, not lasered • Right side, lasered (end of number series)

Block diagram

The following figure shows the block diagram of CPU 1516-3 PN/DP.

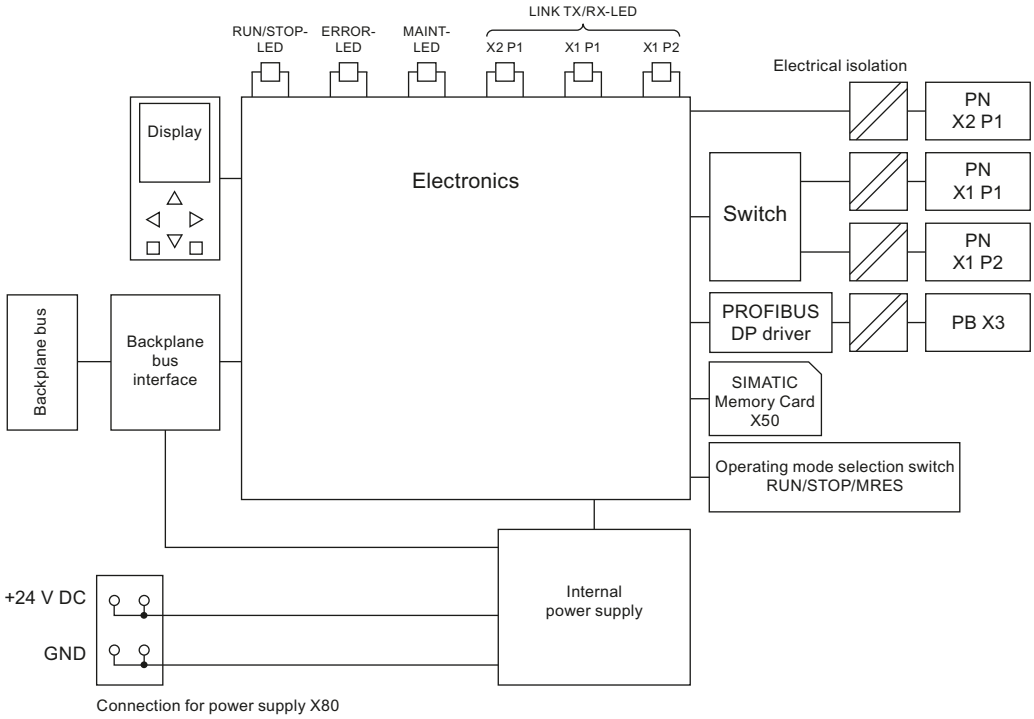


Figure 3-1 Block diagram CPU 1516-3 PN/DP

Interrupts, error messages, diagnostics and system alarms

4

The status and error displays of the CPU 1516-3 PN/DP are described below.

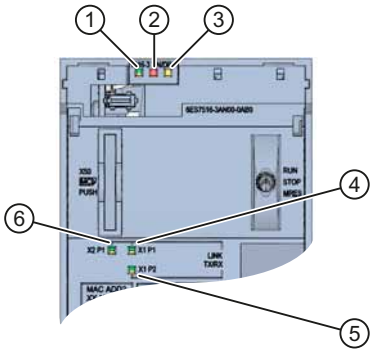
You can find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on "Diagnostics" and "System alarms" in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

4.1 Status and error display of the CPU

LED display

The figure below shows the CPU 1516-3 PN/DP LEDs.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX-LED for X1 P1 port (yellow/green LED)
⑤ LINK RX/TX-LED for X1 P2 port (yellow/green LED)
⑥ LINK RX/TX-LED for X2 P1 port (yellow/green LED)

Figure 4-1 CPU 1516-3 PN/DP LED (without front cover)

Meaning of the LED displays

CPU 1516-3 PN/DP has three LEDs to signal the current operating status and diagnostics status. The following table shows the meaning of the various combinations of colors for the RUN/STOP, ERROR and MAINT LEDs.

Table 4- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	Missing or insufficient power supply on the CPU.
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	CPU is in RUN mode.
LED green	LED flashes red	LED off	A diagnostics event is pending.
LED green	LED off	LED yellow	Maintenance demanded for the plant. The affected hardware must be replaced within a short period of time.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be replaced within a reasonable time period.
			Firmware update successfully completed.
LED yellow	LED off	LED off	CPU is in STOP mode.
LED yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

Meaning of the LEDs of the interfaces: X1 P1, X1 P2 and X2 P1

Each port has a LINK RX/TX-LED. The table below shows the various "LED scenarios" of ports for the CPU 1516-3 PN/DP.

Table 4- 2 Meaning of the LED

LINK TX/RX-LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is being performed.
LED green	There is no Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.
LED flickers yellow	Data is currently being received from a communication partner on Ethernet via the PROFINET interface of the PROFINET device.

Technical specifications

5

	6ES7516-3AN00-0AB0
Product type designation	CPU 1516-3 PN/DP
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0
Display	
• Screen diagonal (cm)	6.1 cm
Control and display elements	
• Number of buttons	6
• Mode selector switch	1
Installation type/mounting	
• Rail mounting possible	Yes
• Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
• Low limit of permitted range (DC)	19.2 V
• High limit of permitted range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption (rated value)	0.85 A
• Inrush current, max.	2.4 A; rated value
• I^2t	0.39 A^2s
Power	
• Power consumption from the backplane bus (balanced)	6.7 W
• Incoming power to the backplane bus	12 W
Power loss	
• Power loss, typ.	7 W

	6ES7516-3AN00-0AB0
Memory	
Work memory	
• Integrated (for program)	1 MB
• Integrated (for data)	5 MB
Load memory	
• Plug-in (SIMATIC memory card), max.	2 GB
Buffering	
• Maintenance-free	Yes
CPU processing time	
• For bit operations, typ.	10 ns
• For word operations, typ.	12 ns
• For fixed-point arithmetic, typ.	16 ns
• For floating-point arithmetic, typ.	64 ns
CPU blocks	
• Number of blocks (total)	6000
DB	
• Number, max.	6000; number range: 1 to 65535
• Size, max.	5 MB
FB	
• Number, max.	5998; number range: 1 to 65535
• Size, max.	512 KB
FC	
• Number, max.	5999; number range: 1 to 65535
• Size, max.	512 KB
OB	
• Size, max.	512 KB
• Number of free-cycle OBs	100
• Number of time-of-day interrupt OBs	20
• Number of time-delay interrupt OBs	20
• Number of cyclic interrupt OBs	20
• Number of hardware interrupt OBs	50
• Number of DPV1 interrupt OBs	3
• Number of isochronous mode OBs	2
• Number of technology synchronization interrupt OBs	2
• Number of restart OBs	100

	6ES7516-3AN00-0AB0
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic interrupt OBs	1
Nesting depth	
• Per priority class	24
Timers/counters and their retentivity	
S7 counters	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC counters	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
S7 timers	
• Quantity	2048
Retentivity	
• Adjustable	Yes
IEC timers	
• Quantity	Unlimited (limited only by work memory)
Retentivity	
• Adjustable	Yes
Data areas and their retentivity	
• Total retentive data area (including timers, counters, bit memories), max.	512 KB; for bit memories, timers, counters, DBs and technological data (axes), usable retentive memory: 472 KB
Bit memory	
• Number, max.	16 KB
• Number of clock memories	8; 8 clock memory bits, summarized in one clock memory byte
Local data	
• Per priority class, max.	64 KB max. 16 KB per block
Address area	
• Number of I/O modules	8192
I/O address area	
• Inputs	32 KB; all inputs are in the process image
• Outputs	32 KB; all outputs are in the process image

	6ES7516-3AN00-0AB0
Of which per IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Of which per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
• Number of process image partitions, max.	32
Address space per module	
• Number of I/O submodules	10
Hardware configuration	
• Modules per rack, max.	32; CPU + 31 modules
• Rack, number of rows, max.	1
Number of DP masters	
• Integrated	1
• Via CM	8; a maximum of 8 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted in total
Number of IO controllers	
• Integrated	1
PtP CM	
• Number of PtP CMs	The number of PtP CMs you can connect is only limited by the available slots
Time	
Clock	
Type	Hardware clock
• Deviation per day, max.	10 s; typ.: 2 s
• Buffered period	6 wk; at 40 °C ambient temperature, typ.
Time synchronization	
• Supported	Yes
• On DP, master	Yes
• in AS, Master	Yes
• in AS, Slave	Yes
• On Ethernet via NTP	Yes
Interfaces	
• Number of PROFINET interfaces	2
• Number of interfaces PROFIBUS	1

	6ES7516-3AN00-0AB0
1. Interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ 45 (Ethernet)	Yes
Protocols	
• PROFINET IO controller	Yes
• PROFINET IO device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes
• Web server	Yes
• Media redundancy	Yes
2. Interface	
Interface hardware	
• Number of ports	1
• Integrated switch	No
• RJ 45 (Ethernet)	Yes
Protocols	
• PROFINET IO controller	No
• PROFINET IO device	No
• SIMATIC communication	Yes
• Open IE communication	Yes
• Web server	Yes
3. Interface	
Interface hardware	
• Number of ports	1
• RS 485	Yes
Protocols	
• SIMATIC communication	Yes
• PROFIBUS DP master	Yes
• PROFIBUS DP slave	No

	6ES7516-3AN00-0AB0
Interface hardware	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
RS 485	
• Transmission rate, max.	12 Mbps
Number of connections	
• Number of connections, max.	256
• Number of connections reserved for ES/HMI/Web	10
• Number of connections via integrated interfaces	128
Protocols	
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PN devices
• Number of connectable IO devices, max.	256; a maximum of 768 distributed I/O devices can be connected by means of CPs/CMs via PROFIBUS or PROFINET.
• Number of IO devices that you can connect for RT, max.	256
• Of which are in line, max.	256
• Number of IO devices with IRT and the "high performance" option, max.	64
• Number of IO devices that can be activated/deactivated simultaneously, max.	8
• Number of IO devices per tool, max.	8

	6ES7516-3AN00-0AB0
Update times	The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data.
with RT	
• for send cycle of 250 µs	250 µs to 128 ms
• for send cycle of 500 µs	500 µs to 256 ms
• for send cycle of 1 ms	1 ms to 512 ms
• for send cycle of 2 ms	2 ms to 512 ms
• for send cycle of 4 ms	4 ms to 512 ms
with IRT and "high performance" option	
• for send cycle of 250 µs	250 µs to 4 ms
• for send cycle of 500 µs	500 µs to 8 ms
• for send cycle of 1 ms	1 ms to 16 ms
• for send cycle of 2 ms	2 ms to 32 ms
• for send cycle of 4 ms	4 ms to 64 ms
For IRT with the "high performance" option and parameter assignment for so-called "odd-numbered" send cycles	Update time = set "odd-numbered" send cycle (any multiple of 125 µs: 375 µs, 625 µs to 3.875 µs)
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT, supported	Yes
• MRP, supported	Yes
• PROFIenergy	Yes
SIMATIC communication	
• S7 communication as server	Yes
• S7 communication as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
• Data length, max.	64 KB
• ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB

	6ES7516-3AN00-0AB0
• UDP	Yes
• Data length, max.	1472 bytes
• DHCP	No
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
Web server	
• HTTP	Yes; standard and user-defined pages
• HTTPS	Yes; standard and user-defined pages
PROFIBUS	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Constant bus cycle time	Yes
• Number of DP slaves	125; a maximum of 768 distributed I/O devices can be connected by means of CPs/CMs via PROFIBUS or PROFINET.
• Activation/deactivation of DP slaves	Yes
Media redundancy	
• Changeover time on line interruption, typ.	200 ms
• Number of ring nodes, max.	50
Slots	
• SIMATIC Memory Card required	Yes
Isochronous mode	
• Isochronous mode (application synchronized up to terminal)	Yes
• Constant bus cycle time	Yes
S7 signaling functions	
• Number of stations that can be logged in for message functions, max.	32
• Block-related alarms	Yes
• Number of configurable interrupts, max.	10000
• Number of simultaneously active interrupts	1000

	6ES7516-3AN00-0AB0
Test/commissioning functions	
Status/modify	
• Status/modify tag	Yes
Tags	Inputs, outputs, memory bits, DBs, timers, counters
• Of which are status tags, max.	200; per job
• Of which are modify tags, max.	200; per job
Force	
Forcing, tags	Inputs, outputs
• Number of tags, max.	200
• Status block	Yes; up to 8 at the same time
• Single-step	No
Diagnostic buffer	
• Available	Yes
• No. of entries, max.	3200
• Of which are power failure-proof	500
Interrupts/diagnostics/status information	
Diagnostic indicator LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
• Motion	Yes
• Speed-controlled axis	
• Number of speed-controlled axes, max.	20; a total of up to 20 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Positioning axis	
• Number of positioning axes, max.	20; a total of up to 20 axes (speed-controlled axis, positioning axis, external encoders) are supported
• External encoder	
• Number of external encoders, max.	20; a total of up to 20 axes (speed-controlled axis, positioning axis, external encoders) are supported
• Controller	
• PID_Compact	Yes; universal PID controller with integrated optimization

	6ES7516-3AN00-0AB0
• PID_3Step	Yes; PID controller with integrated optimization for valves
• Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C; display: 50 °C, the display is switched off at an operating temperature of typically 50 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C; display: 40 °C, the display is switched off at an operating temperature of typically 40 °C
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
Know-how protection	
• User program protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• Password for display	Yes
• Protection level: Read-only	Yes
• Protection level: Read/write protection	Yes
• Protection level: Complete protection	Yes
Cycle-time monitoring	
• Low limit	Adjustable minimum cycle time
• High limit	Adjustable maximum cycle time
Dimensions	
• Width	70 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	845 g

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in this section. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimensional drawings for CPU 1516-3 PN/DP

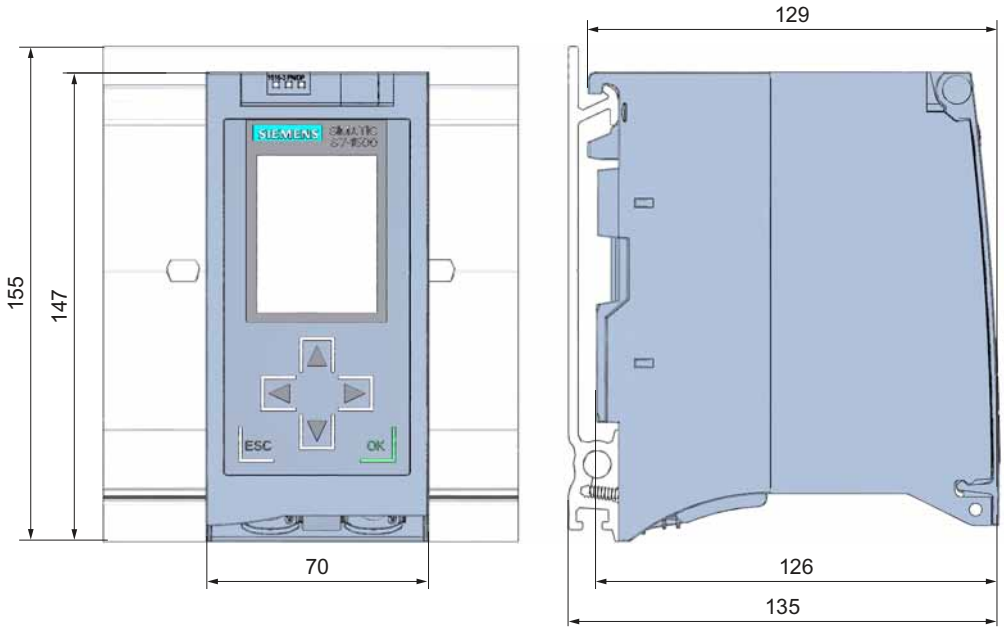


Figure A-1 Dimensional drawing of CPU 1516-3 PN/DP, front and side views

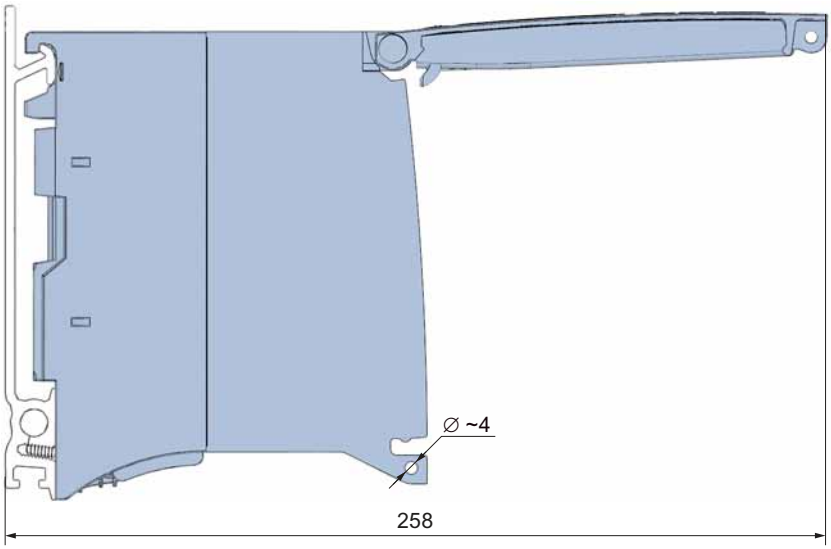


Figure A-2 Dimensional drawing CPU 1516-3 PN/DP, side view with open front cover

SIEMENS

SIMATIC

S7-1500/ET 200MP Power supply module PS 25W 24VDC (6ES7505-0KA00-0AB0)

Manual

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01/2013

A5E31825931-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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Preface

Preface

Purpose of this documentation

This manual supplements the system manuals:

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)

Functions that concern the systems in general are described in these manuals.

The information in this manual along with the system manuals/function manuals will enable you to commission the systems.

Conventions

The term "CPU" as used in this manual refers to both the central modules of the S7-1500 automation system and to the interface modules of the ET 200MP distributed I/O system.

Please observe notes labeled as follows:

Note

A note contains important information about the product described in the documentation and its use, or about a specific section of the documentation to which you should pay particular attention.

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You can register for a product-specific newsletter here.

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Documentation guide

1

Introduction

The modular documentation of the S7-1500 and ET 200MP system families covers all aspects of your automation system.

The documentation consists of different modules that are divided into system manuals, function manuals and manuals.

The following table provides an overview of the documents that complement this manual. Information in the manual overrides specifications in the system manual.

Overview of the documentation for the power supply module PS 25W 24VDC

The table below lists additional documentation for using the PS 25W 24VDC benötigen. power supply module.

Table 1- 1 Documentation for the power supply module PS 25W 24VDC

Topic	Documentation	Most important contents
System description	System manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning • Standards and approvals • Electromagnetic compatibility • Mechanical and climatic ambient conditions
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostics evaluation

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7505-5KA00-0AB0

View of the module

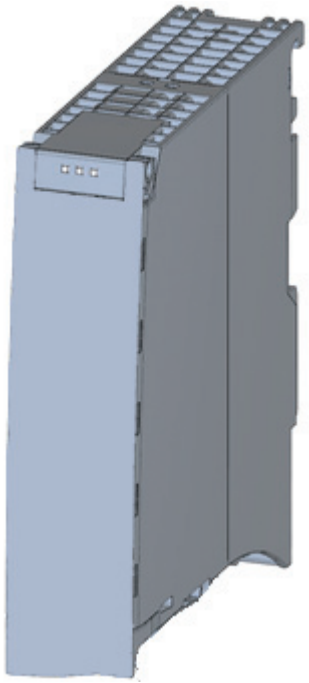


Figure 2-1 View of the PS 25W 24VDC module

Properties

The PS 25W 24VDC power supply module permits the use of additional modules.

The power supply module has the following properties:

- Technical properties
  - Rated input voltage 24 V DC (SELV)
  - Output power 25 W
  - Mains buffering
  - Functional electrical isolation from the bus
- Supported functions
  - Firmware update
  - Identification data I&M0 to I&M4
  - Configuring in RUN
  - Diagnostic alarms
  - Diagnostic interrupts

Accessories

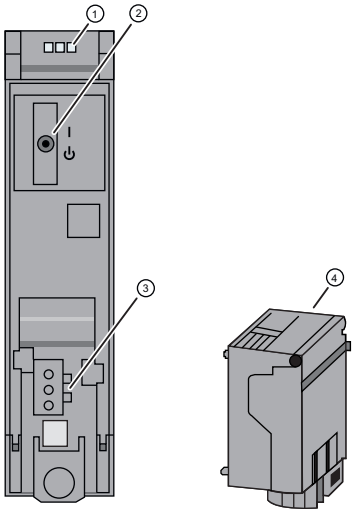
The following components are supplied with the power supply module:

- Power connector
- U connector

These components are also available as spare parts.

2.2 Control and display elements

The following figure shows the control and connection elements of the PS 25W 24VDC behind the front cover as well as the power connector.



① LED displays indicating the current operating state and diagnostic status of the PS
② On/off switch
③ Connection for the power supply by means of the power connector
④ Power connector, inserted in delivery state

Figure 2-2 View of the PS 25W 24VDC (without front cover) and of the power connector

Wiring 3

3.1 Wiring the power supply module

Mains connection

⚠ WARNING

Installation instructions

Risk of death or serious injury.

Observe the general installation instructions applicable in your country when wiring the power supply module.

Fuse the power cables according to their conductor cross-section.

The following applies to mains connection of the power supply module using the power connector:

- The power connector provides connection of the input voltage to the power supply module with touch protection.
- The power connector provides permanent wiring.
- The power connector features an internal strain relief.
- The power connector ensures reverse polarity protection.
- A coding element is used on the power connector to assign it to a specific type of power supply module. A connector coded for 230V AC cannot be inserted into a 24 V DC power supply module.

⚠ DANGER

Do not manipulate or omit the coding element

Changes to the coding element can result in dangerous states in your plant and/or damage to the outputs of the
I/O modules. In order to avoid damage, do not manipulate the coding. The coding element may not be omitted.

Cables

You need flexible cables to wire power to the power supply module. The conductor cross-section must be 1.5 mm^2 (AWG: 16). The diameter of a 3 x 1.5 mm^2 sheathed cable can be no more than 8.5 mm. The ground conductor of flexible cables must be longer than the two other conductors. The fusing must meet the requirements of the corresponding control cabinet.

DANGER

Input voltage

Risk of death or serious injury.

The input voltage of the PS 25W 24VDC must be supplied as safety extra low voltage (SELV).

Reference

Information on installation of the power supply module and wiring of the power connector is available in the system manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

Siemens recommends the use of devices from the SITOP family of products for applications with load power supplies. Wiring information is available in the documentation for the load power supply.

Parameters 4

4.1 Parameters

Parameters of the PS 25W 24VDC

For parameter assignment of the module with STEP 7, you specify the properties of the module using various parameters. The table below shows the configurable parameters.

When the parameters are assigned in the user program, they are transferred to the module with the WRREC instruction (configuring in RUN), see section Parameter data record (Page 27).

Table 4- 1 Configurable parameters and their defaults

Parameters	Value range	Default	Configuring in RUN
Diagnostic/maintenance			
• Supply voltage missing	Yes/No	No	Yes
• Switch position Off	Yes/No	No	Yes

Note

Diagnostic alarms without supply voltage

Even when there is no supply voltage or when the On/Off switch is set to "Off", the power supply module of the CPU or the IM is supplied with enough voltage by the backplane bus that it can generate a diagnostic alarm. The entire diagnostic functionality is still available.

Interrupts, diagnostic alarms, error and status messages

5

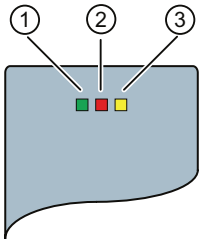
5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is a basic tool for troubleshooting. Usually, you can pinpoint the source of error more precisely by analyzing the module status information in STEP 7, or in the diagnostic buffer of the CPU. These locations contain the corresponding error information in plain text.

LED displays

The following figure shows the LED displays (status and error displays) of the PS 25W 24VDC.



① RUN-LED
② ERROR-LED
③ MAINT-LED

Figure 5-1 LED displays of the PS 25W 24VDC

Meaning of the LED displays

The following table explains the meaning of the status and error displays. You can find remedial measures for diagnostic alarms in the section Diagnostic alarms (Page 19).

Table 5- 1 Status and error displays RUN/ERROR/MAINT

LED			Meaning	Remedy
RUN	ERROR	MAINT		
Off	Off	Off	OFF, PS supplies no bus voltage • External error and diagnostics is not enabled • PS not supplied in the system, no supply voltage connected to the PS and no supply voltage connected to CPU/IM.	Supply PS with voltage Check supply voltage Switch on PS
On	On	On	Startup, all LED displays illuminate briefly after system startup or module startup after firmware update.	-
Flashing	Not relevant	Not relevant	Startup, PS supplies bus voltage, PS waiting for parameter assignment	-
Off	Flashing	Not relevant	Error, PS supplies no bus voltage • No supply voltage and diagnostics not enabled • Internal error	Evaluate diagnostic alarms and carry out appropriate remedial measures, see section Diagnostic alarms (Page 19)
Off	Not relevant	On	Maintenance demanded, PS supplies no bus voltage • Switch is off; supply is present and diagnostics is enabled	Switch on PS
Flashing	Flashing	Flashing	Malfunction LED displays flash permanently	Replace PS

5.2 Diagnostic alarms

Diagnostic alarms

The following table shows the meaning of the diagnostic alarms and possible remedial measures for the respective cause.

One of the following "LED images" indicates directly on the PS that a diagnostic alarm was triggered.

- The red ERROR-LED is flashing.

  Indicates external or internal errors.
- The yellow MAINT-LED is lit.

  Maintenance; a maintenance request is active.
- All three LEDs are flashing permanently

  The PS is in "Defective" state.

In STEP 7, the diagnostic results are displayed in plain text by means of the online and diagnostic view. You can read the diagnostic data records by means of the "RDREC" instruction.

Table 5- 2 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
External error					
Supply voltage missing	266_D	$010A_H$	No supply voltage, or incorrect insertion of the power connector into the PS.	1	Check the supply voltage.
Internal error					
Overtemperature	5_D	0005_H	Overtemperature on the printed circuit board.	3	Check PS load. Isolate PS from mains. Wait one minute before you power on the PS again.
Overvoltage backplane bus	267_D	$010B_H$	High EMC interference or a defective PS, CPU or IM inserted.	3	Eliminate electromagnetic interference. Check inserted modules and bus connectors. Isolate PS from mains. Wait one minute before you power on the PS again.
Low voltage/overload in the power segment	281_D	0119_H	A voltage dip below the valid limit has been detected in the power segment to the right of the PS.	2	Check the modules in the affected segment; replace if necessary. Switch off the PS at the switch, then switch on again.
Error in the power segment	282_D	$011A_H$	PS or module to the right of the PS is defective.	2	Replace the defective module. Switch off the PS at the switch, then switch on again.

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
Safety shutdown	285_D	$011D_H$	Reliable operation of the module is no longer guaranteed.	3	Check ambient conditions. Isolate PS from mains. Wait one minute before you power on the PS again.
Maintenance					
Switch turned off	268_D	$010C_H$	The PS is switched off.	1	Switch on PS.
Malfunction					
Module failure	256_D	0100_H	PS failure.	3	Replace PS.

External errors, internal errors and malfunctions

- External errors occur outside the PS. In the parameterization, specify whether or not an external error can trigger a diagnostic alarm. By default, external errors do not trigger diagnostic alarms.
- Internal errors occur inside the PS. If still possible, an internal error always triggers a diagnostic alarm.
- A malfunction is a static state; the PS must be sent in for repair. If still possible, a defect always triggers a diagnostic alarm.

Explanation of the reactions

1. No power at the power segment to the right of the PS. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus.
2. The modules to the right of the PS are switched off.
3. The PS is switched off retentively. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus. You cannot switch on the module unless you have eliminated the error and disconnected power to the PS for approximately one minute.

5.3 Interrupts

What is a diagnostic interrupt?

You can determine reactions to internal or external errors in the user program, by programming a diagnostic interrupt which interrupts cyclic program execution on the CPU and triggers the diagnostic interrupt OB (OB82). The event which led to the interrupt is entered in the start information of the OB82.

Trigger of a diagnostic interrupt

Events that can trigger a diagnostic alarm can also trigger a diagnostic interrupt:

- Supply voltage missing
- Overtemperature
- Overvoltage on the backplane bus
- Low voltage/overload in the power segment
- Error in the power segment
- Safety shutdown
- Switch position Off
- Malfunction

Reactions to a diagnostic interrupt

You can find the CPU reaction to a diagnostic interrupt in the function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926).

Detailed information on the error event is available in the diagnostic interrupt OB by executing the "RALRM" instruction (read additional interrupt information) and in the STEP 7 Online Help.

Technical specifications

6

Technical specifications of the PS 25W 24VDC

	6ES7505-0KA00-0AB0
Product type designation	PS 25W 24VDC
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP3 or higher
FH technology	
Redundancy	
• Capable of redundancy	Yes
• For increasing performance	Yes
Supply voltage	
• Rated value (DC)	24 V; SELV
• Valid range low limit (DC)	static 19.2 V, dynamic 18.5 V
• Valid range high limit (DC)	static 28.8 V, dynamic 30.2 V
• Reverse polarity protection	Yes
• Short-circuit protection	Yes
Power failure backup	
• Power failure backup time	20 ms
Input current	
• Rated value at 24 V DC	1.3 A
Output current	
• Short-circuit protection	Yes
Power	
• Power feed to the backplane bus	25 W
Power loss	
• Power loss at rated conditions	6.2 W
Interrupts/diagnostics/status information	
• Status display	Yes

	6ES7505-0KA00-0AB0
Electrical isolation	
• Primary/secondary	Yes; electrical isolation for max. 60 V AC/75 V DC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
EMC	
Immunity to surge voltages	
• on the supply lines in accordance with IEC 61000-4-5	Yes; +/- 1 kV (according to IEC 61000-4-5; 1995; symm. surge), +/- 2 kV (according to IEC 61000-4-5; 1995; unsymm. surge), no external protective circuit required
Degree of protection and protection class	
Degree of protection to EN 60529	IP20
• Protection class	3; with ground conductor
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	350 g

Dimensional drawing

A

A.1 Dimensional drawing

Dimensional drawing of the PS 25W 24VDC

This appendix includes the dimensional drawing of the power supply module mounted on a mounting rail and with shielding clamp. You must take into consideration the dimensions when mounting in cabinets, in switch rooms, etc.

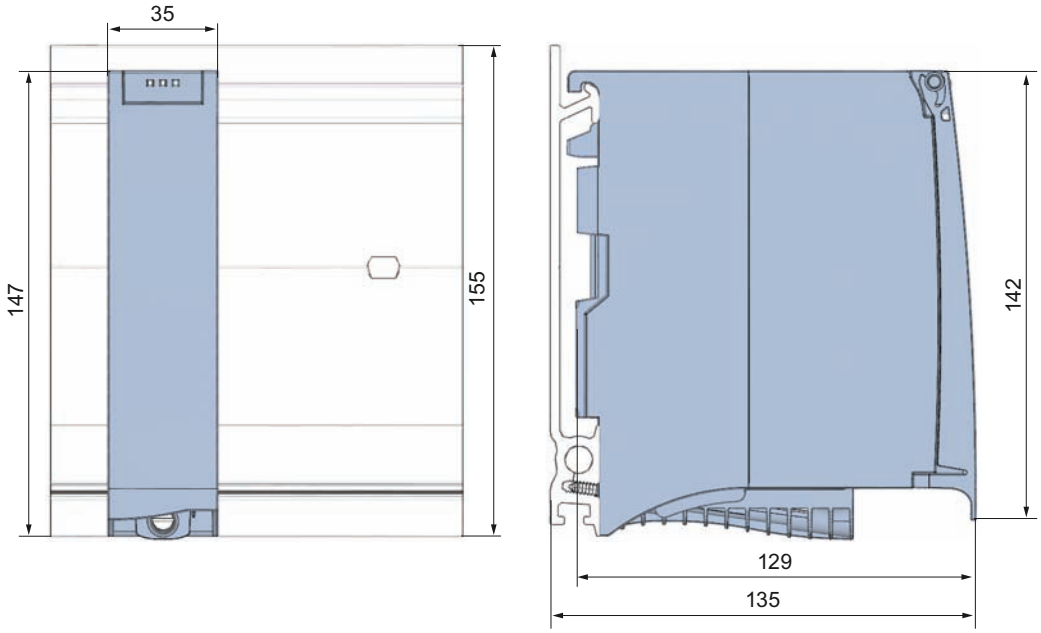


Figure A-1 Dimensional drawing of the PS 25W 24VDC module

This drawing shows the dimensions of the module with open front cover.

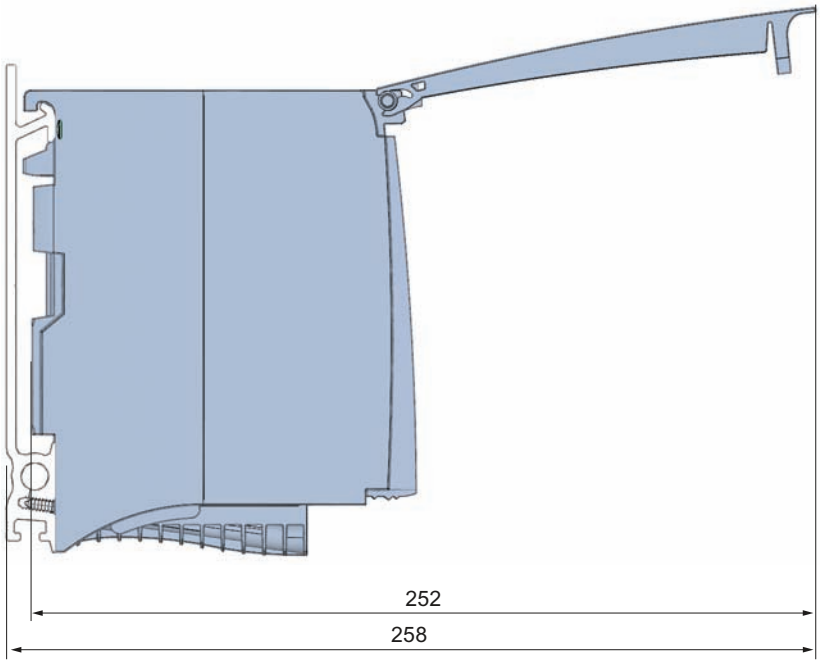


Figure A-2 Dimensional drawing of the PS 25W 24VDC module from side with open front cover

Parameter data record

B

Parameter assignment in the user program

You have the option to re-parameterize the power supply module in RUN mode of CPU.

Changing parameters in RUN mode

The parameters for the power supply module are contained in data record 0. You can use the WRREC instruction to transfer the configurable parameters to the power supply module. The parameters assigned in STEP 7 are not changed permanently in the CPU, which means the parameters assigned in STEP 7 are valid again after a restart.

Output parameter RET_VAL

The power supply module ignores errors that occur during transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the RET_VAL output parameter. If no error occurs, the length of the data actually transferred is entered in RET_VAL.

RET_VAL is 4 bytes long and structured as follows:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error detection
- Byte3: Error_Code_1, error detection
- Byte4: Error_Code_2, manufacturer-specific expansion of the error detection

The description of the WRREC instruction and the general error codes are available in the STEP 7 online help.

Module-specific errors are displayed by means of Error_Code_1 = 224_D or Error_Code_1 = 225_D.

Manufacturer-specific expansions of the error detection of the WRREC instruction have the following meaning:

Table B- 1 Manufacturer-specific expansions of the error detection of the WRREC instruction

Error_Code 1	Error_Code 2	Meaning
224_D Error in the data record header	1_D	The version entered in the data record header is not supported by the module or reserved bits of the version are set.
	2_D	The net length entered in the data record header is incorrect.
225_D Error in the net data (parameters) entered in the data record	1_D	Diagnostic interrupt enable is incorrect
	16_D	Reserved parameters are not 0

Data record structure

The following figure shows the structure of the data record 0.

- A fixed bit pattern is entered in byte 0. It indicates the version of the data record structure. Each time a data record is written, the module checks the written data and accepts only data records with major version 1.
- Byte 1 specifies the maximum data length that can be used for parameter data.
- Byte 2 contains the parameter data.
- Bytes 3 to 11 are reserved.

To enable a parameter in byte 2, set the corresponding bit to "1". The corresponding diagnostics is then activated, for example, for supply voltage monitoring. If you set the corresponding bit to "0", the diagnostics is deactivated.

You are not permitted to change byte 0, byte 1 or bytes 3 to 11.

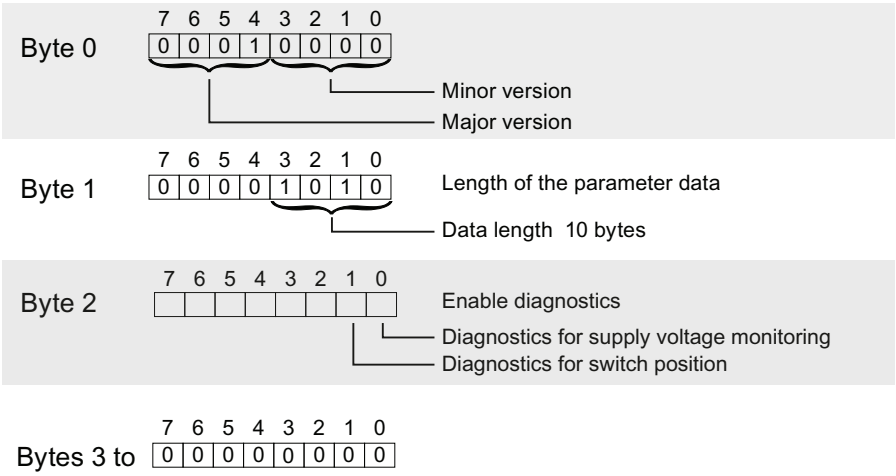


Figure B-1 Structure of data record 0

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S7-1500/ET 200MP Power supply module PS 60W 24/48/60VDC (6ES7505-0RA00-0AB0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Industry Sector
Postfach 48 48
90026 NÜRNBERG
GERMANY

A5E31826009-AA
Ⓟ 01/2013 Technical data subject to change

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Preface

Preface

Purpose of the documentation

This manual complements the system manuals:

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)

Functions that generally concern the systems are described in these manuals.

The information provided in this manual and in the system/function manuals support you in commissioning the systems.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system and for interface modules of the ET 200MP distributed I/O system.

Also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

Introduction

The modular documentation of the S7-1500 and ET 200MP system families covers all aspects of your automation system.

The documentation consists of different modules that are divided into system manuals, function manuals and manuals.

The following table provides an overview of the documents that complement this manual. Information in the manual overrides specifications in the system manual.

Overview of the documentation for the power supply module PS 60W 24/48/60VDC

The table below lists additional documentation for using the PS 60W 24/48/60VDC benötigen. power supply module.

Table 1- 1 Documentation for the power supply module PS 60W 24/48/60VDC

Topic	Documentation	Most important contents
System description	System manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning • Standards and approvals • Electromagnetic compatibility • Mechanical and climatic ambient conditions
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostics evaluation

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7505-0RA00-0AB0

View of the module

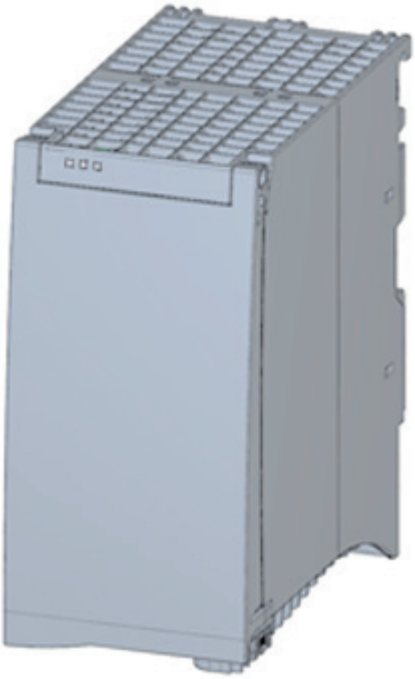


Figure 2-1 View of the PS 60W 24/48/60VDC module

Properties

The PS 60W 24/48/60VDC power supply module supports the use of additional modules.

The power supply module has the following properties:

- Technical properties
  - Rated input voltages 24/48/60 VDC
  - Output power 60 W
  - Power failure backup
  - Electrical isolation to the bus, safe electrical separation to EN 61131-2
- Supported functions
  - Firmware update
  - Identification data I&M0 to I&M4
  - Configuration in RUN
  - Diagnostic alarms
  - Diagnostic interrupts

Accessories

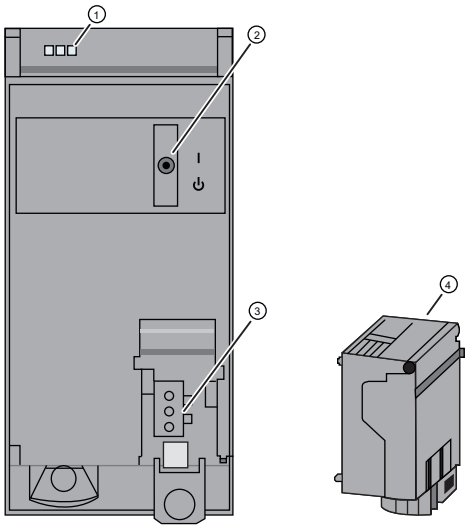
The following components are supplied with the power supply module:

- Power connector
- U connector

These components are also available as spare parts.

2.2 Operating and display elements

The following figure shows the control and connection elements of the PS 60W 24/48/60VDC behind the front panel as well as the power connector.



① LED displays indicating the current operating state and diagnostic status of the PS
② On/off switch
③ Power inlet for the power connector
④ Power connector; inserted in delivery state

Figure 2-2 View of the PS 60W 24/48/60VDC (without front panel) and of the power connector

Wiring 3

3.1 Wiring the power supply module

Mains connection

⚠ WARNING

Installation instructions

Risk of death or serious injury.

Observe the general installation instructions applicable in your country when wiring the power supply module.

Fuse the power cables according to their conductor cross-section.

The following applies to mains connection of the power supply module using the power connector:

- The power connector provides connection of the input voltage to the power supply module with touch protection.
- The power connector provides permanent wiring.
- The power connector features an internal strain relief.
- The power connector ensures reverse polarity protection.
- A coding element is used on the power connector to assign it to a specific type of power supply module. A connector coded for 230V AC cannot be inserted into a 24 V DC power supply module.

⚠ DANGER

Do not manipulate or omit the coding element

Changes to the coding element can result in dangerous states in your plant and/or damage to the outputs of the
I/O modules. In order to avoid damage, do not manipulate the coding. The coding element may not be omitted.

Cables

You need flexible cables to wire power to the power supply module. The conductor cross-section must be 1.5 mm^2 (AWG: 16). The diameter of a 3 x 1.5 mm^2 sheathed cable can be no more than 8.5 mm. The ground conductor of flexible cables must be longer than the two other conductors. The fusing must meet the requirements of the corresponding control cabinet.

Reference

Information on installation of the power supply module and wiring of the power connector is available in the system manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

Siemens recommends the use of devices from the SITOP family of products for applications with load power supplies. Wiring information is available in the documentation for the load power supply.

Parameters 4

4.1 Parameters

Parameters of the PS 60W 24/48/60VDC

Specify the module properties at the various parameters in the course of your STEP 7 parameterization. The following table lists the configurable parameters.

The parameters you define in the user program are transferred to the module by means of WRREC instruction (Configuration in RUN); see chapter Parameter data record (Page 27).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Defaults	Configuration in RUN
Diagnostic/maintenance			
• Supply voltage missing	Yes/No	No	Yes
• Switch position Off	Yes/No	No	Yes

Note

Diagnostic alarms without supply voltage

Regardless of whether the supply voltage is missing or the On/Off switch is set to "Off", the power supply module of the CPU or the IM is still capable of generating diagnostic alarms because it is provided sufficient power from the backplane bus. The entire diagnostic functionality is still available.

Interrupts, diagnostic alarms, error and status alarms 5

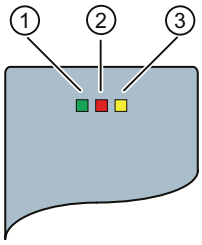
5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is a basic tool for troubleshooting. Usually, you can pinpoint the source of error more precisely by analyzing the module status information in STEP 7, or in the diagnostic buffer of the CPU. These locations contain the corresponding error information in plain text.

LED displays

The following figure shows the LED displays (status and error displays) of PS 60W 24/48/60VDC.



① RUN LED
② ERROR LED
③ MAINT LED

Figure 5-1 LED displays of PS 60W 24/48/60VDC

Meaning of the LED displays

The following table explains the meaning of the status and error displays. You can find remedial measures for diagnostic alarms in chapter Diagnostic alarms (Page 19).

Table 5- 1 Status and error displays RUN/ERROR/MAINT

LED			Meaning	Remedy
RUN	ERROR	MAINT		
Off	Off	Off	OFF; PS returns no bus voltage • External error; diagnostics is disabled • PS not powered in the system, no supply voltage at the PS and CPU/IM.	Switch on power to the PS Check the supply voltage Switch on PS
On	On	On	Startup; all LED displays are lit briefly after system startup, or during module restart after firmware update.	-
Flashing	Not relevant	Not relevant	Startup, PS returns bus voltage, PS waiting for parameterization	-
Off	Flashing	Not relevant	Error, PS supplies no bus voltage • Supply voltage missing and diagnostics is enabled • Internal error	Evaluate diagnostic alarms and take appropriate remedial measures; see chapter Diagnostic alarms (Page 19)
Off	Not relevant	On	Maintenance request, PS returns no bus voltage • Switch is off; power is present and diagnostics is enabled	Switch on PS
Flashing	Flashing	Flashing	Malfunction LEDs flash persistently	Replace PS

5.2 Diagnostic alarms

Diagnostic alarms

The following table shows the meaning of the diagnostic alarms and possible remedial measures for the respective cause.

One of the following "LED images" indicates directly on the PS that a diagnostic alarm was triggered.

- The red ERROR-LED is flashing.

  Indicates external or internal errors.
- The yellow MAINT-LED is lit.

  Maintenance; a maintenance request is active.
- All three LEDs are flashing permanently

  The PS is in "Defective" state.

In STEP 7, the diagnostic results are displayed in plain text by means of the online and diagnostic view. You can read the diagnostic data records by means of the "RDREC" instruction.

Table 5- 2 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
External error					
Supply voltage missing	266_D	$010A_H$	No supply voltage, or incorrect insertion of the power connector into the PS.	1	Check the supply voltage.
Internal error					
Overtemperature	5_D	0005_H	Overtemperature on the printed circuit board.	3	Check PS load. Isolate PS from mains. Wait one minute before you power on the PS again.
Overvoltage backplane bus	267_D	$010B_H$	High EMC interference or a defective PS, CPU or IM inserted.	3	Eliminate electromagnetic interference. Check inserted modules and bus connectors. Isolate PS from mains. Wait one minute before you power on the PS again.
Low voltage/overload in the power segment	281_D	0119_H	A voltage dip below the valid limit has been detected in the power segment to the right of the PS.	2	Check the modules in the affected segment; replace if necessary. Switch off the PS at the switch, then switch on again.
Error in the power segment	282_D	$011A_H$	PS or module to the right of the PS is defective.	2	Replace the defective module. Switch off the PS at the switch, then switch on again.

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
Safety shutdown	285_D	$011D_H$	Reliable operation of the module is no longer guaranteed.	3	Check ambient conditions. Isolate PS from mains. Wait one minute before you power on the PS again.
Maintenance					
Switch turned off	268_D	$010C_H$	The PS is switched off.	1	Switch on PS.
Malfunction					
Module failure	256_D	0100_H	PS failure.	3	Replace PS.

External errors, internal errors and malfunctions

- External errors occur outside the PS. In the parameterization, specify whether or not an external error can trigger a diagnostic alarm. By default, external errors do not trigger diagnostic alarms.
- Internal errors occur inside the PS. If still possible, an internal error always triggers a diagnostic alarm.
- A malfunction is a static state; the PS must be sent in for repair. If still possible, a defect always triggers a diagnostic alarm.

Explanation of the reactions

1. No power at the power segment to the right of the PS. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus.
2. The modules to the right of the PS are switched off.
3. The PS is switched off retentively. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus. You cannot switch on the module unless you have eliminated the error and disconnected power to the PS for approximately one minute.

See also

S7-1500 automation system
(http://support.automation.siemens.com/WW/view/en/59191792)

5.3 Interrupts

What is a diagnostic interrupt?

You can determine reactions to internal or external errors in the user program, by programming a diagnostic interrupt which interrupts cyclic program execution on the CPU and triggers the diagnostic interrupt OB (OB82). The event which led to the interrupt is entered in the start information of the OB82.

Trigger of a diagnostic interrupt

Events that can trigger a diagnostic alarm can also trigger a diagnostic interrupt:

- Supply voltage missing
- Overtemperature
- Overvoltage on the backplane bus
- Low voltage/overload in the power segment
- Error in the power segment
- Safety shutdown
- Switch position Off
- Malfunction

Reactions to a diagnostic interrupt

You can find the CPU reaction to a diagnostic interrupt in the function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926).

Detailed information on the error event is available in the diagnostic interrupt OB by executing the "RALRM" instruction (read additional interrupt information) and in the STEP 7 Online Help.

Technical specifications

6

Technical specifications of the PS 60W 24/48/60VDC

	6ES7505-0RA00-0AB0
Product type designation	PS 60W 24/48/60V DC
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP3 or higher
FH technology	
Redundancy	
• Capable of redundancy	Yes
• For increasing performance	Yes
Supply voltage	
• Rated value (DC)	24 V / 48 V / 60 V
• Valid range low limit (DC)	static 19.2 V, dynamic 18.5 V
• Valid range high limit (DC)	static 72 V, dynamic 75.5 V
• Reverse polarity protection	Yes
• Short-circuit protection	Yes
Power failure backup	
• Power failure backup time	20 ms
Input current	
• Rated value at 24 V DC	3 A
• Rated value at 48 V DC	1.5 A
• Rated value at 60 V DC	1.2 A
Output current	
• Short-circuit protection	Yes
Power	
• Power feed to the backplane bus	60 W
Power loss	
• Power loss at rated conditions	12 W

	6ES7505-0RA00-0AB0
Interrupts/diagnostics/status information	
• Status display	Yes
Electrical isolation	
• Primary/secondary	Yes; electrical isolation for 230 V AC (reinforced insulation)
Insulation	
Insulation tested with	2500 V DC 2s (routine test)
EMC	
Immunity to surge voltages	
• on the supply lines in accordance with IEC 61000-4-5	Yes; +/- 1 kV (according to IEC 61000-4-5; 1995; symm. surge), +/- 2 kV (according to IEC 61000-4-5; 1995; unsymm. surge), no external protective circuit required
Degree of protection and protection class	
Degree of protection to EN 60529	IP20
• Protection class	1; with ground conductor
Dimensions	
• Width	70 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	600 g

Dimensional drawing

A

A.1 Dimensional drawing

Dimensional drawing of PS 60W 24/48/60VDC

This appendix includes the dimensional drawing of the power supply module that is installed on a mounting rail with shielding bracket. Take the dimensions into account for installation in cabinets, control rooms, etc.

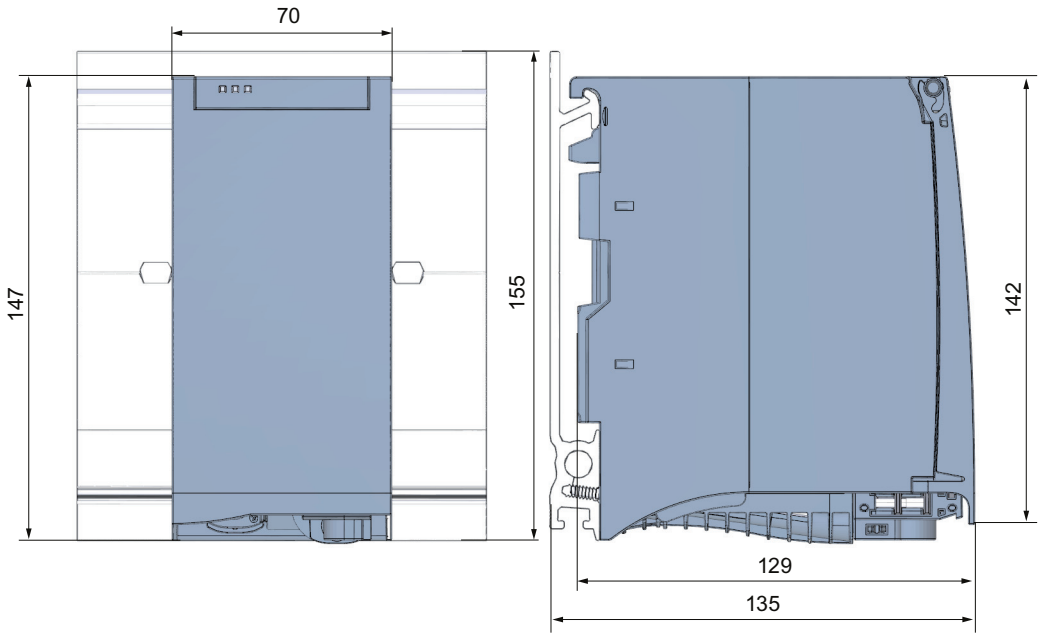


Figure A-1 Dimensional drawing of PS 60W 24/48/60VDC module

This figure shows the dimensions of the module with open front panel.

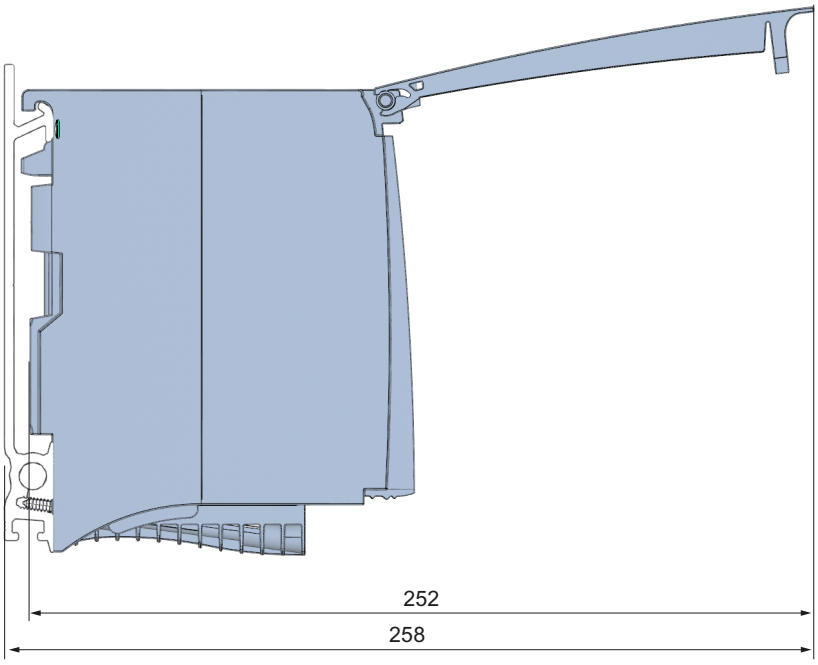


Figure A-2 Dimensional drawing of PS 60W 24/48/60VDC module, side view with open front panel

Parameter data record

B

Parameter assignment in the user program

You have the option to re-parameterize the power supply module in RUN mode of CPU.

Changing parameters in RUN mode

The parameters for the power supply module are contained in data record 0. You can use the WRREC instruction to transfer the configurable parameters to the power supply module. The parameters assigned in STEP 7 are not changed permanently in the CPU, which means the parameters assigned in STEP 7 are valid again after a restart.

Output parameter RET_VAL

The power supply module ignores errors that occur during transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the RET_VAL output parameter. If no error occurs, the length of the data actually transferred is entered in RET_VAL.

RET_VAL is 4 bytes long and structured as follows:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error detection
- Byte3: Error_Code_1, error detection
- Byte4: Error_Code_2, manufacturer-specific expansion of the error detection

The description of the WRREC instruction and the general error codes are available in the STEP 7 online help.

Module-specific errors are displayed by means of Error_Code_1 = 224_D or Error_Code_1 = 225_D.

Manufacturer-specific expansions of the error detection of the WRREC instruction have the following meaning:

Table B- 1 Manufacturer-specific expansions of the error detection of the WRREC instruction

Error_Code 1	Error_Code 2	Meaning
224_D Error in the data record header	1_D	The version entered in the data record header is not supported by the module or reserved bits of the version are set.
	2_D	The net length entered in the data record header is incorrect.
225_D Error in the net data (parameters) entered in the data record	1_D	Diagnostic interrupt enable is incorrect
	16_D	Reserved parameters are not 0

Data record structure

The following figure shows the structure of the data record 0.

- A fixed bit pattern is entered in byte 0. It indicates the version of the data record structure. Each time a data record is written, the module checks the written data and accepts only data records with major version 1.
- Byte 1 specifies the maximum data length that can be used for parameter data.
- Byte 2 contains the parameter data.
- Bytes 3 to 11 are reserved.

To enable a parameter in byte 2, set the corresponding bit to "1". The corresponding diagnostics is then activated, for example, for supply voltage monitoring. If you set the corresponding bit to "0", the diagnostics is deactivated.

You are not permitted to change byte 0, byte 1 or bytes 3 to 11.

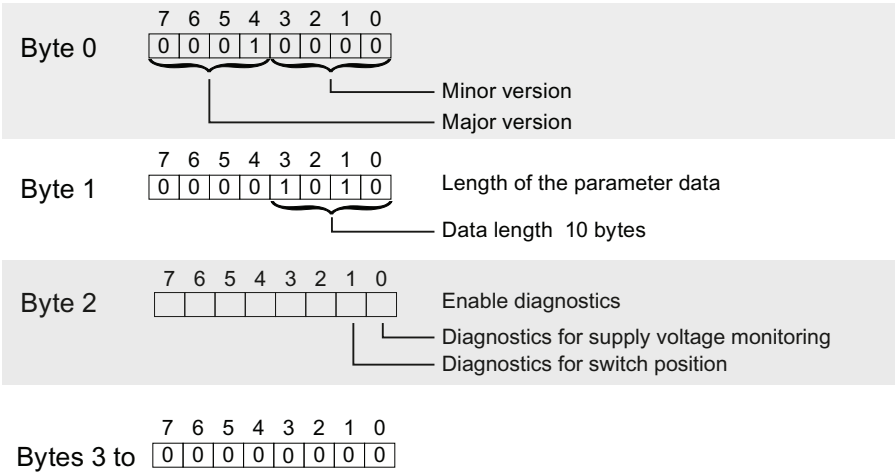


Figure B-1 Structure of data record 0

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SIMATIC

S7-1500/ET 200MP Power supply module PS 60W 120/230V AC/DC (6ES7507-0RA00-0AB0)

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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GERMANY

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Ⓟ 01/2013 Technical data subject to change

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Preface

Preface

Purpose of the documentation

This manual complements the system manuals:

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)

Functions that generally concern the systems are described in these manuals.

The information provided in this manual and in the system/function manuals support you in commissioning the systems.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system and for interface modules of the ET 200MP distributed I/O system.

Also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Open-source software is used in the firmware of the product described. The open-source software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

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Documentation guide 1

Introduction

The modular documentation of the S7-1500 and ET 200MP system families covers all aspects of your automation system.

The documentation consists of different modules that are divided into system manuals, function manuals and manuals.

The following table provides an overview of the documents that complement this manual. Information in the manual overrides specifications in the system manual.

Overview of the documentation for the power supply module PS 60W 120/230VAC

The table below lists additional documentation for using the PS 60W 120/230VAC benötigen. power supply module.

Table 1- 1 Documentation for the power supply module PS 60W 120/230VAC

Topic	Documentation	Most important contents
System description	System manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installation • Wiring • Commissioning • Standards and approvals • Electromagnetic compatibility • Mechanical and climatic ambient conditions
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostics evaluation

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7507-0RA00-0AB0

View of the module

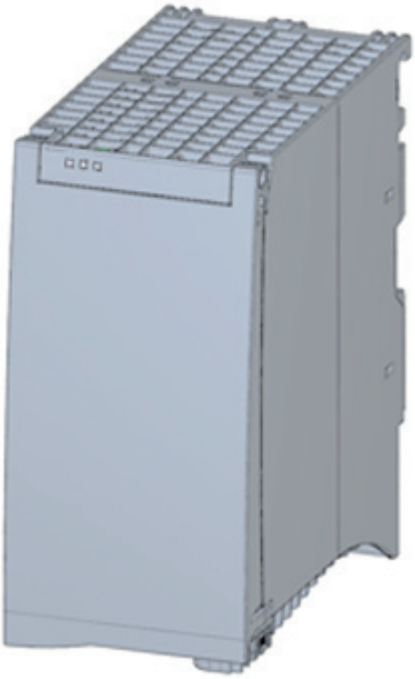


Figure 2-1 View of the PS 60W 120/230V AC/DC module

Properties

The PS 60W 120/230V AC/DC power supply module supports the use of additional modules.

The power supply module has the following properties:

- Technical properties
  - Rated input voltages 120 V AC/DC and 230 V AC/DC
  - Output power 60 W
  - Power failure backup
  - Electrical isolation to the bus, safe electrical separation to EN 61131-2
- Supported functions
  - Firmware update
  - Identification data I&M0 to I&M4
  - Configuration in RUN
  - Diagnostic alarms
  - Diagnostic interrupts

Accessories

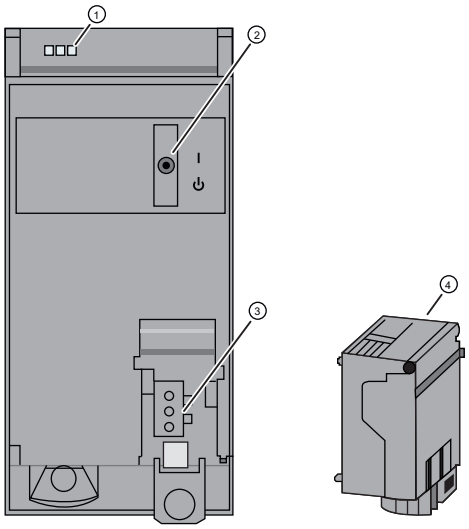
The following components are supplied with the power supply module:

- Power connector
- U connector

These components are also available as spare parts.

2.2 Operating and display elements

The following figure shows the control and connection elements of the PS 60W 120/230 V UC behind the front panel as well as the power connector.



① LED displays indicating the current operating state and diagnostic status of the PS
② On/off switch
③ Power inlet for the power connector
④ Power connector; inserted in delivery state

Figure 2-2 View of the PS 60W 120/230V AC/DC (without front panel) and of the power connector

Wiring 3

3.1 Wiring the power supply module

Mains connection

⚠ WARNING

Installation instructions

Risk of death or serious injury.

Observe the general installation instructions applicable in your country when wiring the power supply module.

Fuse the power cables according to their conductor cross-section.

The following applies to mains connection of the power supply module using the power connector:

- The power connector provides connection of the input voltage to the power supply module with touch protection.
- The power connector provides permanent wiring.
- The power connector features an internal strain relief.
- A coding element is used on the power connector to assign it to a specific type of power supply module. A connector coded for 230V AC cannot be inserted into a 24 V DC power supply module.

⚠ DANGER

Do not manipulate or omit the coding element

Changes to the coding element can result in dangerous states in your plant and/or damage to the outputs of the
I/O modules. In order to avoid damage, do not manipulate the coding. The coding element may not be omitted.

Cables

You need flexible cables to wire power to the power supply module. The conductor cross-section must be 1.5 mm^2 (AWG: 16). You must fuse conductors with a cross-section of 1.5 mm^2 externally with a 16 A circuit breaker (B or C characteristic). The diameter of a 3 x 1.5 mm^2 sheathed cable can be no more than 8.5 mm. The ground conductor of flexible cables must be longer than the two other conductors. The fusing must meet the requirements of the corresponding control cabinet.

Note

You can operate the PS 60W AC in vertical mode at 120V AC/DC in the first segment only. The clearance next to the PS should be at least 70 mm; see the figure below.

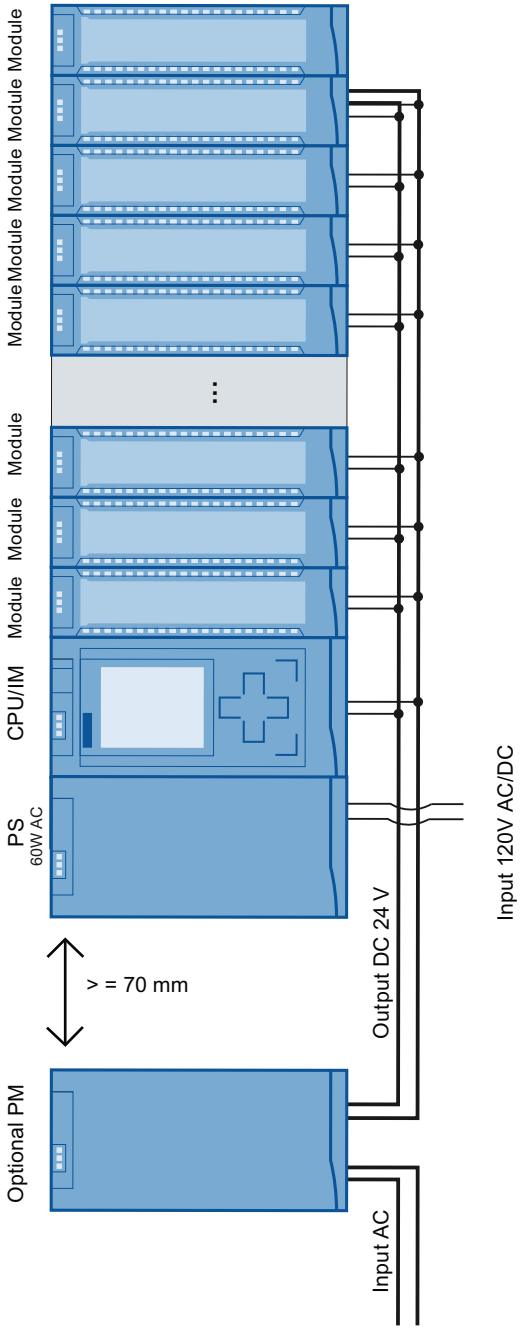


Figure 3-1 Vertical mode

Reference

For information on installation of the power supply module and wiring of the power connector, refer to the system manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

Siemens recommends the use of devices from the SITOP family of products for applications with load power supplies. Wiring information is available in the documentation for the load power supply.

Parameters 4

4.1 Parameters

Parameters of the PS 60W 120/230V AC/DC

Specify the module properties at the various parameters in the course of your STEP 7 parameterization. The following table lists the configurable parameters.

The parameters you define in the user program are transferred to the module by means of WRREC instruction (Configuration in RUN); see chapter Parameter data record (Page 29).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Defaults	Configuration in RUN
Diagnostic/maintenance			
• Supply voltage missing	Yes/No	No	Yes
• Switch position Off	Yes/No	No	Yes

Note

Diagnostic alarms without supply voltage

Regardless of whether the supply voltage is missing or the On/Off switch is set to "Off", the power supply module of the CPU or the IM is still capable of generating diagnostic alarms because it is provided sufficient power from the backplane bus. The entire diagnostic functionality is still available.

Interrupts, diagnostic alarms, error and status alarms 5

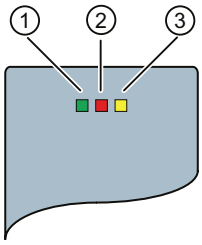
5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is a basic tool for troubleshooting. Usually, you can pinpoint the source of error more precisely by analyzing the module status information in STEP 7, or in the diagnostic buffer of the CPU. These locations contain the corresponding error information in plain text.

LED displays

The following figure shows the LED displays (status and error displays) of the PS 60W 120/230V AC/DC.



① RUN LED
② ERROR LED
③ MAINT LED

Figure 5-1 LED displays of the PS 60W 120/230V AC/DC

Meaning of the LED displays

The following table explains the meaning of the status and error displays. You can find remedial measures for diagnostic alarms in chapter Diagnostic alarms (Page 21).

Table 5- 1 Status and error displays RUN/ERROR/MAINT

LED			Meaning	Remedy
RUN	ERROR	MAINT		
Off	Off	Off	OFF; PS returns no bus voltage • External error; diagnostics is disabled • PS not powered in the system, no supply voltage at the PS and CPU/IM.	Switch on power to the PS Check the supply voltage Switch on PS
On	On	On	Startup; all LED displays are lit briefly after system startup, or during module restart after firmware update.	-
Flashing	Not relevant	Not relevant	Startup, PS returns bus voltage, PS waiting for parameterization	-
Off	Flashing	Not relevant	Error, PS supplies no bus voltage • Supply voltage missing and diagnostics is enabled • Internal error	Evaluate diagnostic alarms and take appropriate remedial measures; see chapter Diagnostic alarms (Page 21)
Off	Not relevant	On	Maintenance request, PS returns no bus voltage • Switch is off; power is present and diagnostics is enabled	Switch on PS
Flashing	Flashing	Flashing	Malfunction LEDs flash persistently	Replace PS

5.2 Diagnostic alarms

Diagnostic alarms

The following table shows the meaning of the diagnostic alarms and possible remedial measures for the respective cause.

One of the following "LED images" indicates directly on the PS that a diagnostic alarm was triggered.

- The red ERROR-LED is flashing.

  Indicates external or internal errors.
- The yellow MAINT-LED is lit.

  Maintenance; a maintenance request is active.
- All three LEDs are flashing permanently

  The PS is in "Defective" state.

In STEP 7, the diagnostic results are displayed in plain text by means of the online and diagnostic view. You can read the diagnostic data records by means of the "RDREC" instruction.

Table 5- 2 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
External error					
Supply voltage missing	266_D	$010A_H$	No supply voltage, or incorrect insertion of the power connector into the PS.	1	Check the supply voltage.
Internal error					
Overtemperature	5_D	0005_H	Overtemperature on the printed circuit board.	3	Check PS load. Isolate PS from mains. Wait one minute before you power on the PS again.
Overvoltage backplane bus	267_D	$010B_H$	High EMC interference or a defective PS, CPU or IM inserted.	3	Eliminate electromagnetic interference. Check inserted modules and bus connectors. Isolate PS from mains. Wait one minute before you power on the PS again.
Low voltage/overload in the power segment	281_D	0119_H	A voltage dip below the valid limit has been detected in the power segment to the right of the PS.	2	Check the modules in the affected segment; replace if necessary. Switch off the PS at the switch, then switch on again.
Error in the power segment	282_D	$011A_H$	PS or module to the right of the PS is defective.	2	Replace the defective module. Switch off the PS at the switch, then switch on again.
Safety shutdown	285_D	$011D_H$	Reliable operation of the module is no longer guaranteed.	3	Check ambient conditions. Isolate PS from mains. Wait one minute before you power on the PS again.

Diagnostic alarm	Error code		Meaning	Reaction	Remedial measures
	Dec.	Hex.			
Maintenance					
Switch turned off	268_D	$010C_H$	The PS is switched off.	1	Switch on PS.
Malfunction					
Module failure	256_D	0100_H	PS failure.	3	Replace PS.

External errors, internal errors and malfunctions

- External errors occur outside the PS. In the parameterization, specify whether or not an external error can trigger a diagnostic alarm. By default, external errors do not trigger diagnostic alarms.
- Internal errors occur inside the PS. If still possible, an internal error always triggers a diagnostic alarm.
- A malfunction is a static state; the PS must be sent in for repair. If still possible, a defect always triggers a diagnostic alarm.

Explanation of the reactions

1. No power at the power segment to the right of the PS. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus.
2. The modules to the right of the PS are switched off.
3. The PS is switched off retentively. Alarm is only generated if the PS is still powered by the CPU or IM via the backplane bus. You cannot switch on the module unless you have eliminated the error and disconnected power to the PS for approximately one minute.

5.3 Interrupts

What is a diagnostic interrupt?

You can determine reactions to internal or external errors in the user program, by programming a diagnostic interrupt which interrupts cyclic program execution on the CPU and triggers the diagnostic interrupt OB (OB82). The event which led to the interrupt is entered in the start information of the OB82.

Trigger of a diagnostic interrupt

Events that can trigger a diagnostic alarm can also trigger a diagnostic interrupt:

- Supply voltage missing
- Overtemperature
- Overvoltage on the backplane bus
- Low voltage/overload in the power segment
- Error in the power segment
- Safety shutdown
- Switch position Off
- Malfunction

Reactions to a diagnostic interrupt

You can find the CPU reaction to a diagnostic interrupt in the function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926).

Detailed information on the error event is available in the diagnostic interrupt OB by executing the "RALRM" instruction (read additional interrupt information) and in the STEP 7 Online Help.

Technical specifications

6

Technical specifications of the PS 60W 120/230V AC/DC

	6ES7507-0RA00-0AB0
Product type designation	PS 60W 120/230V AC/DC
General information	
Hardware version	E01
Firmware version	V1.0.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP3 or higher
FH technology	
Redundancy	
• Capable of redundancy	Yes
• For increasing performance	Yes
Supply voltage	
Type of supply voltage	AC/DC
• Rated value (DC)	120 V / 230 V
• Valid range low limit (DC)	88 V
• Valid range high limit (DC)	300 V
• Rated value (AC)	120 V / 230 V
• Valid range low limit (AC)	85 V
• Valid range high limit (AC)	264 V
• Short-circuit protection	Yes
Mains frequency	
• Rated value 50 Hz	Yes
• Valid range, low limit	47 Hz
• Valid range, high limit	63 Hz
Power failure backup	
• Power failure backup time	20 ms

	6ES7507-0RA00-0AB0
Input current	
• Rated value at 120 V DC	0.6 A
• Rated value at 230 V DC	0.3 A
• Rated value at 120 V AC	0.6 A
• Rated value at 230 V AC	0.34 A
Output current	
• Short-circuit protection	Yes
Power	
• Power feed to the backplane bus	60 W
Power loss	
• Power loss at rated conditions	12 W
Interrupts/diagnostics/status information	
• Status display	Yes
Electrical isolation	
• Primary/secondary	Yes
Insulation	
Insulation tested with	2500 V DC 2s (routine test)
EMC	
Immunity to surge voltages	
• on the supply lines in accordance with IEC 61000-4-5	Yes; +/- 1 kV (according to IEC 61000-4-5; 1995; symm. surge), +/- 2 kV (according to IEC 61000-4-5; 1995; unsymm. surge), no external protective circuit required
Degree of protection and protection class	
Degree of protection to EN 60529	IP20
• Protection class	1; with ground conductor
Dimensions	
• Width	70 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	600 g

Dimensional drawing

A

A.1 Dimensional drawing

Dimensional drawing of the PS 60W 120/230V AC/DC

This appendix includes the dimensional drawing of the power supply module that is installed on a mounting rail with shielding bracket. Take the dimensions into account for installation in cabinets, control rooms, etc.

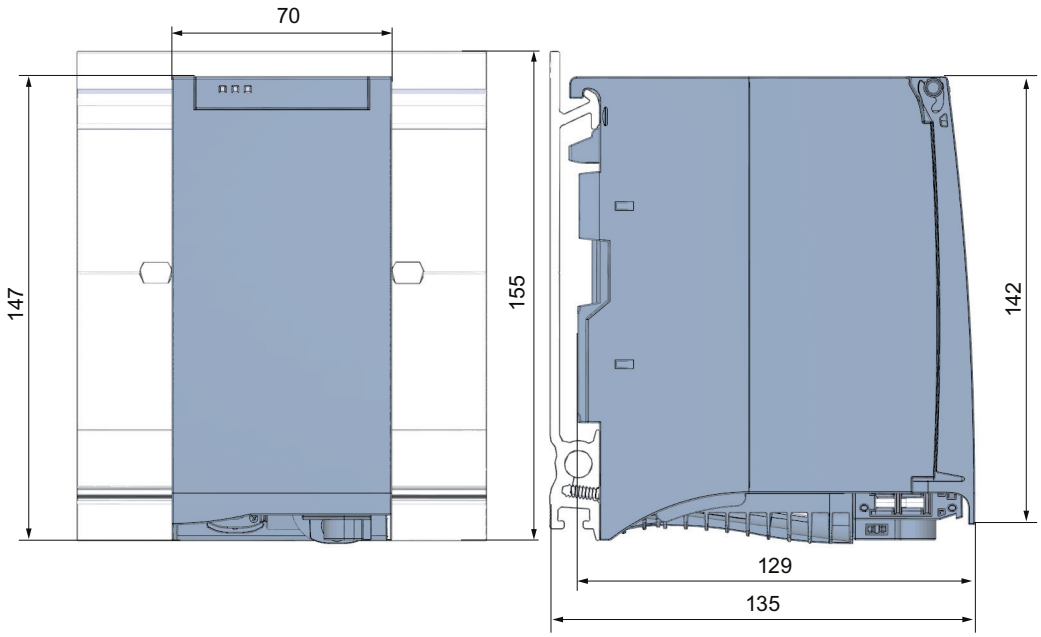


Figure A-1 Dimensional drawing of the PS 60W 120/230V AC/DC module

This figure shows the dimensions of the module with open front panel.

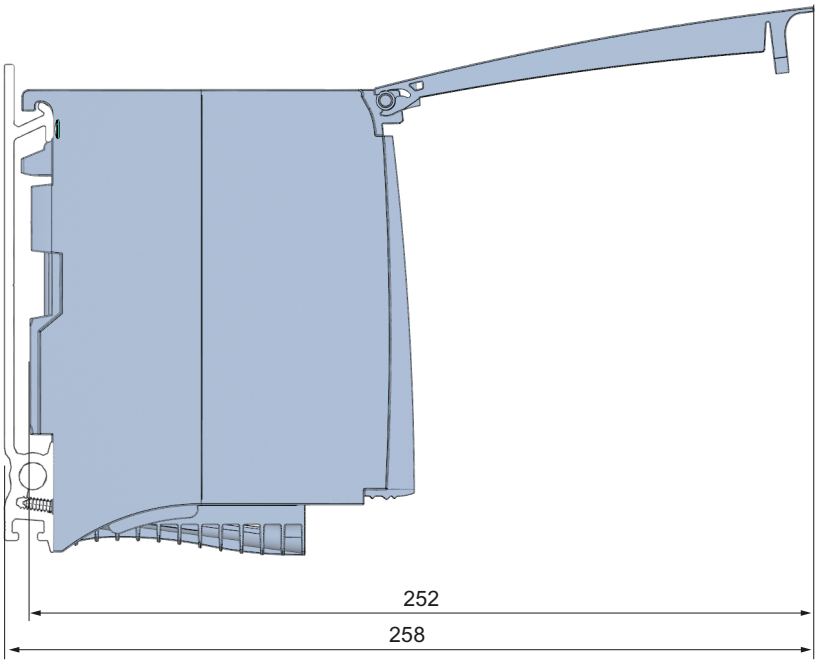


Figure A-2 Dimensional drawing of the PS 60W 120/230V AC/DC module, side view with open front panel

Parameter data record

B

Parameter assignment in the user program

You have the option to re-parameterize the power supply module in RUN mode of CPU.

Changing parameters in RUN mode

The parameters for the power supply module are contained in data record 0. You can use the WRREC instruction to transfer the configurable parameters to the power supply module. The parameters assigned in STEP 7 are not changed permanently in the CPU, which means the parameters assigned in STEP 7 are valid again after a restart.

Output parameter RET_VAL

The power supply module ignores errors that occur during transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the RET_VAL output parameter. If no error occurs, the length of the data actually transferred is entered in RET_VAL.

RET_VAL is 4 bytes long and structured as follows:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error detection
- Byte3: Error_Code_1, error detection
- Byte4: Error_Code_2, manufacturer-specific expansion of the error detection

The description of the WRREC instruction and the general error codes are available in the STEP 7 online help.

Module-specific errors are displayed by means of Error_Code_1 = 224_D or Error_Code_1 = 225_D.

Manufacturer-specific expansions of the error detection of the WRREC instruction have the following meaning:

Table B- 1 Manufacturer-specific expansions of the error detection of the WRREC instruction

Error_Code 1	Error_Code 2	Meaning
224_D Error in the data record header	1_D	The version entered in the data record header is not supported by the module or reserved bits of the version are set.
	2_D	The net length entered in the data record header is incorrect.
225_D Error in the net data (parameters) entered in the data record	1_D	Diagnostic interrupt enable is incorrect
	16_D	Reserved parameters are not 0

Data record structure

The following figure shows the structure of the data record 0.

- A fixed bit pattern is entered in byte 0. It indicates the version of the data record structure. Each time a data record is written, the module checks the written data and accepts only data records with major version 1.
- Byte 1 specifies the maximum data length that can be used for parameter data.
- Byte 2 contains the parameter data.
- Bytes 3 to 11 are reserved.

To enable a parameter in byte 2, set the corresponding bit to "1". The corresponding diagnostics is then activated, for example, for supply voltage monitoring. If you set the corresponding bit to "0", the diagnostics is deactivated.

You are not permitted to change byte 0, byte 1 or bytes 3 to 11.

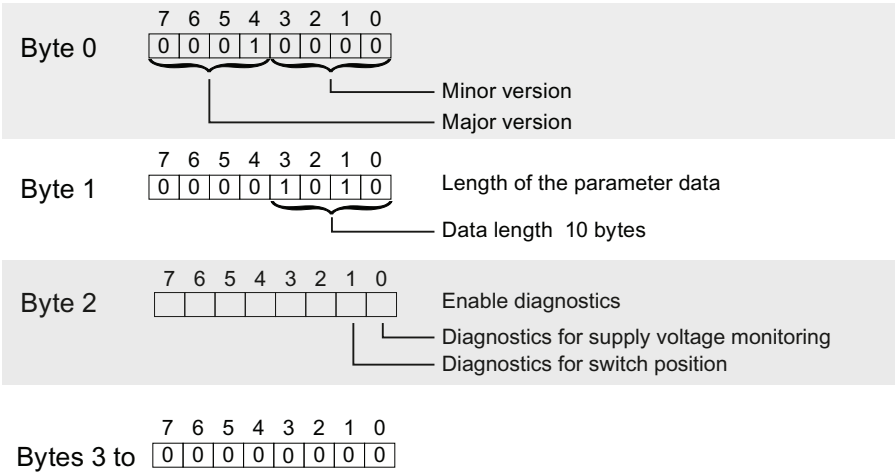


Figure B-1 Structure of data record 0

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S7-1500/ET 200MP Load power supply module PM 70 W 120/230VAC (6EP1332-4BA00)

Manual

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Parameter 4

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Technical specifications 6

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Parameter data set B

01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of this documentation

This manual supplements the system manuals:

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)

General system functions are described there.

The information in this manual along with the System/Function manuals enables you to commission the systems.

Conventions

In the following, if "CPU" is mentioned, then this refers to the central modules of the S7-1500 automation system, as well as the interface modules of the ET 200MP distributed I/O.

Also observe the notes marked as follows:

Note

A note refers to important information about the product described in the documentation, for handling the product or to the part of the documentation to which special attention should be given.

Note on IT security

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You can register for a product-specific newsletter here.

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Products used from other manufacturers should also be taken into account here.

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Documentation guide 1

Introduction

The documentation of the S7-1500 and ET 200MP system families has a modular structure, and includes topics associated with your automation system.

The complete documentation comprises various modules, which are subdivided into System Manuals, Function Manuals and Equipment Manuals.

An overview of the documents, which supplement this Manual, is provided in the following table.

Overview of the documentation for the power supply module PM 70 W 120/230 VAC

The following table lists additional documentation, which you require when using the load power supply module PM 70 W 120/230 VAC .

Table 1- 1 Documentation for the PM 70 W 120/230 VAC load power supply module

Subject	Documentation	Most important content
Description of the system	System Manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) System Manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Planning its use • Installation • Connection • Commissioning • Standards and approvals • Electromagnetic compatibility • Mechanical and climatic environmental conditions
Configuring control systems so that they are interference-proof	Function Manual Configuring control systems so that they are interference-proof (http://support.automation.siemens.com/WW/view/en/59193566)	• Basic principles • Electromagnetic compatibility • Lightning protection
System diagnostics	Function Manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation, hardware/software

SIMATIC Manuals

In the Internet (http://www.siemens.com/automation/service&support) you will find all of the current manuals for SIMATIC products, that you can download at no charge.

Product overview

2

2.1 Properties

Order number

6EP1332-4BA00

View of the module

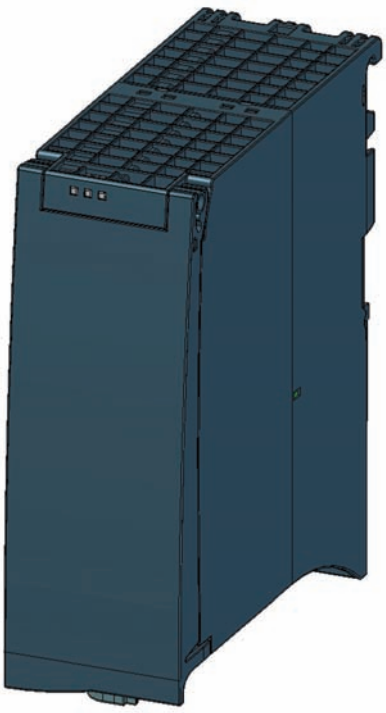


Figure 2-1 View of the PM 70 W 120/230 VAC load power supply module

Properties

The load power supply module PM 70 W 120/230 VAC feeds input and output circuits (load circuits) as well as sensors and actuators

The load power supply module has the following properties:

- Technical properties
  - Rated input voltage 120/230 V AC, 50/60 Hz
  - Automatic voltage range switchover
  - 24 V DC rated output voltage
  - 3 A rated output current
  - 70 W output power
  - Power failure buffering

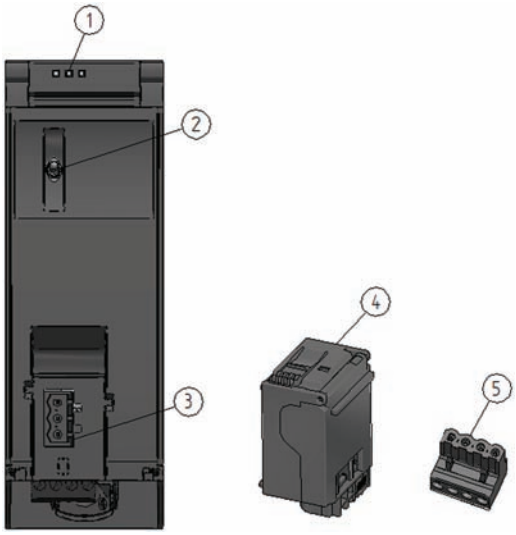
Accessories

The following components can be supplied with the power module:

- Line connector
- Pluggable 24 V DC output terminal

2.2 Operator controls and display elements

The following diagram shows the operating and connection elements of the PM 70 W 120/230 VAC load power supply module behind the front cover, the line connector and the pluggable 24 V DC output terminal



① LED displays showing the actual operating state and diagnostics state of the PM
② On / off switch
③ Power supply connection via the line connector
④ Line connector, inserted when delivered
⑤ Pluggable 24 V DC output terminal, inserted when delivered

Figure 2-2 View of the PM 70 W 120/230 VAC power supply module (without front cover), the line connector and the pluggable 24 V DC output terminal

Connection 3

3.1 Connecting up the power supply module

Line connection

⚠ WARNING
Installation instructions Death or severe injury can occur. When connecting up the power supply module, carefully observe the general installation instructions that are valid in your particular country. Protect the line connection cables corresponding to the cable cross-section.

The following applies to the line connection of the load power supply module with the line connector:

- The line connector allows the supply voltage to be connected to the load power supply with touch protection.
- The line connector facilitates permanent wiring to be established.
- The line connector has a strain relief mechanism.
- When supplied, every line connector is assigned to a power supply module type using a coding element. A connector, coded for 230 V AC, cannot be inserted in a 24 V DC power supply module.

24 V DC output

The following applies to the 24 V DC output of the load power supply module with pluggable 24 V DC output terminal:

- The 24 V DC output terminal allows loads to be connected with a 24 V DC input.
- The 24 V DC output terminal facilitates permanent wiring to be established.
- The 24 V DC output terminal guarantees protection against reverse polarity.

Cables

You must use flexible cables to connect the load power supply module. The wire cross-section can be 0.5 mm² up to 2.5 mm² (AWG: 24 to 12). A miniature circuit breaker or motor circuit breaker must be provided at the input side.

Clearance to adjacent modules

For a horizontal system configuration (cable outlet towards the bottom), no installation clearances are required to the right-hand adjacent module; on the other hand, if there is a module to the left, then a minimum clearance of 10 mm must be provided.

For vertical system configurations (cable outlet to the right), a minimum clearance of 25 mm must be maintained to the upper adjacent module. If there is a lower adjacent module, then a minimum clearance of 20 mm must be maintained

Reference

Information on installing the load power supply module and wiring the line connector and the pluggable 24 V DC output terminal is provided in the System Manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/de/59191792) and in the operating instructions for the load power supply module.

Parameter

4

PM 70 W 120/230 VAC parameters

The PM 70 W 120/230 VAC power supply module cannot be parameterized via STEP 7.

Alarms, diagnostic, error and status messages 5

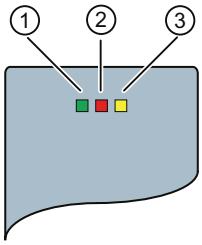
5.1 Status and error displays

Introduction

The diagnostics provided by the LEDs provides the first resource to locate faults.

LED displays

The LED displays (status and error displays) of the PM 70 W 120/230 VAC load power supply module can be seen in the following diagram.



① RUN LED
② ERROR LED
③ MAINT LED

Figure 5-1 LED displays of the PM 70 W 120/230 VAC load power supply module

Meaning of the LED displays

The significance of the status and error displays of the PM 70 W 120/230 VAC power supply module are explained in the following table.

Table 5- 1 RUN/ERROR/MAINT status and error displays

LED			Meaning	Remedy
RUN	ERROR	MAINT		
□ off	□ off	□ off	POWER OFF PM deactivated • No power at the PM • Standby switch in the "lower" position • Device inactive • No 24 V DC output voltage	Check the line supply Supply the PM with power Switch on the PM
■ on	□ off	□ off	POWER ON The PM supplies a 24 V DC output voltage • Line supply voltage is available at the PM • Standby switch in the "upper" position • Device active and in the regular operating mode • 24 V DC output voltage is available	-
□ off	■ on	□ off	ERROR PM is operating in the overload mode • Line supply voltage is available at the PM • Standby switch in the "upper" position • Device is active, however, in the "Overload" operating mode • The connected load draws more current than the PM can supply • 24 V DC output voltage drops	Reduce the load current drawn by the connected load Install a load power supply with a higher rating
□ off	□ off	■ on	MAINTENANCE PM is in the standby mode • Line supply voltage is available at the PM • Standby switch in the "lower" position • Device is active, however, in the standby mode • No 24 V DC output voltage	Switch on the PM by bringing the standby switch into the "upper" position

5.2 Diagnostic messages

The PM 70 W 120/230 VAC load power supply module does not initiate diagnostic messages in the CPU or STEP 7. You can identify the device status directly at the PM based on the "LED statuses", as explained in Chapter Status and error displays (Page 17).

5.3 Alarms

The PM 70 W 120/230 VAC load power supply module does not initiate any alarms in the CPU or STEP 7. You can identify the device status directly at the PM based on the "LED statuses", as explained in Chapter Status and error displays (Page 17).

Technical specifications

6

Technical data of the PM 70 W 120/230 VAC load power supply module

	6EP1332-4BA00
Product type designation	PM 70 W 120/230 VAC
General Information	
Hardware product version	1
Firmware version	Not applicable
Engineering mit	
can be configured in the STEP 7 TIA-Portal / integrated from version	Not applicable
can be configured in STEP 7 / integrated from version	Not applicable
PROFIBUS from GSD version / GSD revision	Not applicable
Power supply	
• Rated value (AC)	120 V or 230 V (automatic switchover)
• Permissible range, lower limit (AC)	85 V or 170 V
• Permissible range, upper limit (AC)	132 V or 264 V
Input current	
• Rated value at 120 VAC	1.40 A
• Rated value at 230 VAC	0.80 A
Mains frequency	
• Rated value 50 Hz	Yes
• Rated value 60 Hz	Yes
• Permissible range, lower limit	45 Hz
• Permissible range, upper limit e	65 Hz
Line and power failure bypass	
• Line/power failure bypass time	20 ms
Output current	
• Rated value	3 A
• Short-circuit protection	Yes
Power	
• 24 V DC output power	194 W

	6EP1332-4BA00
Power loss	
• Power loss, typical.	10.6 W
Alarms / diagnostics / status information	
• Status display	Yes (using the device LEDs)
Electrical isolation	
• Primary/secondary	Yes
Degree of protection and protection class	
• Degree of protection to EN 60529	IP20
• Protection class	I with protective conductor
Dimensions	
• Width	50 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	452 g

Dimension drawing

A

Dimension drawing of the PM 70 W 120/230 VAC load power supply module

The dimension drawing of the load power supply module, mounted on a rail with shield bar, is provided in this attachment. These dimensions must be taken into account when mounting in cabinets, switchgear rooms etc.

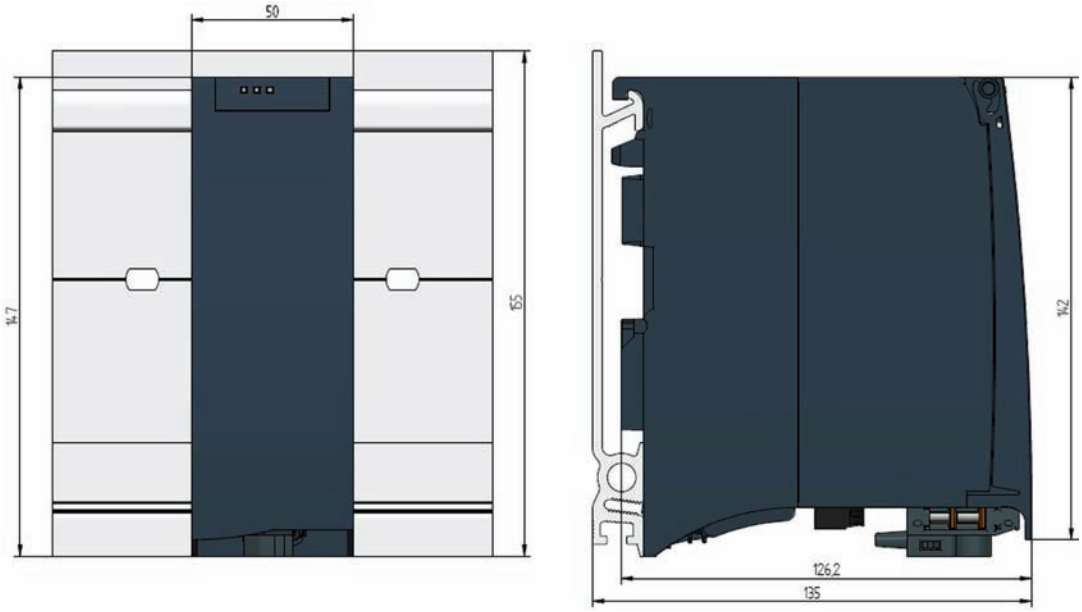


Figure A-1 Dimension drawing of the PM 70 W 120/230 VAC load power supply module

This drawing shows the module dimensions with the front cover open.

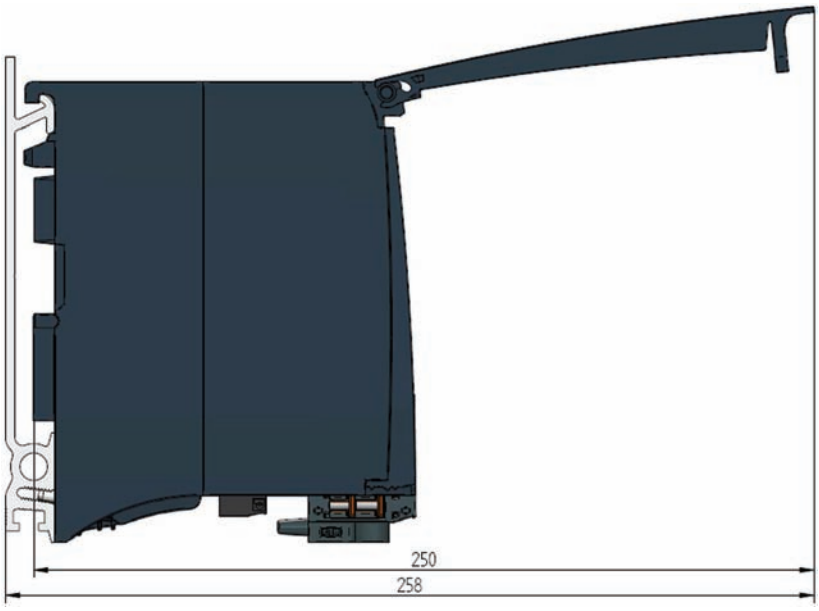


Figure A-2 Dimension drawing of the PM 70 W 120/230VAC load power supply module, side view with the front cover open

Parameter data set

B

The PM 70 W 120/230 VAC load power supply module does not provide any way of assigning parameters.

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S7-1500/ET 200MP Load power supply module PM 190 W 120/230 VAC (6EP1333-4BA00)

Manual

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01/2013

A5E31691095-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

A5E31691095-AA
Ⓟ 01/2013 Technical data subject to change

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Preface

Purpose of this documentation

This manual supplements the system manuals:

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)

General system functions are described there.

The information in this manual along with the System/Function manuals enables you to commission the systems.

Conventions

In the following, if "CPU" is mentioned, then this refers to the central modules of the S7-1500 automation system, as well as the interface modules of the ET 200MP distributed I/O.

Also observe the notes marked as follows:

Note

A note refers to important information about the product described in the documentation, for handling the product or to the part of the documentation to which special attention should be given.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide 1

Introduction

The documentation of the S7-1500 and ET 200MP system families has a modular structure, and includes topics associated with your automation system.

The complete documentation comprises various modules, which are subdivided into System Manuals, Function Manuals and Equipment Manuals.

An overview of the documents, which supplement this Manual, is provided in the following table.

Overview of the documentation for the power supply module PM 190 W 120/230 VAC

The following table lists additional documentation that you require when using the load power supply module PM 190 W 120/230 VAC .

Table 1- 1 Documentation for the PM 190 W 120/230 VAC load power supply module

Subject	Documentation	Most important content
Description of the system	System Manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) System Manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Planning its use • Installation • Connection • Commissioning • Standards and approvals • Electromagnetic compatibility • Mechanical and climatic environmental conditions
Configuring control systems so that they are interference-proof	Function Manual Configuring control systems so that they are interference-proof (http://support.automation.siemens.com/WW/view/en/59193566)	• Basic principles • Electromagnetic compatibility • Lightning protection
System diagnostics	Function Manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation, hardware/software

SIMATIC Manuals

In the Internet (http://www.siemens.com/automation/service&support) you will find all of the current manuals for SIMATIC products, which you can download at no charge.

Product overview

2

2.1 Properties

Order number

6EP1333-4BA00

View of the module

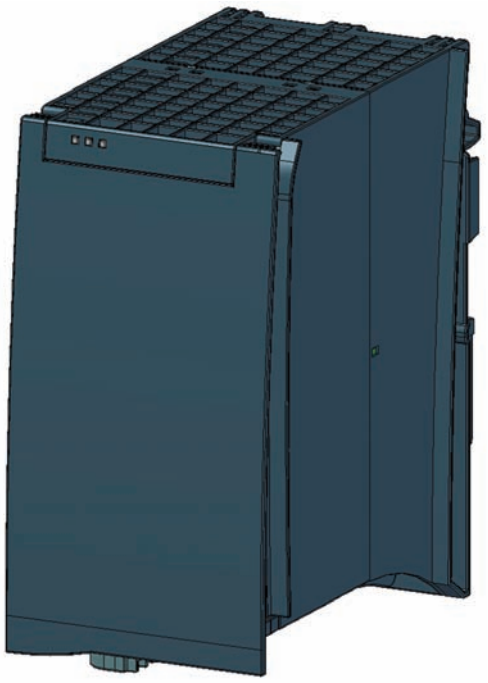


Figure 2-1 View of the PM 190 W 120/230 VAC load power supply module

Properties

The load power supply module PM 190 W 120/230 VAC feeds input and output circuits (load circuits) as well as sensors and actuators

The load power supply module has the following properties:

- Technical properties
  - Rated input voltage 120/230 V AC, 50/60 Hz
  - Automatic voltage range switchover
  - 24 V DC rated output voltage
  - 8 A rated output current
  - 190 W output power
  - Power failure buffering

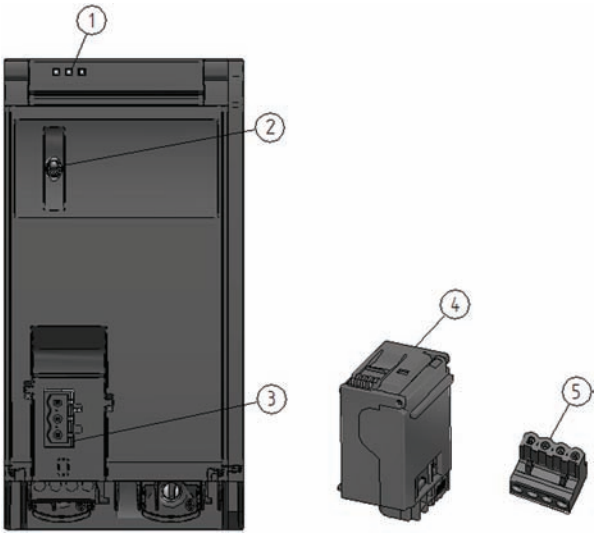
Accessories

The following components can be supplied with the power module:

- Line connector
- Pluggable 24 V DC output terminal

2.2 Operating and display elements

The following diagram shows the operating and connection elements of the PM 190 W 120/230 VAC load power supply module behind the front cover, the line connector and the pluggable 24 V DC output terminal



① LED displays showing the actual operating state and diagnostics state of the PM
② On / off switch
③ Power supply connection via the line connector
④ Line connector, inserted when delivered
⑥ Pluggable 24 V DC output terminal, inserted when delivered

Figure 2-2 View of the PM 190 W 120/230 VAC power supply module (without front cover), the line connector and the pluggable 24 V DC output terminal

Connection 3

3.1 Connecting up the power supply module

Line connection

⚠ WARNING
Installation instructions Death or severe injury can occur. When connecting up the power supply module, carefully observe the general installation instructions that are valid in your particular country. Protect the line connection cables corresponding to the cable cross-section.

The following applies to the line connection of the load power supply module with the line connector:

- The line connector allows the supply voltage to be connected to the load power supply with touch protection.
- The line connector facilitates permanent wiring to be established.
- The line connector has a strain relief mechanism.
- When supplied, every line connector is assigned to a power supply module type using a coding element. A connector, coded for 230 V AC, cannot be inserted in a 24 V DC power supply module.

24 V DC output

The following applies to the 24 V DC output of the load power supply module with pluggable 24 V DC output terminal:

- The 24 V DC output terminal allows loads to be connected with a 24 V DC input.
- The 24 V DC output terminal facilitates permanent wiring to be established.
- The 24 V DC output terminal guarantees protection against reverse polarity.

Cables

You must use flexible cables to connect the load power supply module. The wire cross-section can be 0.5 mm² up to 2.5 mm² (AWG: 24 to 12). A miniature circuit breaker or motor circuit breaker must be provided at the input side.

Clearance to adjacent modules

For a horizontal system configuration (cable outlet towards the bottom), no installation clearances are required to the right-hand adjacent module; on the other hand, if there is a module to the left, then a minimum clearance of 10 mm must be provided.

For vertical system configurations (cable outlet to the right), a minimum clearance of 25 mm must be maintained to the upper adjacent module. If there is a lower adjacent module, then a minimum clearance of 20 mm must be maintained

Reference

Information on installing the load power supply module and wiring the line connector and the pluggable 24 V DC output terminal is provided in the System Manual S7-1500 automation system (http://support.automation.siemens.com/WW/view/de/59191792) and in the operating instructions for the load power supply module.

Parameter

4

PM 190 W 120/230 VAC parameters

The PM 190 W 120/230 VAC power supply module cannot be parameterized via STEP 7.

Alarms, diagnostic, error and status messages 5

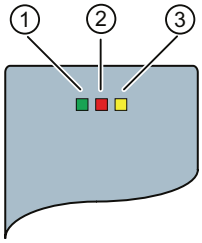
5.1 Status and error displays

Introduction

The diagnostics provided by the LEDs provides the first resource to locate faults.

LED displays

The LED displays (status and error displays) of the PM 190 W 120/230 VAC load power supply module can be seen in the following diagram.



① RUN LED
② ERROR LED
③ MAINT LED

Figure 5-1 LED displays of the PM 190 W 120/230 VAC load power supply module

Meaning of the LED displays

The significance of the status and error displays of the PM 190 W 120/230 VAC power supply module are explained in the following table.

Table 5- 1 RUN/ERROR/MAINT status and error displays

LED			Meaning	Remedy
RUN	ERROR	MAINT		
□ off	□ off	□ off	POWER OFF PM deactivated • No power at the PM • Standby switch in the "lower" position • Device inactive • No 24 V DC output voltage	Check the line supply Supply the PM with power Switch on the PM
■ on	□ off	□ off	POWER ON The PM supplies a 24 V DC output voltage • Line supply voltage is available at the PM • Standby switch in the "upper" position • Device active and in the regular operating mode • 24 V DC output voltage is available	-
□ off	■ on	□ off	ERROR PM is operating in the overload mode • Line supply voltage is available at the PM • Standby switch in the "upper" position • Device is active, however, in the "Overload" operating mode • The connected load draws more current than the PM can supply • 24 V DC output voltage drops	Reduce the load current drawn by the connected load Install a load power supply with a higher rating
□ off	□ off	■ on	MAINTENANCE PM is in the standby mode • Line supply voltage is available at the PM • Standby switch in the "lower" position • Device is active, however, in the standby mode • No 24 V DC output voltage	Switch on the PM by bringing the standby switch into the "upper" position

5.2 Diagnostic messages

The PM 190 W 120/230 VAC load power supply module does not initiate diagnostic messages in the CPU or STEP 7. You can identify the device status directly at the PM based on the "LED statuses", as explained in Chapter Status and error displays (Page 17).

5.3 Alarms

The PM 190 W 120/230 VAC load power supply module does not initiate any alarms in the CPU or STEP 7. You can identify the device status directly at the PM based on the "LED statuses", as explained in Chapter Status and error displays (Page 17).

Technical specifications

6

Technical data of the PM 190 W 120/230 VAC load power supply module

	6EP1333-4BA00
Product type designation	PM 190 W 120/230 VAC
General Information	
Hardware product version	1
Firmware version	Not applicable
Engineering mit	
can be configured in the STEP 7 TIA-Portal / integrated from version	Not applicable
can be configured in STEP 7 / integrated from version	Not applicable
PROFIBUS from GSD version / GSD revision	Not applicable
Power supply	
• Rated value (AC)	120 V or 230 V (automatic switchover)
• Permissible range, lower limit (AC)	85 V or 170 V
• Permissible range, upper limit (AC)	132 V or 264 V
Input current	
• Rated value at 120 VAC	3.70 A
• Rated value at 230 VAC	1.70 A
Mains frequency	
• Rated value 50 Hz	Yes
• Rated value 60 Hz	Yes
• Permissible range, lower limit	45 Hz
• Permissible range, upper limit e	65 Hz
Line and power failure bypass	
• Line/power failure bypass time	20 ms
Output current	
• Rated value	8 A
• Short-circuit protection	Yes
Power	
• 24 V DC output power	194 W

	6EP1333-4BA00
Power loss	
• Power loss, typical.	19.6 W
Alarms / diagnostics / status information	
• Status display	Yes (using the device LEDs)
Electrical isolation	
• Primary/secondary	Yes
Degree of protection and protection class	
• Degree of protection to EN 60529	IP20
• Protection class	I with protective conductor
Dimensions	
• Width	75 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	736 g

Dimension drawing

A

Dimension drawing of the PM 190 W 120/230 VAC load power supply module

The dimension drawing of the load power supply module, mounted on a rail with shield bar, is provided in this attachment. These dimensions must be taken into account when mounting in cabinets, switchgear rooms etc.

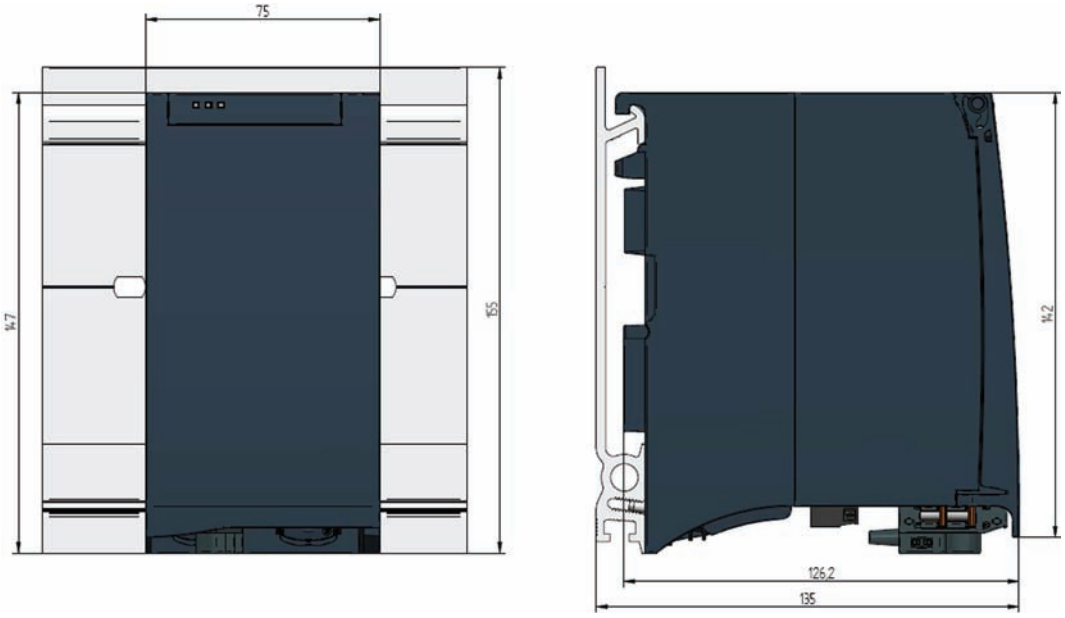


Figure A-1 Dimension drawing of the PM 190 W 120/230 VAC load power supply module

This drawing shows the module dimensions with the front cover open.

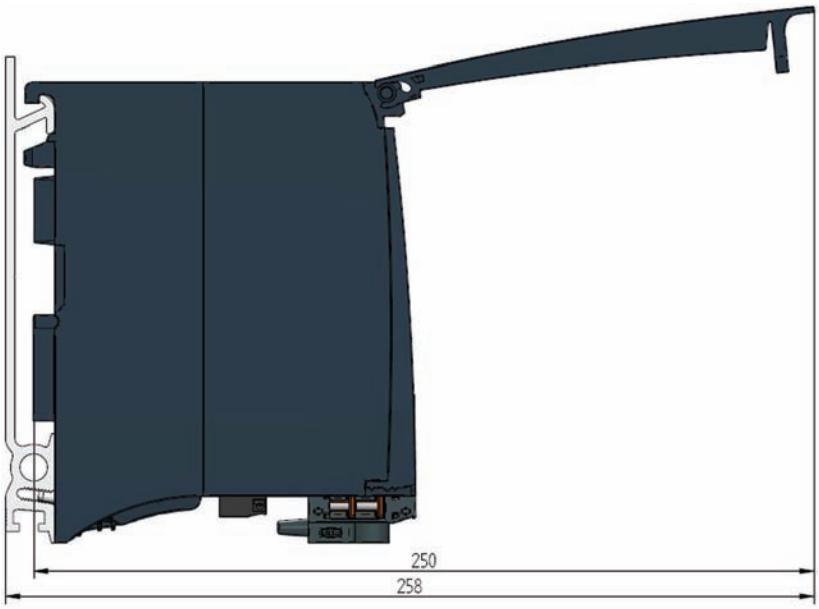


Figure A-2 Dimension drawing of the PM 190 W 120/230VAC load power supply module, side view with the front cover open

Parameter data set

B

The PM 190 W 120/230 VAC load power supply module does not provide any way of assigning parameters.

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S7-1500/ET 200MP DQ 32x24VDC/0.5A ST Digital Output Module (6ES7522-1BL00-0AB0)

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Parameter data records B

08/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
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If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Ⓟ 08/2013 Technical data subject to change

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital output module DQ 32x24VDC/0.5A ST

The following table lists further documentation that you will need when using the DQ 32x24VDC/0.5A ST digital output module.

Table 1- 1 Documentation for digital output module DQ 32x24VDC/0.5A ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7522-1BL00-0AB0

View of the module

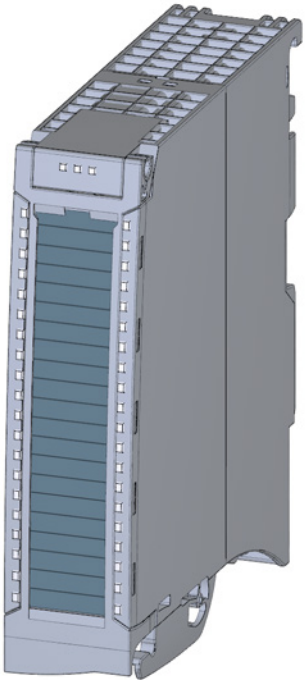


Figure 2-1 View of the DQ 32x24VDC/0.5A ST module

Properties

Properties of the digital module:

- Technical properties
  - 32 DO; electrically isolated in groups of 8
  - Rated output voltage 24 V DC
  - Rated output current 0.5 A per channel
  - Assignable substitute values (per channel)
  - Assignable diagnostics (per channel group)
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Hardware compatible to digital output module DQ 16x24VDC/0.5A ST (6ES7522-1BH00-0AB0)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The module supports the following functions:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring 3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

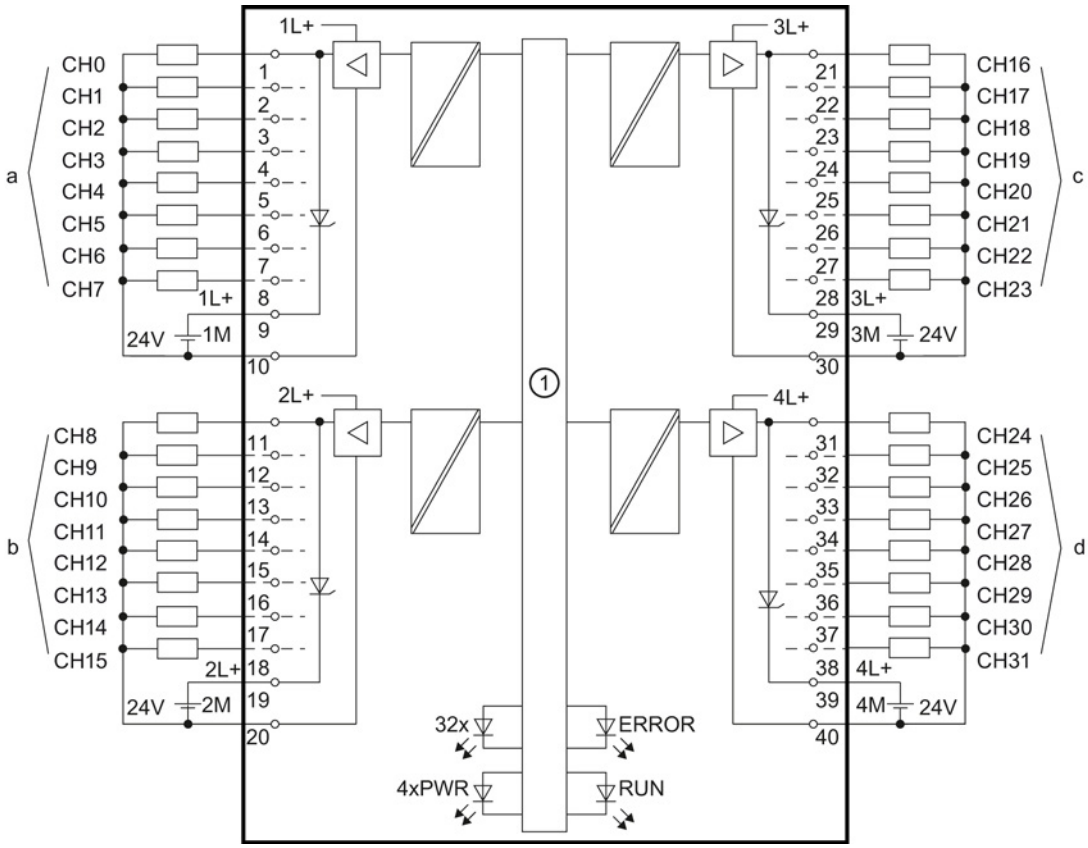
Abbreviations used

Meaning of the abbreviations used in the following figures:

xL+	Supply voltage connection
xM	Ground connection
CHx	Channel or display of the channel status
PWRx	Display for the supply voltage (POWER)

Block diagram and terminal assignment

The example in the following figure shows the terminal assignment and channel addressing (output byte a to output byte d).



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Note

Upon activation of the 24 V supply voltage, there is a "1" signal at the module outputs for approx. 50 µs.

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to connect the four load groups to the same potential (non-isolated). This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between the following terminals:
   - 9 and 29 (L+)
   - 10 and 30 (M)
   - 19 and 39 (L+)
   - 20 and 40 (M).
3. Insert the jumpers between terminals 29 and 39, as well as 30 and 40.
4. Use the terminals 9 and 10 to loop the potential to the next module.

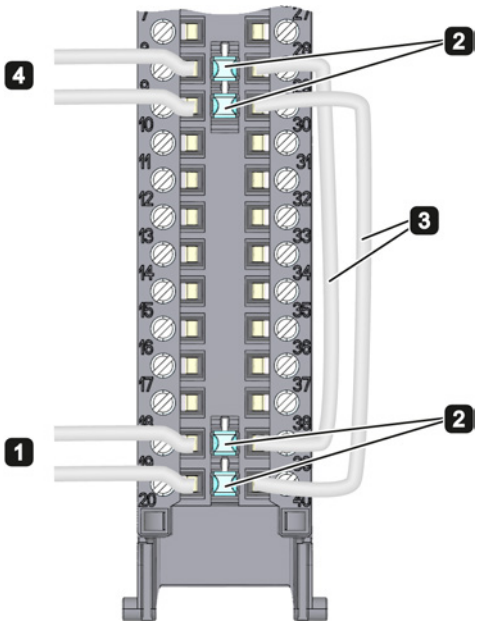


Figure 3-2 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded.

Parameters/address space 4

4.1 Parameters

DQ 32x24VDC/0.5A ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 33).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel group	Channel group
• Short circuit to M	Yes/No	No	Yes	Channel group	Channel group
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Channel

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of DQ 32x24VDC/0.5A ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 32-channel without value status	DQ 32x24VDC/0.5A ST	X	X
1 x 32-channel with value status	DQ 32x24VDC/0.5A ST QI	X	X
4 x 8-channel without value status	DQ 32x24VDC/0.5A ST S	X	---
4 x 8-channel with value status	DQ 32x24VDC/0.5A ST S QI	X	---
1 x 32-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 32x24VDC/0.5A ST MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 32x24VDC/0.5A ST QI
- DQ 32x24VDC/0.5A ST S QI
- DQ 32x24VDC/0.5A ST MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Special characteristics of short-circuit to ground

If a channel is short-circuited, all bits of the corresponding value status input byte are set to 0. The module signals all channels of the relevant byte as faulty.

Address space for configuration as 32-channel DQ 32x24VDC/0.5A ST

The following figure shows the assignment of the address space for the configuration as a 32-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "For example, AB a" stands for module start address output byte a.

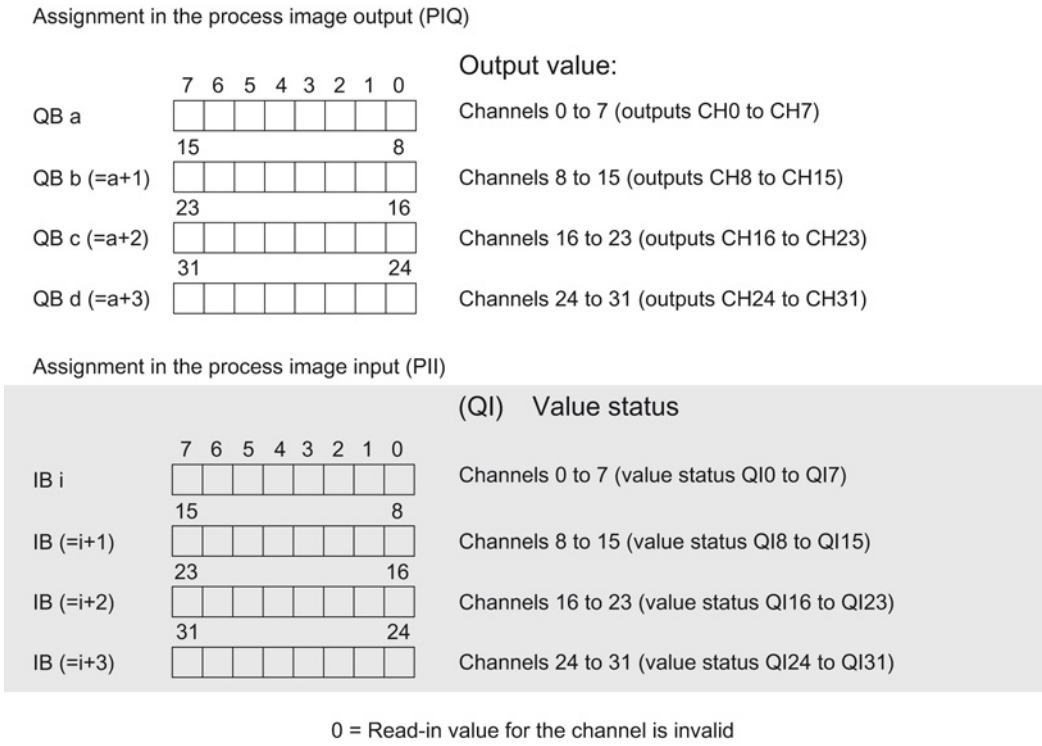


Figure 4-1 Address space for configuration as 32-channel DQ 32x24VDC/0.5A ST with value status

Address space for configuration as 4 x 8-channel DQ 32x24VDC/0.5A ST S QI

For the configuration as a 4 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Contrary to the 1 x 32-channel module configuration, each of the four submodules has a freely assignable start address. The addresses for the respective value status of a submodule can also be assigned by the user.

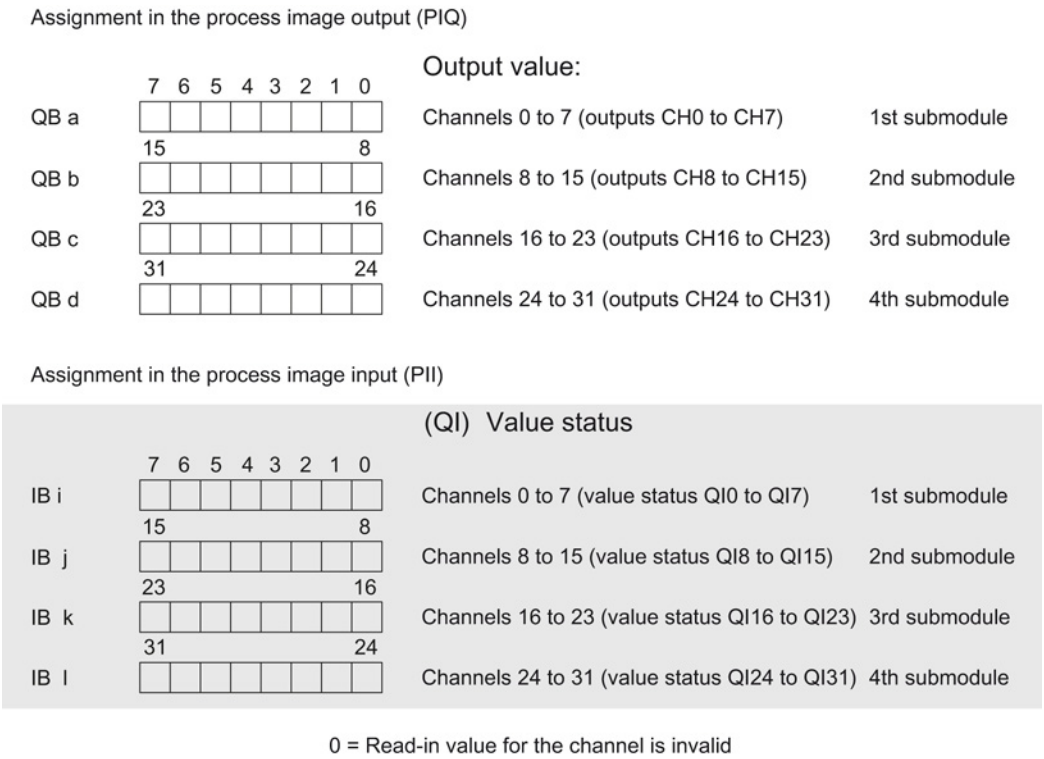


Figure 4-2 Address space for configuration as 4 x 8-channel DQ 32x24VDC/0.5A ST S QI with value status

Address space for configuration as 1 x 32-channel DQ 32x24VDC/0.5A ST MSO

For the configuration as a 1 x 32-channel module (module-internal Shared Output, MSO), channels 0 to 31 of the module are copied to multiple submodules. Channels 0 to 31 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 31.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 31.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1 and 2 and the value status.

Assignment in the process image output (PIQ) for 1st submodule

1st submodule (basic submodule):

	7 6 5 4 3 2 1 0	
QB a		Channels 0 to 7 (outputs CH0 to CH7)
QB (=a+1)	15 … 8	Channels 8 to 15 (outputs CH8 to CH15)
QB (=a+2)	23 … 16	Channels 16 to 23 (outputs CH16 to CH23)
QB (=a+3)	31 … 24	Channels 24 to 31 (outputs CH24 to CH31)

(QI) Value status

	7 6 5 4 3 2 1 0	
IB i		Channels 0 to 7 (value status QI0 to QI7)
IB (=i+1)	15 … 8	Channels 8 to 15 (value status QI8 to QI15)
IB (=i+2)	23 … 16	Channels 16 to 23 (value status QI16 to QI23)
IB (=i+3)	31 … 24	Channels 24 to 31 (value status QI24 to QI31)

Assignment in the process image input (PII) for 2nd submodule

2nd submodule (MSO submodule):
Read-back output values

	7 6 5 4 3 2 1 0	
IB b		Channels 0 to 7 (outputs CH0 to CH7)
IB (=b+1)	15 … 8	Channels 8 to 15 (outputs CH8 to CH15)
IB (=b+2)	23 … 16	Channels 16 to 23 (outputs CH16 to CH23)
IB (=b+3)	31 … 24	Channels 24 to 31 (outputs CH24 to CH31)

(QI) Value status

	7 6 5 4 3 2 1 0	
IB (=b+4)		Channels 0 to 7 (value status QI0 to QI7)
IB (=b+5)	15 … 8	Channels 8 to 15 (value status QI8 to QI15)
IB (=b+6)	23 … 16	Channels 16 to 23 (value status QI16 to QI23)
IB (=b+7)	31 … 24	Channels 24 to 31 (value status QI24 to QI31)

0 = Read-in value for the channel is invalid

Figure 4-3 Address space for configuration as 1 x 32-channel DQ 32x24VDC/0.5A ST S MSO with value status

The following figure shows the assignment of the address space with submodules 3 and 4 and the value status.

Assignment in the process image input (PII) for 3rd and 4th submodules

	7 6 5 4 3 2 1 0	3rd submodule (MSO submodule): Read-back output values
IB c		Channels 0 to 7 (outputs CH0 to CH7)
IB (=c+1)	15 … 8	Channels 8 to 15 (outputs CH8 to CH15)
IB (=c+2)	23 … 16	Channels 16 to 23 (outputs CH16 to CH23)
IB (=c+3)	31 … 24	Channels 24 to 31 (outputs CH24 to CH31)
	7 6 5 4 3 2 1 0	(QI) Value status
IB (=c+4)		Channels 0 to 7 (value status QI0 to QI7)
IB (=c+5)	15 … 8	Channels 8 to 15 (value status QI8 to QI15)
IB (=c+6)	23 … 16	Channels 16 to 23 (value status QI16 to QI23)
IB (=c+7)	31 … 24	Channels 24 to 31 (value status QI24 to QI31)
	7 6 5 4 3 2 1 0	4th submodule (MSO submodule): Read-back output values
IB d		Channels 0 to 7 (outputs CH0 to CH7)
IB (=d+1)	15 … 8	Channels 8 to 15 (outputs CH8 to CH15)
IB (=d+2)	23 … 16	Channels 16 to 23 (outputs CH16 to CH23)
IB (=d+3)	31 … 24	Channels 24 to 31 (outputs CH24 to CH31)
	7 6 5 4 3 2 1 0	(QI) Value status
IB (=d+4)		Channels 0 to 7 (value status QI0 to QI7)
IB (=d+5)	15 … 8	Channels 8 to 15 (value status QI8 to QI15)
IB (=d+6)	23 … 16	Channels 16 to 23 (value status QI16 to QI23)
IB (=d+7)	31 … 24	Channels 24 to 31 (value status QI24 to QI31)

0 = Read-in value for the channel is invalid

Figure 4-4 Address space for configuration as 1 x 32-channel DQ 32x24VDC/0.5A ST S MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED displays (status and error displays) of DQ 32x24VDC/0.5A ST.

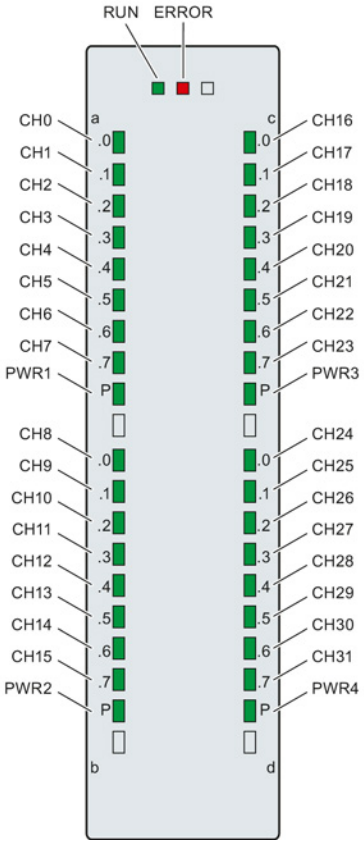


Figure 5-1 LEDdisplays of the module DQ 32x24VDC/0.5A ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic reports can be found in chapter Diagnostics alarms (Page 25).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., short-circuit to ground).	Evaluate the diagnostics data and eliminate the error (e.g., check the cables).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR1/PWR2/PWR3/PWR4 status display

LED PWRx	Meaning	Remedy
Off	Supply voltage L+ too low or missing	Check the L+ supply voltage.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
Off	0 = Status of the output signal	---
On	1 = Status of the output signal	---

5.2 Interrupts

Digital output module DQ 32x24VDC/0.5A ST supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Short-circuit to ground

For more information on the error event, refer to the error OB with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 Online Help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Short circuit to M	1_H	Short-circuit or overload at the channel	Check the wiring/actuator. Check the ambient temperature.
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel

Technical specifications

6

Technical specifications of the DQ 32x24VDC/0.5 A ST

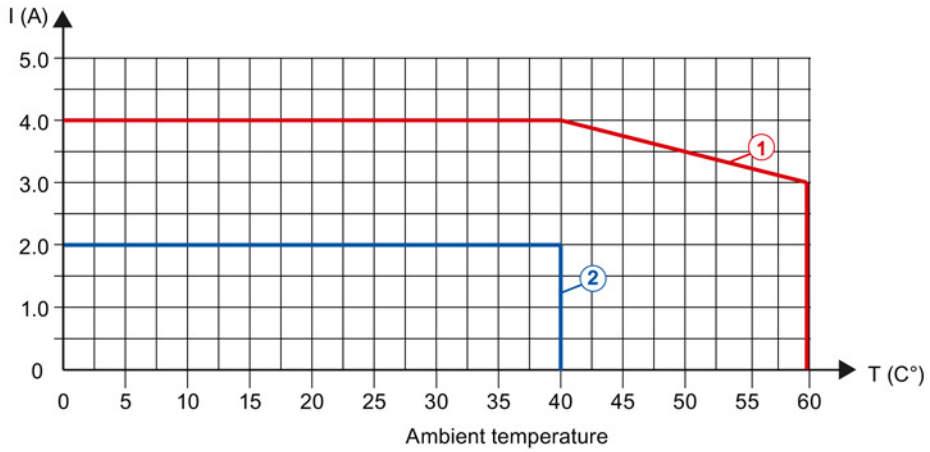
	6ES7522-1BL00-0AB0
Product type designation	DQ 32x24VDC/0.5A ST
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes; through internal protection with 7 A per group
Input current	
Current consumption, max.	60 mA
Output voltage	
Rated value (DC)	24 V
Power	
Power consumption from the backplane bus	1.1 W
Power loss	
Power loss, typ.	3.5 W

	6ES7522-1BL00-0AB0
Digital outputs	
Type of digital output	Transistor
Number of outputs	32
Switching to P potential	Yes
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic clocking
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	L+ (-53 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "1", min.	L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A
for signal "1" permissible range, max.	0.5 A
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	100 µs
"1" to "0", max.	500 µs
Parallel switching of 2 outputs	
For logic operations	Yes
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	0.5 Hz; acc. to IEC 947-5-1, DC13
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per channel	0.5 A; (see additional description in the manual)
Max. current per group	4 A; (see additional description in the manual)
Max. current per module	16 A; (see additional description in the manual)
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m

	6ES7522-1BL00-0AB0
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	70 µs
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	Yes
Fuse blown	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	8
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	280 g

Power reduction (derating) to aggregate current of outputs (per group)

The following graphs show the loading capacity of the outputs in relation to the mounting position and the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Details on aggregate current of outputs (per group)

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

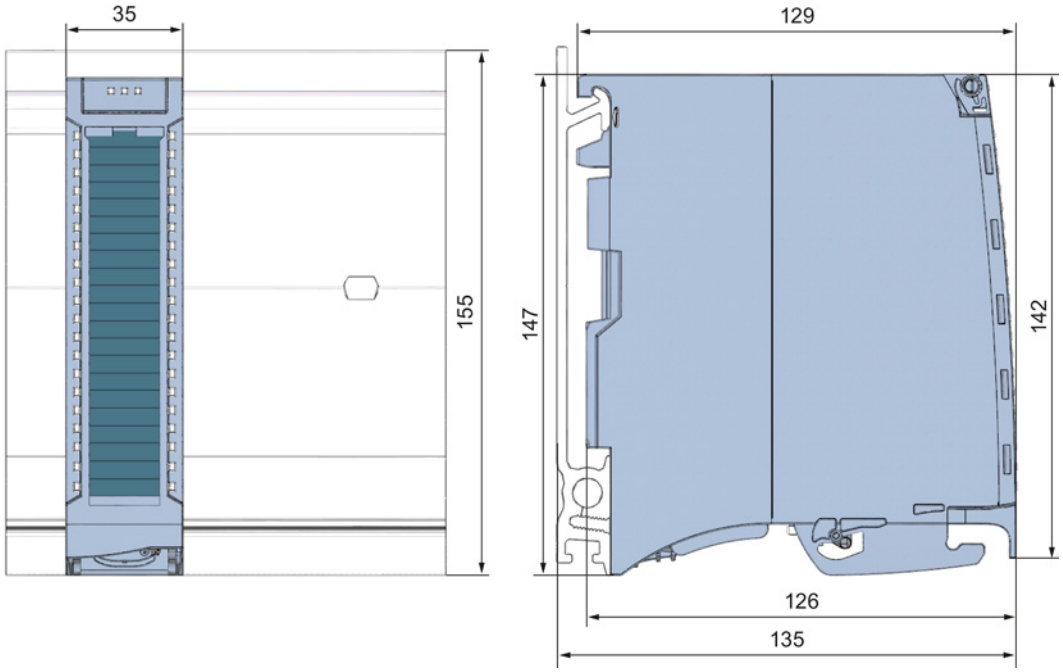


Figure A-1 Dimensional drawing of the DQ 32x24VDC/0.5A ST module

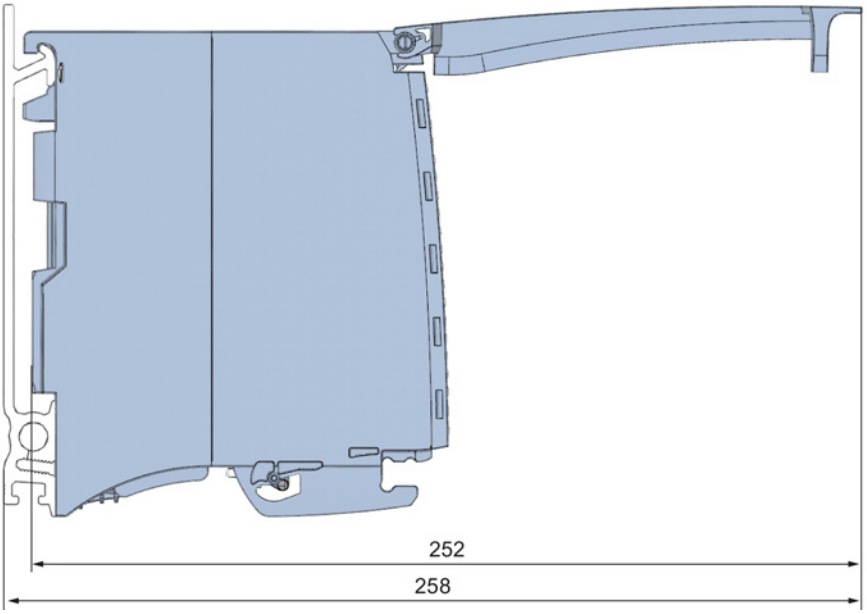


Figure A-2 Dimensional drawing of the DQ 32x24VDC/0.5A ST module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option of reassigning the module parameters in RUN (e.g., the reaction of the individual channels to CPU STOP can be changed in RUN without affecting the other channels)

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 95. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

For the configuration as a 1 x 32-channel module, the parameters are located in data records 64 to 95 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- …
- Data record 94 for channel 30
- Data record 95 for channel 31

For the configuration as a 4 x 8-channel module, the module has 4 submodules with eight channels each. The parameters for the channels are located in data records 64 to 71 and are assigned as follows:

- Data records 64 to 71 for channels 0 to 7 (submodule 1)
- Data records 64 to 71 for channels 8 to 15 (submodule 2)
- Data records 64 to 71 for channels 16 to 23 (submodule 3)
- Data records 64 to 71 for channels 24 to 31 (submodule 4)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 31 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

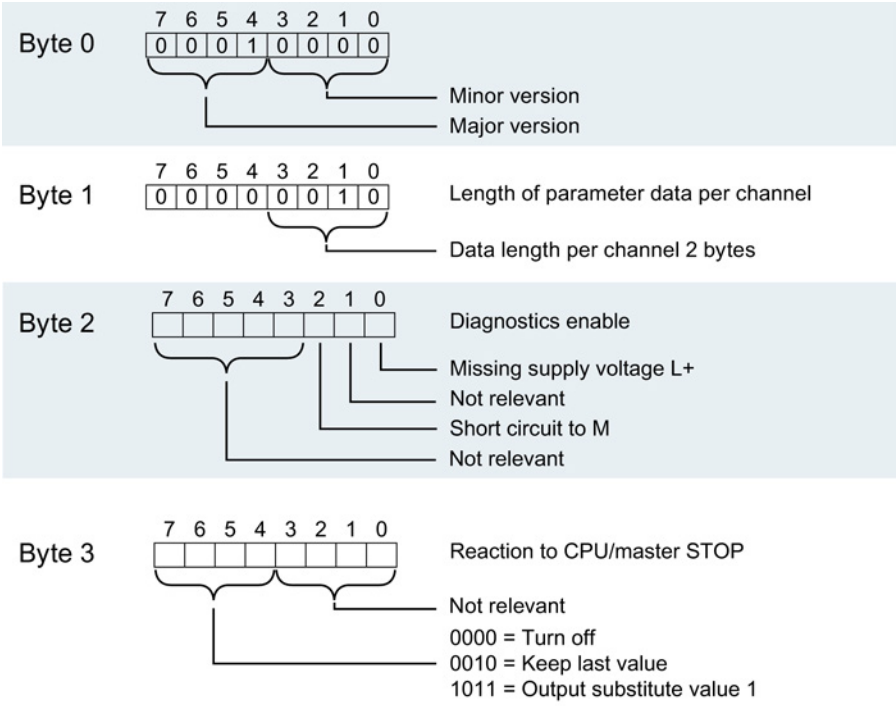


Figure B-1 Structure of data record 64: Bytes 0 to 3

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S7-1500/ET 200MP DQ 16x24VDC/0.5A ST Digital Output Module (6ES7522-1BH00-0AB0)

Manual

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08/2013

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital output module DQ 16x24VDC/0.5A ST

The following table lists further documentation that you will need when using the DQ 16x24VDC/0.5A ST digital output module.

Table 1- 1 Documentation for digital output module DQ 16x24VDC/0.5A ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view/en/68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7522-1BH00-0AB0

View of the module

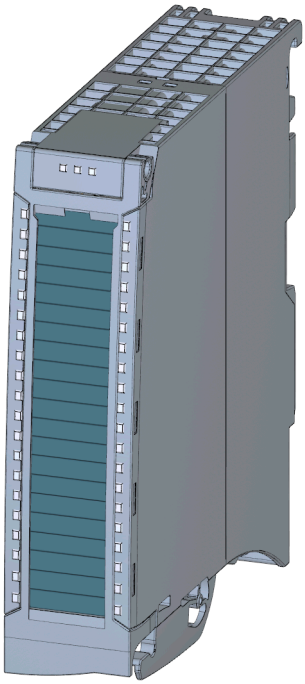


Figure 2-1 View of the DQ 16x24VDC/0.5A ST module

Properties

Properties of the digital module:

- Technical properties
  - 16 DO; electrically isolated in groups of 8
  - Rated output voltage 24 V DC
  - Rated output current 0.5 A per channel
  - Assignable substitute values (per channel)
  - Assignable diagnostics (per channel group)
  - Suitable for solenoid valves, DC contactors, and indicator lights

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring 3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

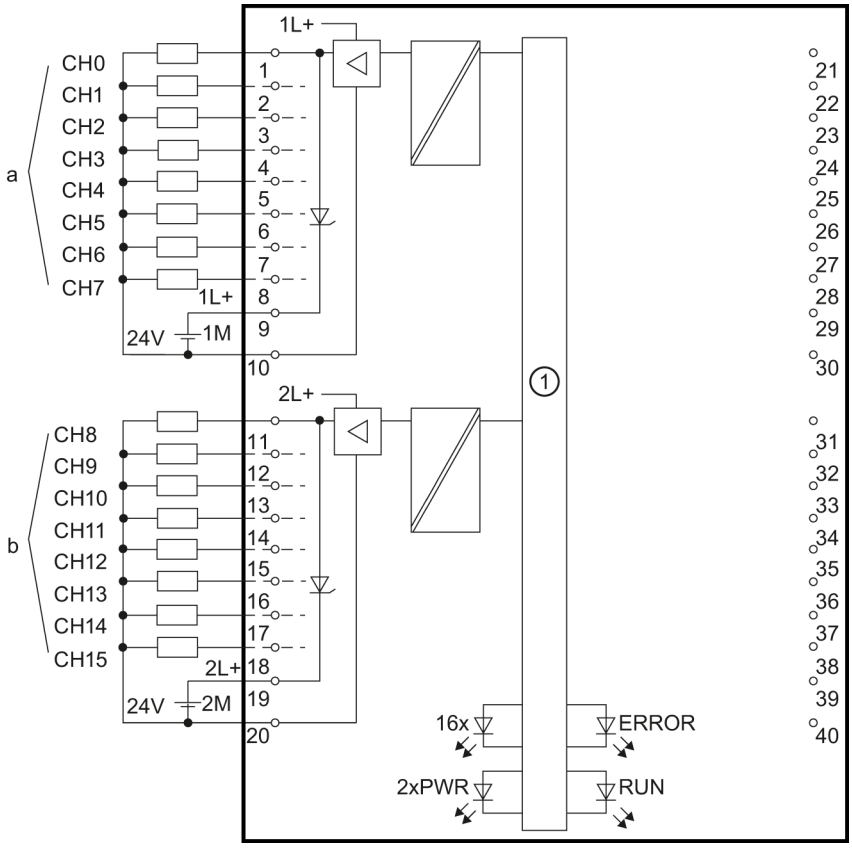
Abbreviations used

Meaning of the abbreviations used in the following figures:

xL+	Supply voltage connection
xM	Ground connection
CHx	Channel or display of the channel status
PWRx	Display for the supply voltage (POWER)

Block diagram and terminal assignment

The example in the following figure shows the terminal assignment and channel addressing (output byte a and output byte b).



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Note

Upon activation of the 24 V supply voltage, there is a "1" signal at the module outputs for approx. 50 µs.

Tip: Using the potential jumpers

If you want to supply both load groups with the same potential (non-isolated), use the potential jumpers supplied with the front connector. This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between terminals
   - 9 and 29 (L+)
   - 10 and 30 (M)
   - 19 and 39 (L+)
   - 20 and 40 (M)
3. Insert the jumpers between terminals 29 and 39, as well as 30 and 40.
4. Use the terminals 19 and 20 to distribute the potential to the next module.

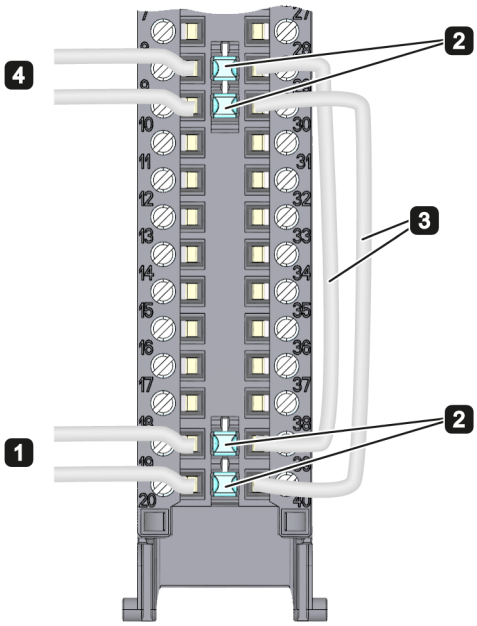


Figure 3-2 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded.

Parameters/address space 4

4.1 Parameters

DQ 16x24VDC/0.5 ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 33).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel group	Channel group
• Short circuit to M	Yes/No	No	Yes	Channel group	Channel group
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Channel

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of DQ 16x24VDC/0.5A ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DQ 16x24VDC/0.5A ST	X	X
1 x 16-channel with value status	DQ 16x24VDC/0.5A ST QI	X	X
2 x 8-channel without value status	DQ 16x24VDC/0.5A ST S	X	---
2 x 8-channel with value status	DQ 16x24VDC/0.5A ST S QI	X	---
1 x 16-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 16x24VDC/0.5A ST MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 16x24VDC/0.5A ST QI
- DQ 16x24VDC/0.5A ST S QI
- DQ 16x24VDC/0.5A ST MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Special characteristics of short-circuit to ground

If a channel is short-circuited, all bits of the corresponding value status input byte are set to 0. The module signals all channels of the relevant byte as faulty.

Address space for configuration as 16-channel DQ 16x24VDC/0.5A ST

The following figure shows the assignment of the address space for the configuration as a 16-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "For example, AB a" stands for module start address output byte a.

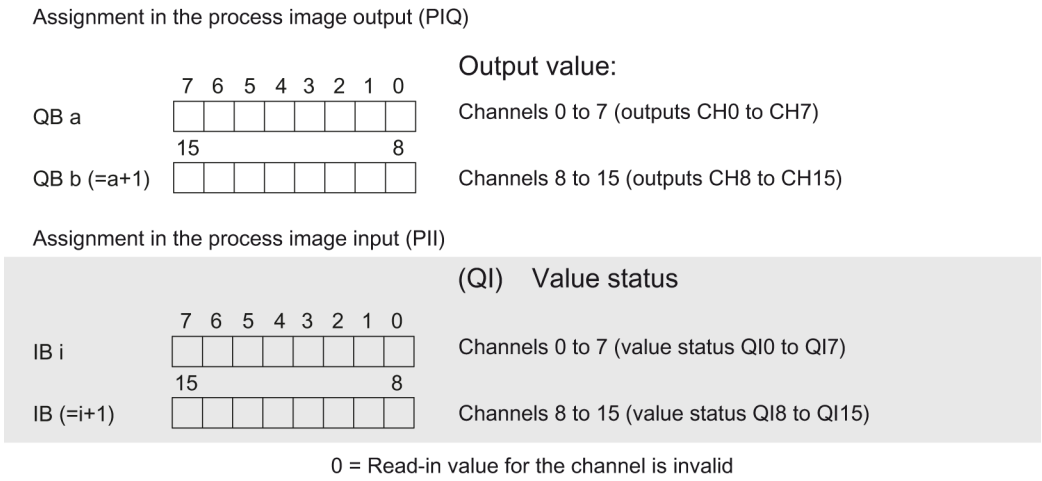


Figure 4-1 Address space for configuration as 16-channel DQ 16x24VDC/0.5A ST with value status

Address space for configuration as 2 x 8-channel DQ 16x24VDC/0.5A ST S QI

For the configuration as a 2 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Contrary to the 1 x 16-channel module configuration, each of the two submodules has a freely assignable start address. The addresses for the respective value status of a submodule can also be assigned by the user.

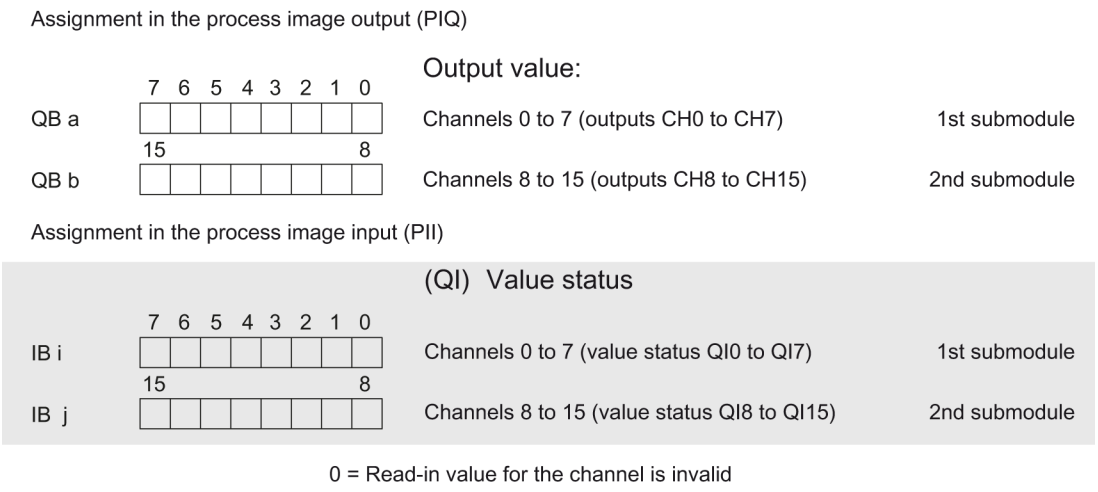


Figure 4-2 Address space for configuration as 2 x 8-channel DQ 32x24VDC/0.5A ST S QI with value status

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A ST MSO

For the configuration as a 1 x 16-channel module (module-internal shared output, MSO), channels 0 to 15 of the module are copied to multiple submodules. Channels 0 to 16 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 15.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 15.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1 and 2 and the value status.

Assignment in the process image output (PIQ) for 1st submodule

1st submodule (basic submodule):

	7 6 5 4 3 2 1 0	
QB a		Channels 0 to 7 (outputs CH0 to CH7)
	15 8	
QB (=a+1)		Channels 8 to 15 (outputs CH8 to CH15)

(QI) Value status

	7 6 5 4 3 2 1 0	
IB i		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=i+1)		Channels 8 to 15 (value status QI8 to QI15)

Assignment in the process image input (PII) for 2nd submodule

2nd submodule (MSO submodule):
Read-back output values

	7 6 5 4 3 2 1 0	
IB b		Channels 0 to 7 (outputs CH0 to CH7)
	15 8	
IB (=b+1)		Channels 8 to 15 (outputs CH8 to CH15)

(QI) Value status

	7 6 5 4 3 2 1 0	
IB (=b+2)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=b+3)		Channels 8 to 15 (value status QI8 to QI15)

0 = Read-in value for the channel is invalid

Figure 4-3 Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A ST S MSO with value status

The following figure shows the assignment of the address space with submodules 3 and 4 and the value status.

Assignment in the process image input (PII) for 3rd and 4th submodules

		3rd submodule (MSO submodule): Read-back output values
	7 6 5 4 3 2 1 0	
IB c		Channels 0 to 7 (outputs CH0 to CH7)
	15 8	
IB (=c+1)		Channels 8 to 15 (outputs CH8 to CH15)
		(QI) Value status
	7 6 5 4 3 2 1 0	
IB (=c+2)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=c+3)		Channels 8 to 15 (value status QI8 to QI15)
		4th submodule (MSO submodule): Read-back output values
	7 6 5 4 3 2 1 0	
IB d		Channels 0 to 7 (outputs CH0 to CH7)
	15 8	
IB (=d+1)		Channels 8 to 15 (outputs CH8 to CH15)
		(QI) Value status
	7 6 5 4 3 2 1 0	
IB (=d+2)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=d+3)		Channels 8 to 15 (value status QI8 to QI15)

0 = Read-in value for the channel is invalid

Figure 4-4 Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A ST S MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of DQ 16x24VDC/0.5A ST.

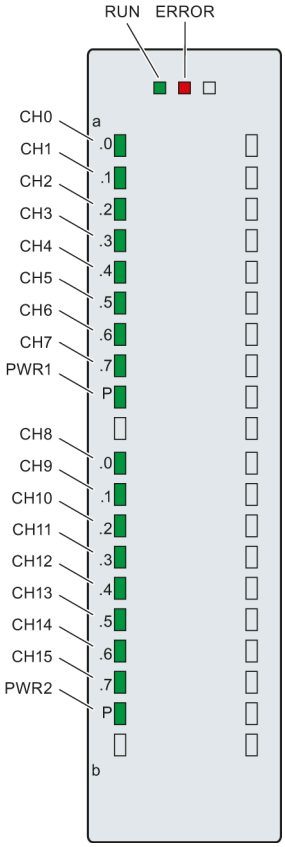


Figure 5-1 LEDdisplays of the module DQ 16x24VDC/0.5A ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 25).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., short-circuit to ground).	Evaluate the diagnostics data and eliminate the error (e.g., check the cables).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR1 / PWR2 status display

LED PWRx	Meaning	Remedy
Off	Supply voltage L+ too low or missing	Check the L+ supply voltage.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
Off	0 = Status of the output signal	---
On	1 = Status of the output signal	---

5.2 Interrupts

Digital output module DQ 16x24VDC/0.5A ST supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Short-circuit to ground

For more information on the error event, refer to the error OB with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 Online Help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Short circuit to M	1_H	Short-circuit or overload at the channel	Check the wiring/actuator. Check the ambient temperature.
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel

Technical specifications

6

Technical specifications of the DQ 16x24VDC/0.5A ST

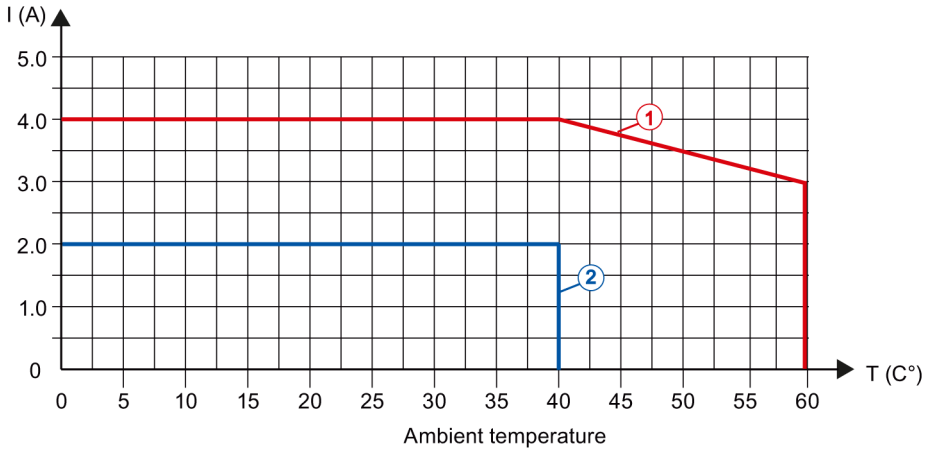
	6ES7522-1BH00-0AB0
Product type designation	DQ 16x24VDC/0,5A ST
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes; through internal protection with 7 A per group
Input current	
Current consumption, max.	30 mA
Output voltage	
Rated value (DC)	24 V
Power	
Power consumption from the backplane bus	1.1 W
Power loss	
Power loss, typ.	2 W

	6ES7522-1BH00-0AB0
Digital outputs	
Type of digital output	Transistor
Number of outputs	16
Switching to P potential	Yes
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic clocking
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	L+ (-53 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "1", min.	L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A
for signal "1" permissible range, max.	0.5 A
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	100 µs
"1" to "0", max.	500 µs
Parallel switching of 2 outputs	
For logic operations	Yes
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	0.5 Hz; acc. to IEC 947-5-1, DC13
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per channel	0.5 A; (see additional description in the manual)
Max. current per group	4 A; (see additional description in the manual)
Max. current per module	8 A; (see additional description in the manual)
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m

	6ES7522-1BH00-0AB0
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	70 µs
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	Yes
Fuse blown	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	8
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	230 g

Power reduction (derating) to aggregate current of outputs (per group)

The following derating graphs show the loading capacity of the outputs in relation to the mounting position and the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Details on aggregate current of outputs (per group)

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

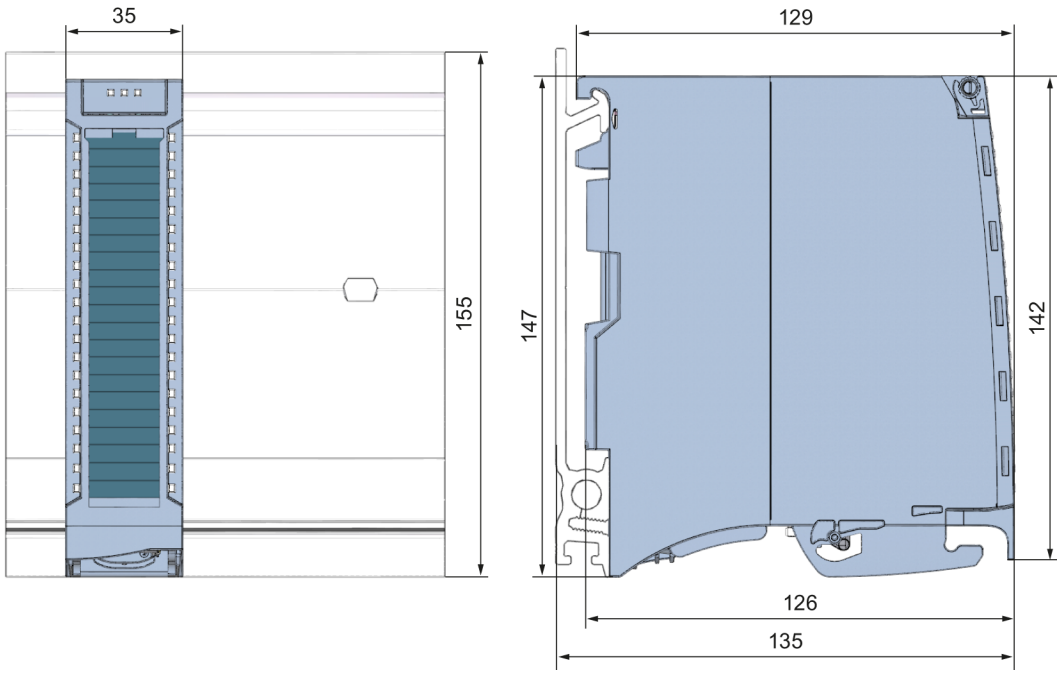


Figure A-1 Dimensional drawing of the DQ 16x24VDC/0.5A ST module

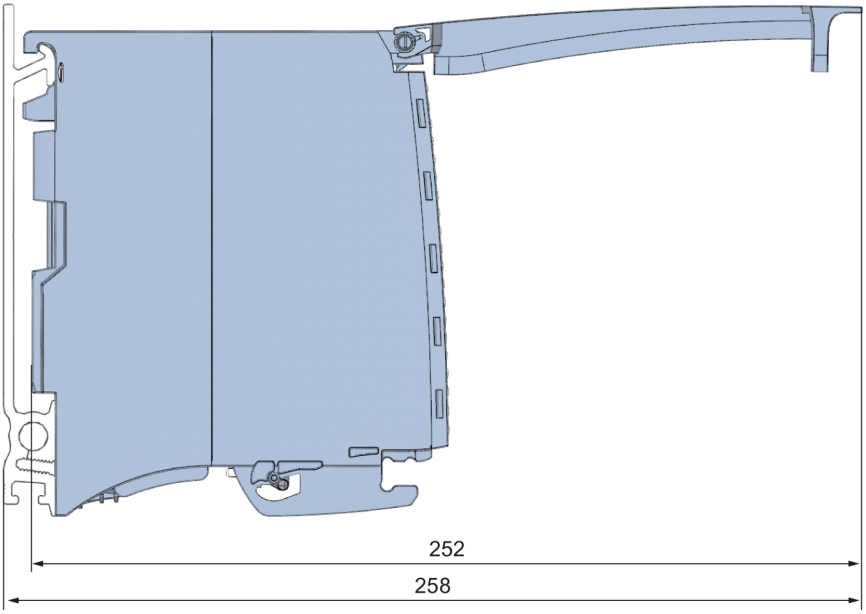


Figure A-2 Dimensional drawing of the DQ 16x24VDC/0.5A ST module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the modules in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels)

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 78. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

For the configuration as a 1 x 16-channel module, the parameters are located in data records 64 to 79 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- …
- Data record 78 for channel 14
- Data record 79 for channel 15

For the configuration as a 2 x 8-channel module, the module has 2 submodules with eight channels each. The parameters for the channels are located in data records 64 to 71 and are assigned as follows:

- Data records 64 to 71 for channels 0 to 7 (submodule 1)
- Data records 64 to 71 for channels 8 to 15 (submodule 2)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 15 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

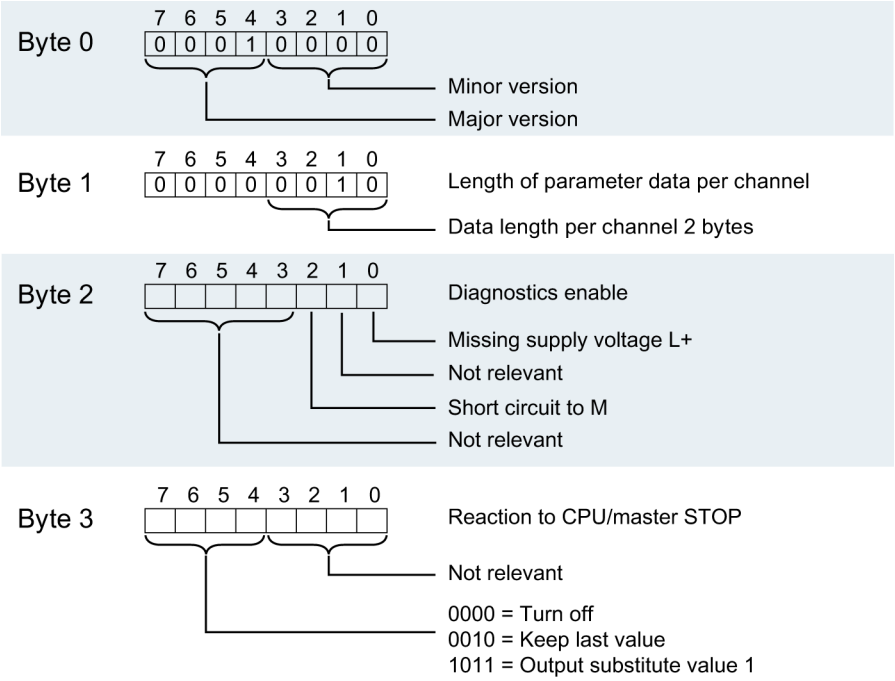


Figure B-1 Structure of data record 64: Bytes 0 to 3

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S7-1500/ET 200MP DQ 8x230VAC/2A ST Digital Output Module (6ES7522-5FF00-0AB0)

Manual

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08/2013

A5E03485733-02

Legal information

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital output module DQ 8x230VAC/2A ST

The following table lists further documentation that you will need when using the DQ 8x230VAC/2A ST digital output module.

Table 1- 1 Documentation for digital output module DQ 8x230VAC/2A ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7522-5FF00-0AB0

View of the module

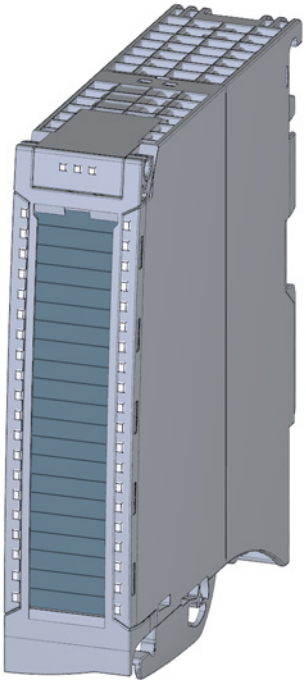


Figure 2-1 View of the DQ 8x230VAC/2A ST module

Properties

Properties of the digital module:

- Technical properties
  - 8 digital outputs (Triac)
  - Rated output voltage 120 V/230 V AC
  - Rated output current 2 A
  - Assignable substitute values (per channel)
  - Suitable for solenoid valves, DC contactors, indicator lights and smaller single phase drives

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various connection options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Note

Do not insert the potential jumpers included with the front connector!

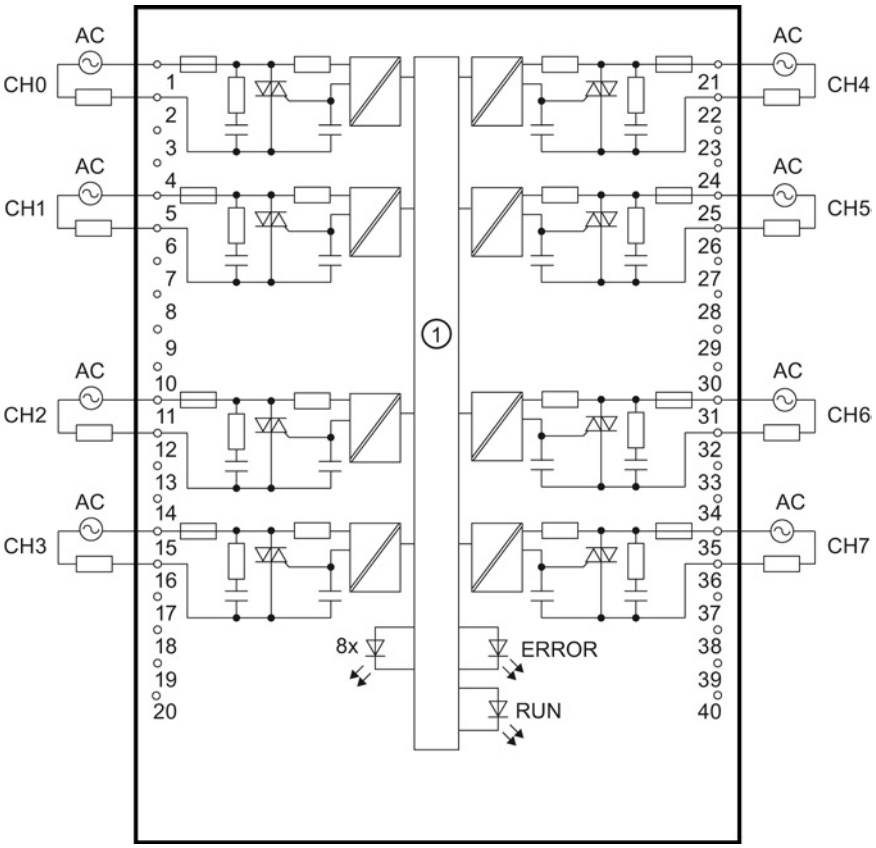
Abbreviations used

Meaning of the abbreviations used in the following figures:

CHx	Channel or display of the channel status

Block diagram and terminal assignment

The example in the following figure shows the terminal assignment and the assignment of the channels.



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Parameters/address space 4

4.1 Parameters

DQ 8x230VAC/2A ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 25).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Channel

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of DQ 8x230VAC/2A ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x230VAC/2A ST	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x230VAC/2A ST MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the DQ 8x230VAC/2A ST MSO module:

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 8-channel DQ 8x230VAC/2A ST

The following figure shows the assignment of the address space for the configuration as a 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "For example, AB a" stands for module start address output byte a.

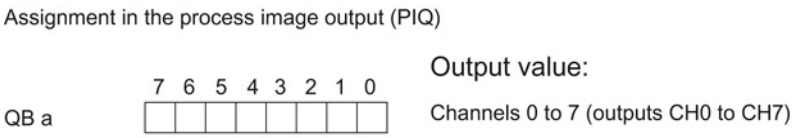


Figure 4-1 Address space for configuration as 8-channel DQ 8x230VAC/2A ST

Address space for configuration as 1 x 8-channel DQ 8x230VAC/2A ST MSO

For the configuration as a 1 x 8-channel module (module-internal shared output, MSO), channels 0 to 7 of the module are copied to multiple submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status.

Assignment in the process image output (PIQ) for 1st submodule

	7 6 5 4 3 2 1 0	1st submodule (basic submodule):
QB a		Channels 0 to 7 (outputs CH0 to CH7)
IB i		(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 2nd submodule

	7 6 5 4 3 2 1 0	2nd submodule (MSO submodule): Read-back output values
IB b		Channels 0 to 7 (outputs CH0 to CH7)
IB (=b+1)		(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 3rd submodule

	7 6 5 4 3 2 1 0	3rd submodule (MSO submodule): Read-back output values
IB c		Channels 0 to 7 (outputs CH0 to CH7)
IB (=c+1)		(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 4th submodule

	7 6 5 4 3 2 1 0	4th submodule (MSO submodule): Read-back output values
IB d		Channels 0 to 7 (outputs CH0 to CH7)
IB (=d+1)		(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

0 = Read-in value for the channel is invalid

Figure 4-2 Address space for configuration as 1 x 8-channel DQ 8x230VAC/2A ST S MSO with value status

Diagnostic alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of DQ 8x230VAC/2A ST.

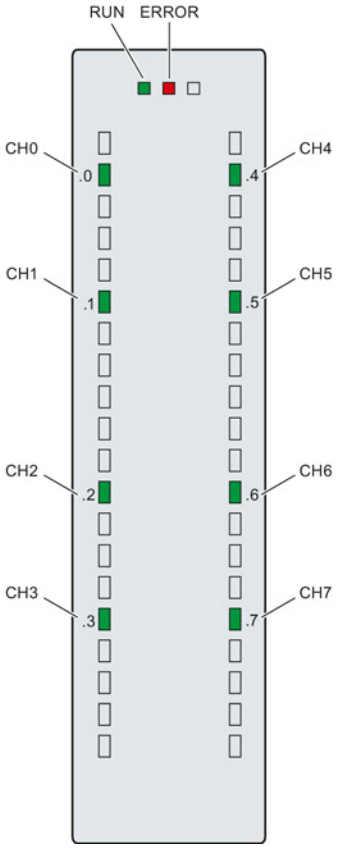


Figure 5-1 LEDdisplays of the module DQ 8x230VAC/2A ST

Meaning of the LED displays

The following table explains the meaning of the status and error displays.

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 CHx status display

LED CHx	Meaning	Remedy
Off	0 = Status of the output signal	---
On	1 = Status of the output signal	---

Technical specifications

6

Technical specifications of the DQ 8x230VAC/2A ST

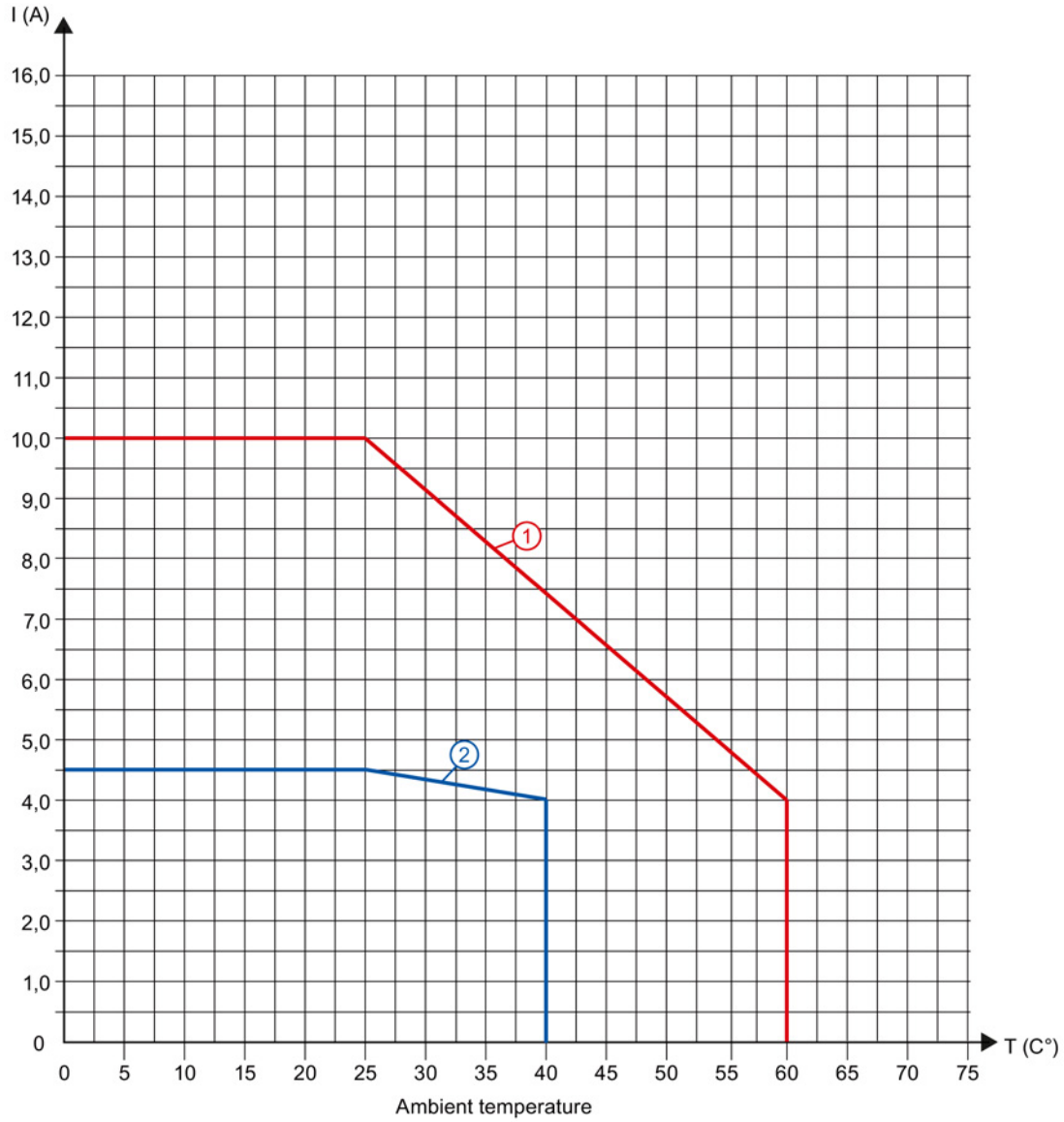
	6ES7522-5FF00-0AB0
Product type designation	DQ 8x230VAC/2A ST (Triac)
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
Output voltage	
Rated value (AC)	120/230 V AC; 50/60Hz
Power	
Power consumption from the backplane bus	0.9 W
Power loss	
Power loss, typ.	10.8 W
Digital outputs	
Type of digital output	Triac
Number of outputs	8
Switching to P potential	Yes
Digital outputs, configurable	Yes
Short-circuit protection	No
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	50 W
Output voltage	
Type of output voltage	AC
for signal "1", min.	L1 (-1.5 V) at maximum output current; L1 (-8.5 V) at minimum output current

	6ES7522-5FF00-0AB0
Output current	
for signal "1" rated value	2 A
for signal "1" permissible range, min.	10 mA
for signal "1" permissible range, max.	15 A; (for max. 1 AC cycle)
for signal "0" residual current, max.	2 mA
Output delay with resistive load	
"0" to "1", max.	1 AC cycle
"1" to "0", max.	1 AC cycle
Parallel switching of 2 outputs	
For logic operations	No
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	10 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	1 Hz
Total current of outputs	
Max. current per channel	2 A; (see additional description in the manual)
Max. current per group	2 A; (see additional description in the manual)
Max. current per module	10 A; (see additional description in the manual)
Triac outputs	
Size of motor starter according to NEMA, max.	5
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	No
Diagnostics alarms	
Diagnostics	No
Monitoring of supply voltage	No
Wire break	No
Short-circuit	No
Fuse blown	No

	6ES7522-5FF00-0AB0
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	No
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels, in groups of	1
Between the channels and the backplane bus	Yes
between the channels and the load voltage L1	Yes
Permitted potential difference	
Between different circuits	250 V AC between the channels and the backplane bus; 500 V AC between the channels
Isolation	
Isolation tested with	2500 V DC
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	290 g

Power reduction (derating) to aggregate current of outputs (per module)

The following graphs show the loading capacity of the outputs in relation to the mounting position and the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Details on aggregate current of outputs (per module)

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

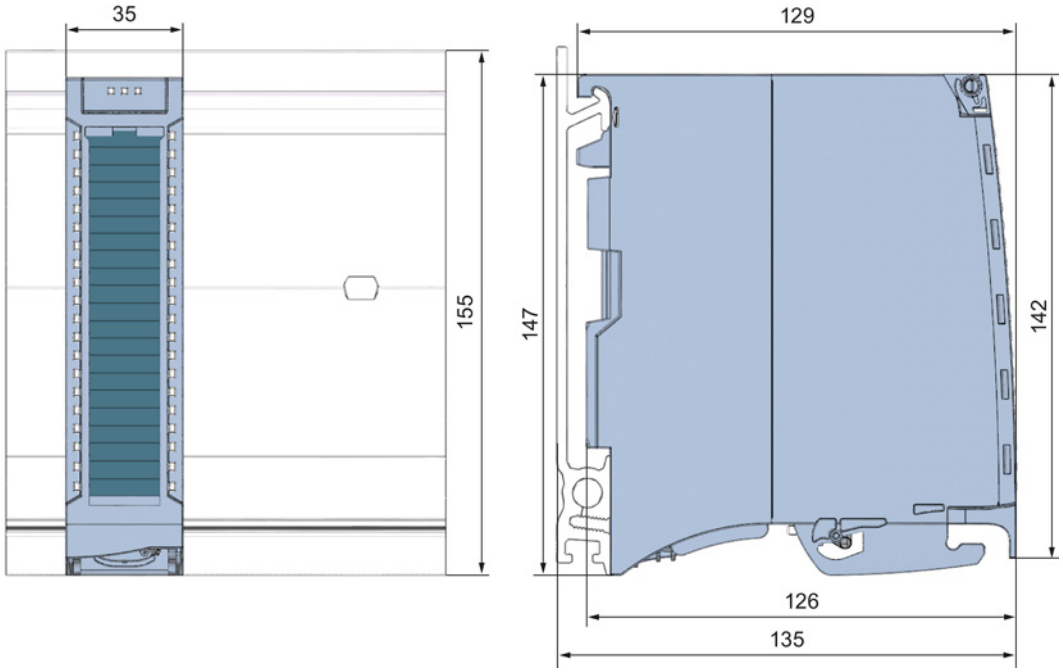


Figure A-1 Dimensional drawing of the DQ 8x230VAC/2A ST module

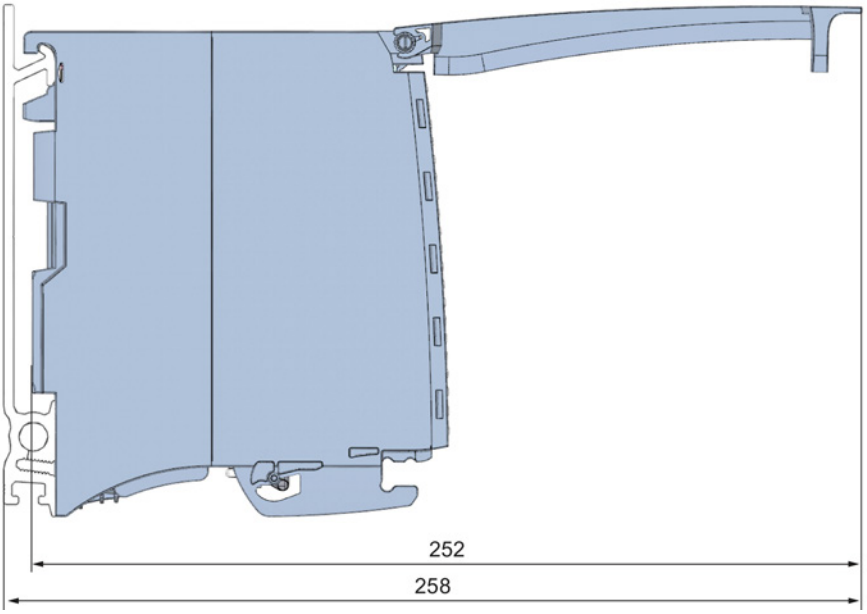


Figure A-2 Dimensional drawing of the DQ 8x230VAC/2A ST module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 71. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The channel parameters of the module are included in data records 64 to 71 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- Data record 66 for channel 2
- Data record 67 for channel 3
- Data record 68 for channel 4
- Data record 69 for channel 5
- Data record 70 for channel 6
- Data record 71 for channel 7

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

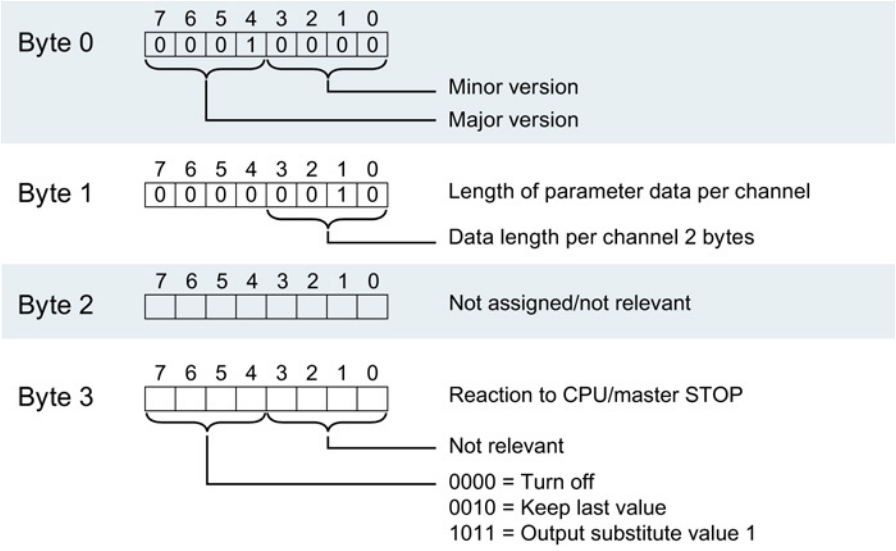


Figure B-1 Structure of data record 64: Bytes 0 to 3

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S7-1500/ET 200MP DQ 8x230VAC/5A ST Digital Output Module (6ES7522-5HF00-0AB0)

Manual

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08/2013

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital output module DQ 8x230VAC/5A ST

The following table lists further documentation that you will need when using the DQ 8x230VAC/5A ST digital output module.

Table 1- 1 Documentation for digital output module DQ 8x230VAC/5A ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7522-5HF00-0AB0

View of the module

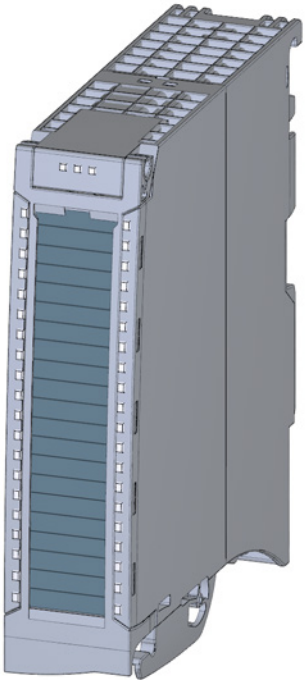


Figure 2-1 View of the DQ 8x230VAC/5A ST module

Properties

Properties of the digital module:

- Technical properties
  - 8 digital outputs (relays)
  - Supply voltage of the 24 V DC relay coils
  - Rated output voltage 230 V AC
  - Rated output current 5 A
  - Assignable substitute values (per channel)
  - Assignable diagnostics (per channel group)
  - Suitable for solenoid valves, DC contactors, and indicator lights

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Abbreviations used

Meaning of the abbreviations used in the following figures:

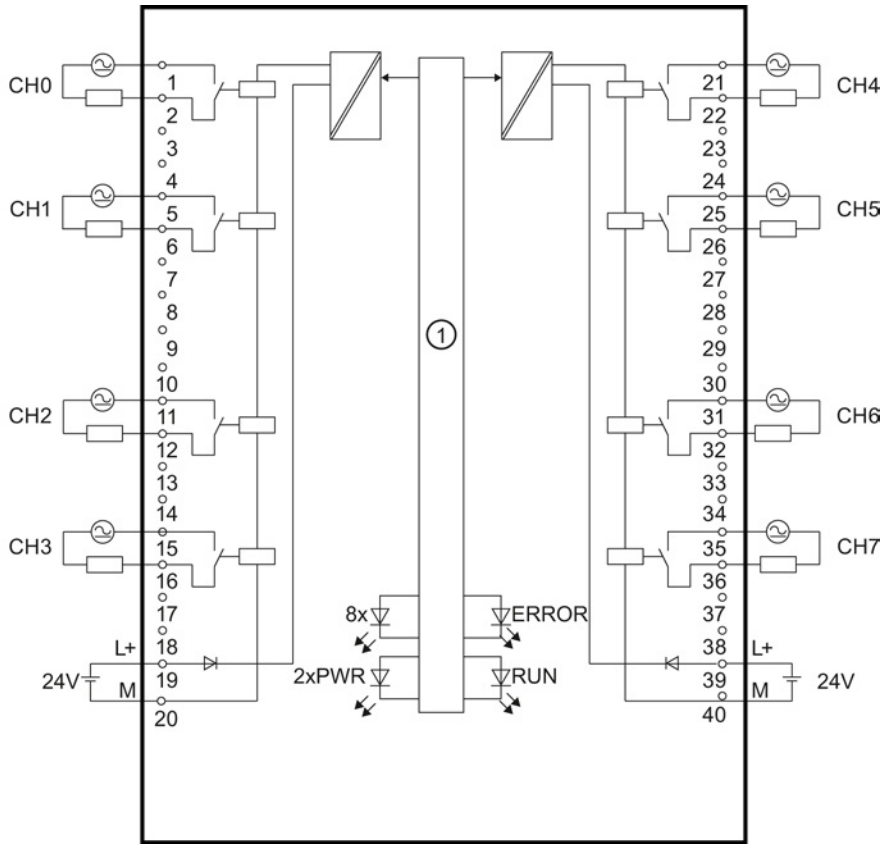
L+	Connection for supply voltage of relay contacts
M	Ground connection
CHx	Channel or display of the channel status
PWRx	Display for the supply voltage (POWER)

Note

Note that the 24V DC supply voltage for this module must always be supplied by terminals 19/20 **and** terminals 39/40. Use the included potential jumpers for this purpose.

Block diagram and terminal assignment

The example in the following figure shows the terminal assignment and the assignment of the channels.



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to distribute the 24V DC supply voltage to a neighboring module. This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between terminals 19 and 39 (L+) and between terminals 20 and 40 (M).
3. Use the terminals 39 and 40 to loop the potential to the next module.

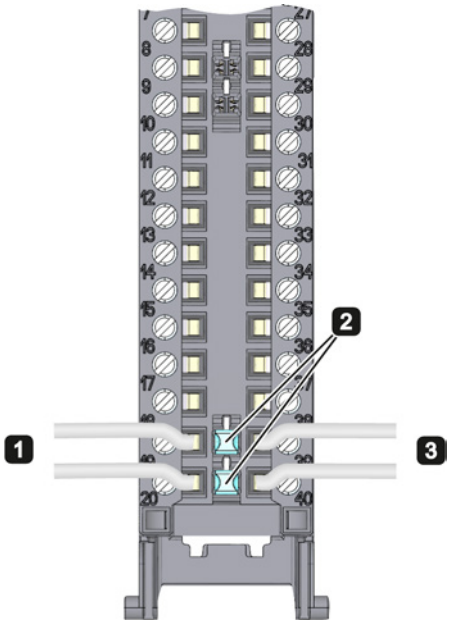


Figure 3-2 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded.

Parameters/address space 4

4.1 Parameters

DQ 8x230VAC/5A ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 31).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel group	Channel group
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Channel

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of DQ 8x230VAC/5A ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x230VAC/5A ST	X	X
1 x 8-channel with value status	DQ 8x230VAC/5A ST QI	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x230VAC/5A ST MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 8x230VAC/5A ST QI
- DQ 8x230VAC/5A ST MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 8-channel DQ 8x230VAC/5A ST

The following figure shows the assignment of the address space for the configuration as a 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "For example, AB a" stands for module start address output byte a.

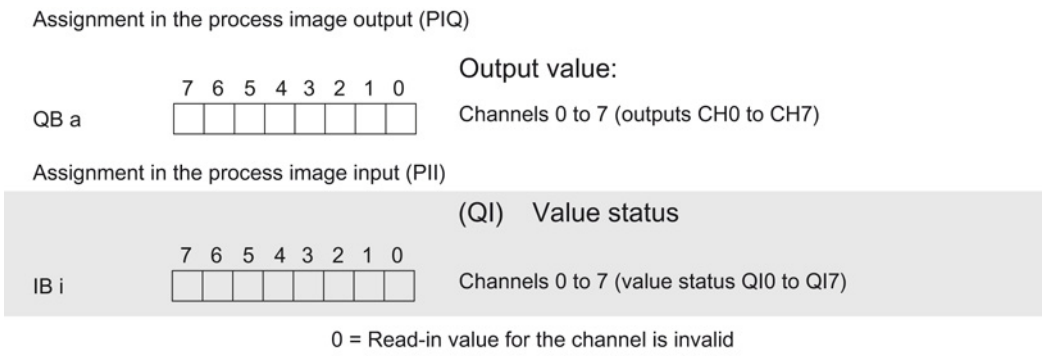


Figure 4-1 Address space for configuration as 8-channel DQ 8x230VAC/5A ST with value status

Address space for configuration as 1 x 8-channel DQ 8x230VAC/5A ST MSO

For the configuration as a 1 x 8-channel module (module-internal shared output, MSO), channels 0 to 7 of the module are copied to multiple submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status.

Assignment in the process image output (PIQ) for 1st submodule

	7 6 5 4 3 2 1 0	1st submodule (basic submodule):
QB a		Channels 0 to 7 (outputs CH0 to CH7)
IB i	7 6 5 4 3 2 1 0	(QI) Value status
		Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 2nd submodule

		2nd submodule (MSO submodule): Read-back output values
IB b	7 6 5 4 3 2 1 0	Channels 0 to 7 (outputs CH0 to CH7)
IB (=b+1)	7 6 5 4 3 2 1 0	(QI) Value status
		Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 3rd submodule

		3rd submodule (MSO submodule): Read-back output values
IB c	7 6 5 4 3 2 1 0	Channels 0 to 7 (outputs CH0 to CH7)
IB (=c+1)	7 6 5 4 3 2 1 0	(QI) Value status
		Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 4th submodule

		4th submodule (MSO submodule): Read-back output values
IB d	7 6 5 4 3 2 1 0	Channels 0 to 7 (outputs CH0 to CH7)
IB (=d+1)	7 6 5 4 3 2 1 0	(QI) Value status
		Channels 0 to 7 (value status QI0 to QI7)

0 = Read-in value for the channel is invalid

Figure 4-2 Address space for configuration as 1 x 8-channel DQ 8x230VAC/5A ST S MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of the DQ 8x230VAC/5A ST.

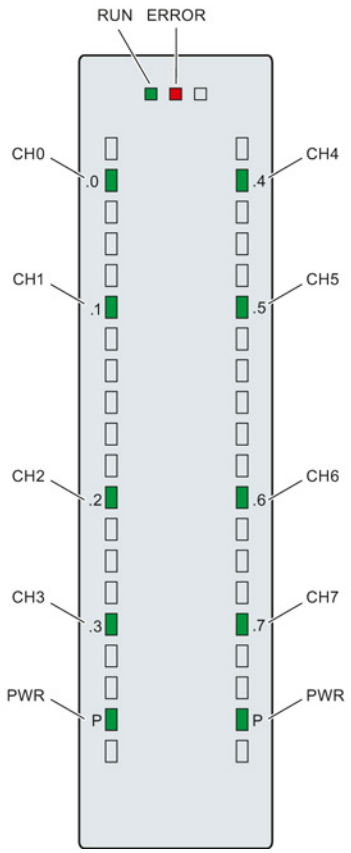


Figure 5-1 LEDdisplays of the module DQ 8x230VAC/5A ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 21).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module error because supply voltage L+ is missing	Evaluate the diagnostics data and eliminate the error.
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	Remedy
Off	Supply voltage L+ too low or missing	Check the L+ supply voltage.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
Off	0 = Status of the output signal	---
On	1 = Status of the output signal	---

5.2 Interrupts

Digital output module DQ 8x230VAC/5A ST supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following event:

- Missing supply voltage L+

For more information on the error event, refer to the error OB with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 Online Help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel

Technical specifications

6

Technical specifications of the DQ 8x230VAC/5A ST

	6ES7522-5HF00-0AB0
Product type designation	DQ 8x230VAC/5A ST (Relay)
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	80 mA
Power	
Power consumption from the backplane bus	0.8 W
Power loss	
Power loss, typ.	5 W
Digital outputs	
Type of digital output	Relay
Number of outputs	8
Switching to M potential	Yes
Switching to P potential	Yes
Digital outputs, configurable	Yes
Short-circuit protection	No
Control of a digital input	possible

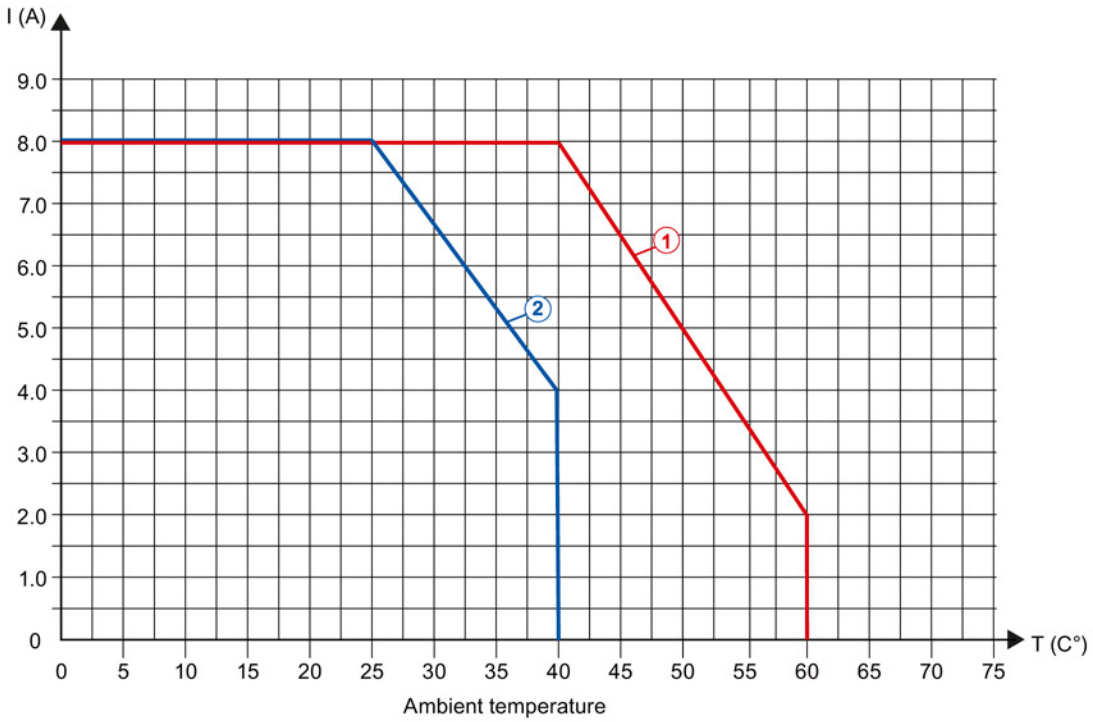
	6ES7522-5HF00-0AB0
Switching capacity of outputs	
With lamp load, max.	1500 W; (10,000 switching cycles)
Low energy/fluorescent lamps with electronic control gear	10 x 58 W (25,000 switching cycles)
Fluorescent tubes, conventionally compensated	1 x 58 W (25,000 switching cycles)
Fluorescent tubes, uncompensated	10 x 58 W (25,000 switching cycles)
Output current	
for signal "1" rated value	5 A
for signal "1" permissible range, min.	5 mA; (10 V)
for signal "1" permissible range, max.	8 A; (thermal continuous current)
for signal "0" residual current, max.	0 A
Parallel switching of 2 outputs	
For logic operations	Yes
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	2 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	2 Hz
Total current of outputs	
Max. current per channel	8 A; (see additional description in the manual)
Max. current per group	8 A; (see additional description in the manual)
Max. current per module	64 A; (see additional description in the manual)
Relay outputs	
Number of relay outputs	8
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	80 mA
External fuse for relay outputs	With miniature circuit breaker with characteristic B for: cos φ 1.0: 600 A cos Φ 0.5 ... 0.7: 900 A Diazed fuse 8 A: 1000 A
Contact connection (internal)	No
Size of motor starter according to NEMA, max.	5
Number of switching cycles, max.	4000000; (see additional description in the manual)
Relay approved acc. to UL 508	Yes; 250 V AC/5 A g.p.; 120 V AC TV-4 Tungsten; A300, R300
Switching capacity of the contacts	
• With inductive load, max.	(see additional description in the manual)
• With resistive load, max.	(see additional description in the manual)
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m

	6ES7522-5HF00-0AB0
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes; Switching of different phases permitted
Between the channels, in groups of	1
Between the channels and the backplane bus	Yes
Between the channels and the load voltage L+	Yes
Permitted potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation) between the backplane bus and the supply voltage L+; 250 V AC between the channels and the supply voltage L+; 250 V AC between the channels and the backplane bus; 500 V AC between the channels
Isolation	
Isolation tested with	between the channels: 2500 V DC; between the channels and backplane bus: 2500 V DC; between L+ and backplane bus 707 V DC (Type Test)
Distributed mode	
Prioritized startup	Yes

	6ES7522-5HF00-0AB0
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	350 g

Power reduction (derating) to aggregate current of outputs (per channel)

The following graphs show the loading capacity of the relay contacts in relation to the mounting position and the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Details on aggregate current of outputs (per channel)

Details on the number of switching cycles

The following tables list the permissible number of switching cycles depending on the applied voltage and current load. Different values apply in each case to resistive and inductive loads.

Table 6- 1 Switching capacity and service life of relay contacts for resistive load

For resistive load		
Voltage	Current	Number of switching cycles (typ.)
24 V DC	8.0 A	0.1 million
	5.0 A	0.2 million
	2.5 A	0.7 million
	2.0 A	1.0 million
	1.5 A	2.0 million
	0.5 A	4.0 million
60 V DC	0.5 A	4.0 million
120 V DC	0.2 A	1.6 million
	0.1 A	2.0 million
24 V AC	8.0 A	0.1 million
48 V AC	8.0 A	0.1 million
	2.0 A	1.6 million
60 V AC	8.0 A	0.1 million
	2.0 A	1.2 million
120 V AC	8.0 A	0.1 million
	5.0 A	0.2 million
	4.0 A	0.3 million
	2.0 A	0.5 million
	1.0 A	0.7 million
	0.5 A	1.5 million
230 V AC	8.0 A	0.1 million
	5.0 A	0.2 million
	4.0 A	0.3 million
	2.5 A	0.4 million
	2.0 A	0.5 million
	1.0 A	0.7 million
	0.5 A	1.5 million
	0.2 A	1.7 million
	0.1 A	2.0 million

Table 6- 2 Switching capacity and lifetime of the relay contacts for inductive load

For inductive load		
Voltage	Current	Number of switching cycles (typ.)
24 V DC	2.5 A	0.25 million
	2.0 A	0.3 million
	1.0 A	0.5 million
	0.5 A	1.0 million
	0.2 A	2.0 million
60 V DC	0.5 A	0.5 million
	0.3 A	1.0 million
120 V DC	0.1 A	1.2 million
	0.2 A	0.5 million
24 V AC	3.0 A	0.5 million
48 V AC	1.5 A	1.0 million
	3.0 A	0.4 million
60 V AC	1.5 A	1.0 million
	3.0 A	0.3 million
120 V AC	5.0 A	0.1 million
	3.0 A	0.2 million
	2.0 A	0.3 million
	1.0 A	0.7 million
	0.5 A	2.0 million
230 V AC	5.0 A	0.1 million
	3.0 A	0.2 million
	2.5 A	0.4 million
	2.0 A	0.3 million
	1.0 A	0.7 million
	0.5 A	2.0 million
	0.2 A	3.0 million
	0.1 A	4.0 million

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

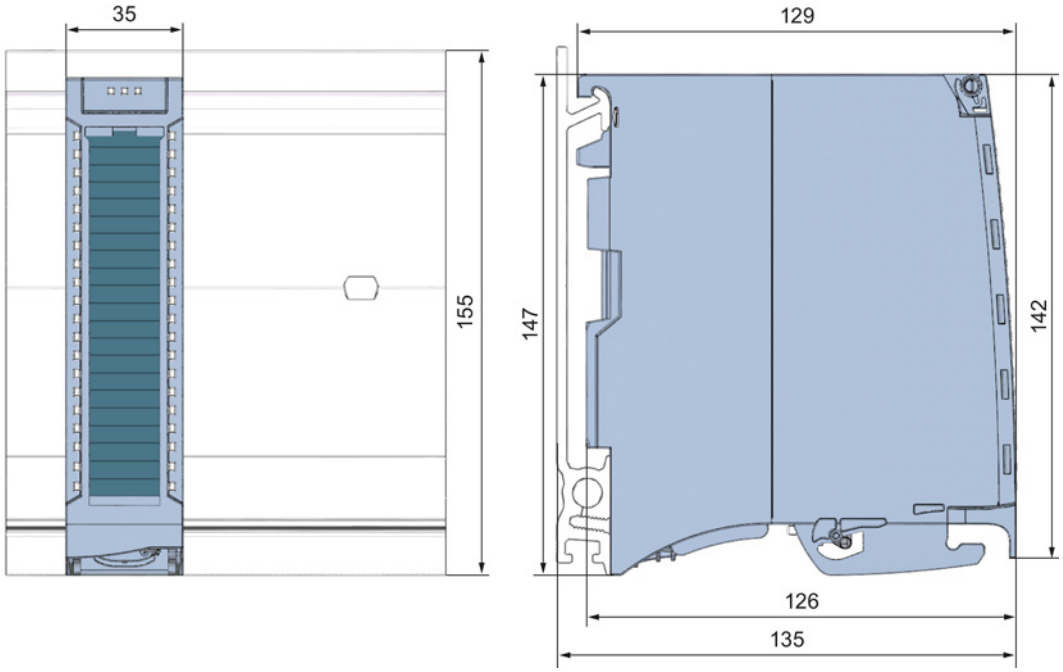


Figure A-1 Dimensional drawing of the DQ 8x230VAC/5A ST module

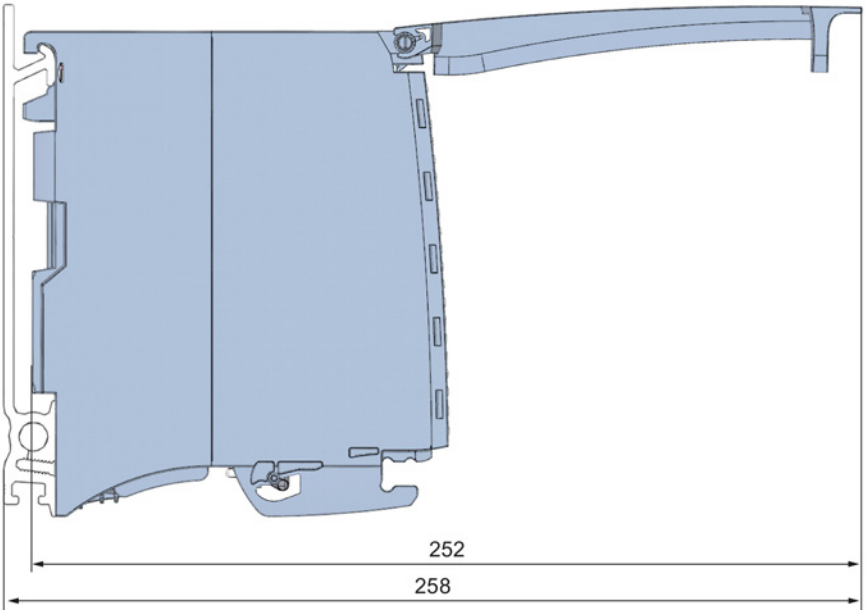


Figure A-2 Dimensional drawing of the DQ 8x230VAC/5A ST module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 71. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The channel parameters of the module are included in data records 64 to 71 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- Data record 66 for channel 2
- Data record 67 for channel 3
- Data record 68 for channel 4
- Data record 69 for channel 5
- Data record 70 for channel 6
- Data record 71 for channel 7

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

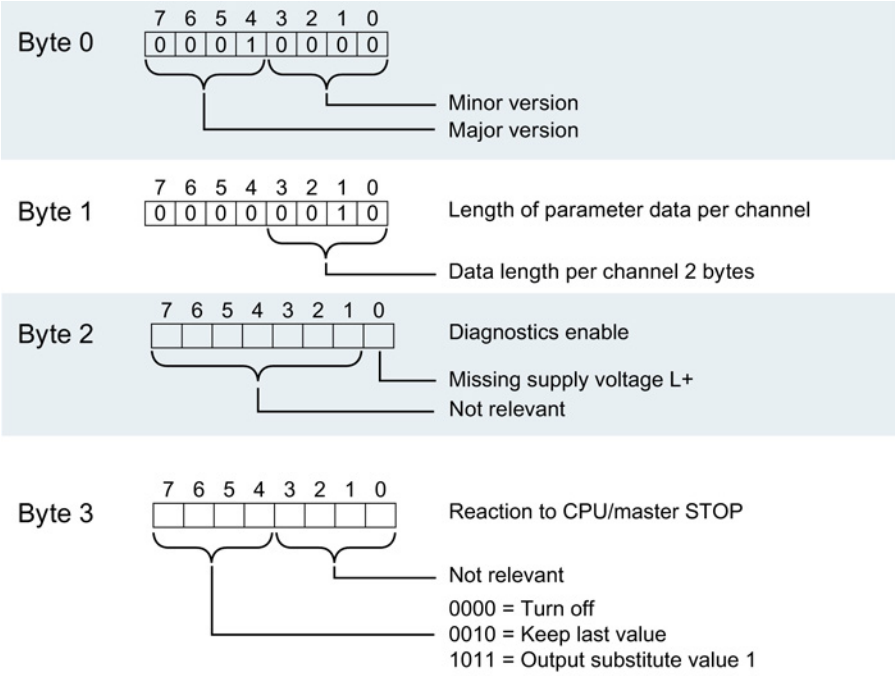


Figure B-1 Structure of data record 64: Bytes 0 to 3

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S7-1500/ET 200MP DQ 8x24VDC/2A HF Digital Output Module (6ES7522-1BF00-0AB0)

Manual

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08/2013

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital output module DQ 8x24VDC/2A HF

The following table lists further documentation that you will need when using the DQ 8x24VDC/2A HF digital output module.

Table 1- 1 Documentation for digital output module DQ 8x24VDC/2A HF

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7522-1BF00-0AB0

View of the module

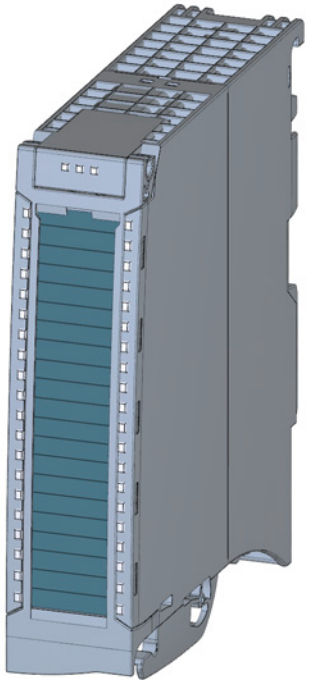


Figure 2-1 View of the DQ 8x24VDC/2A HF module

Properties

Properties of the digital module:

- Technical properties
  - 8 digital outputs
  - Rated output voltage 24 V DC
  - Rated output current 2 A
  - Assignable substitute values (per channel)
  - Configurable diagnostics (per channel)
  - Suitable for solenoid valves, contactors, DC contactors and indicator lights

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information, for example, on front connector wiring and creating cable shields, refer to the section "Wiring" in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

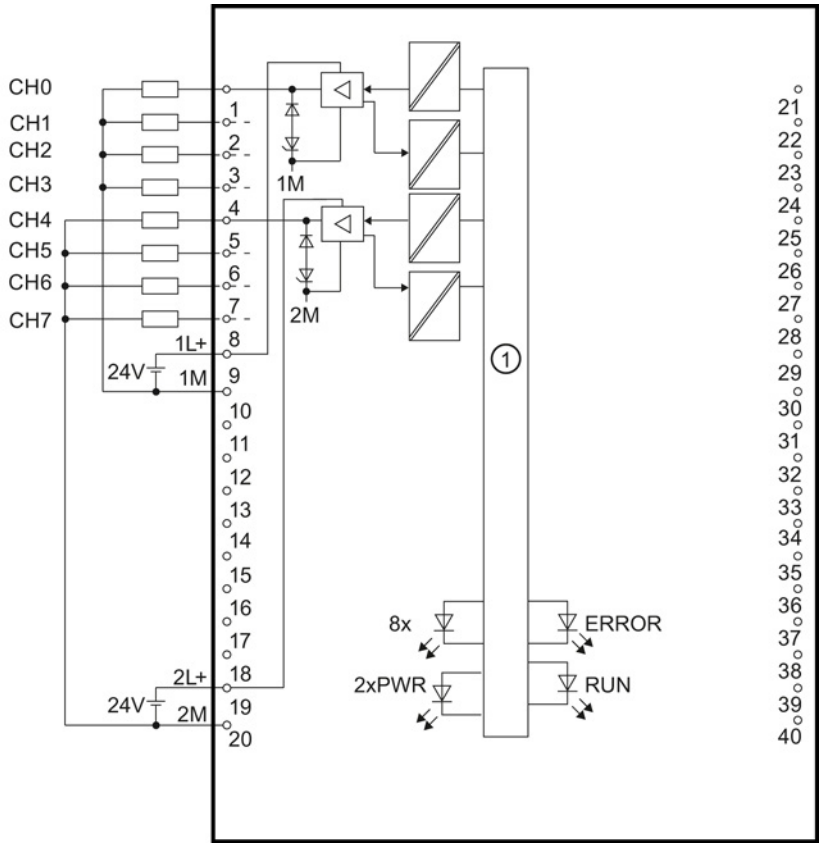
Abbreviations used

Meaning of the abbreviations used in the following figures:

xL+	Supply voltage connection
xM	Ground connection
CHx	Channel or display of the channel status
PWRx	Display for the supply voltage (POWER)

Block diagram and terminal assignment

The example in the following figure shows the terminal assignment and the assignment of the channels.



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to connect the four load groups to the same potential (non-isolated). This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between the following terminals:
   - 9 and 29 (L+)
   - 10 and 30 (M)
   - 19 and 39 (L+)
   - 20 and 40 (M).
3. Insert the jumpers between terminals 29 and 39, as well as 30 and 40.
4. Use the terminals 9 and 10 to loop the potential to the next module.

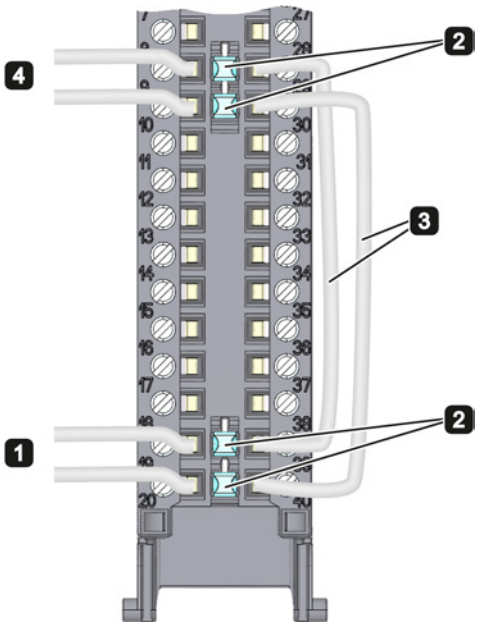


Figure 3-2 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded.

Parameters/address space 4

4.1 Parameters

DQ 8x24VDC/2A HF parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 29).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel*	Channel*
• Short circuit to M	Yes/No	No	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Channel

* If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of DQ 8x24VDC/2A HF

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC/2A HF	X	X
1 x 8-channel with value status	DQ 8x24VDC/2A HF QI	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x24VDC/2A HF MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 8x24VDC/2A HF QI
- DQ 8x24VDC/2A HF MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 8-channel DQ 8x24VDC/2A HF

The following figure shows the assignment of the address space for the configuration as a 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "For example, AB a" stands for module start address output byte a.

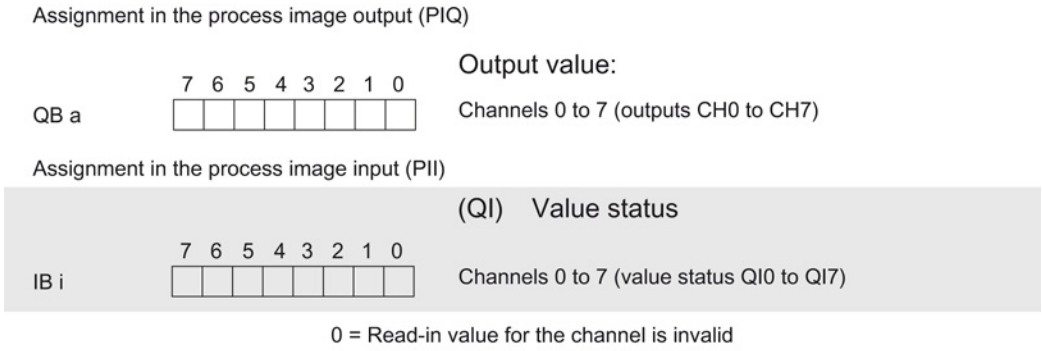


Figure 4-1 Address space for configuration as 8-channel DQ 8x24VDC/2A HF with value status

Address space for configuration as 1 x 8-channel DQ 8x24VDC/2A HF MSO

For the configuration as a 1 x 8-channel module (module-internal shared output, MSO), channels 0 to 7 of the module are copied to multiple submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status.

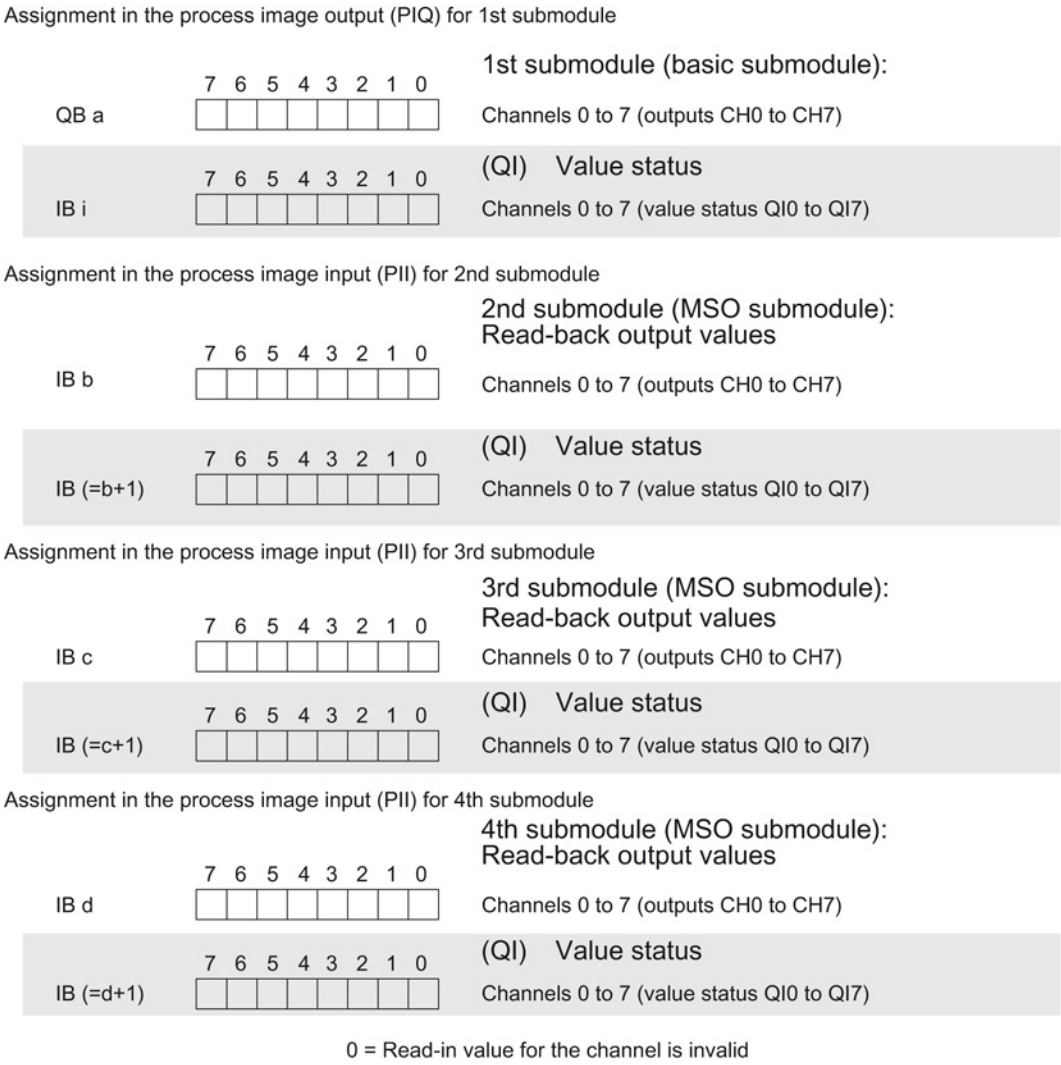


Figure 4-2 Address space for configuration as 1 x 8-channel DQ 8x24VDC/2A HF MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of DQ 8x24VDC/2A HF.

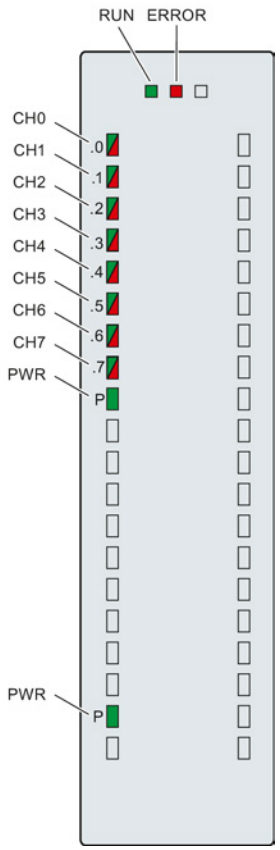


Figure 5-1 LEDdisplays of the module DQ 8x24VDC/2A HF

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 21).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus.	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured.	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., short-circuit to ground).	Evaluate the diagnostics data and eliminate the error (e.g., check the cables).
Flashes	Flashes	Hardware defective.	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	Remedy
Off	Supply voltage L+ too low or missing.	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
□ Off	0 = Status of the output signal.	---
■ On	1 = Status of the output signal.	---
■ On	Channel parameters assigned (channel fault pending; a short-circuit to ground is pending at the respective channel).	Check the wiring and remedy the short-circuit to ground.
	Supply voltage L+ too low or missing.	Check supply voltage L+.

5.2 Interrupts

Digital output module DQ 8x24VDC/2A HF supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Short-circuit to ground

For more information on the error event, refer to the error OB with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 Online Help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Short circuit to M	1_H	Short-circuit or overload at the channel	Check the wiring/actuator. Check the ambient temperature.
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel

Technical specifications

6

Technical specifications of the DQ 8x24VDC/2A HF

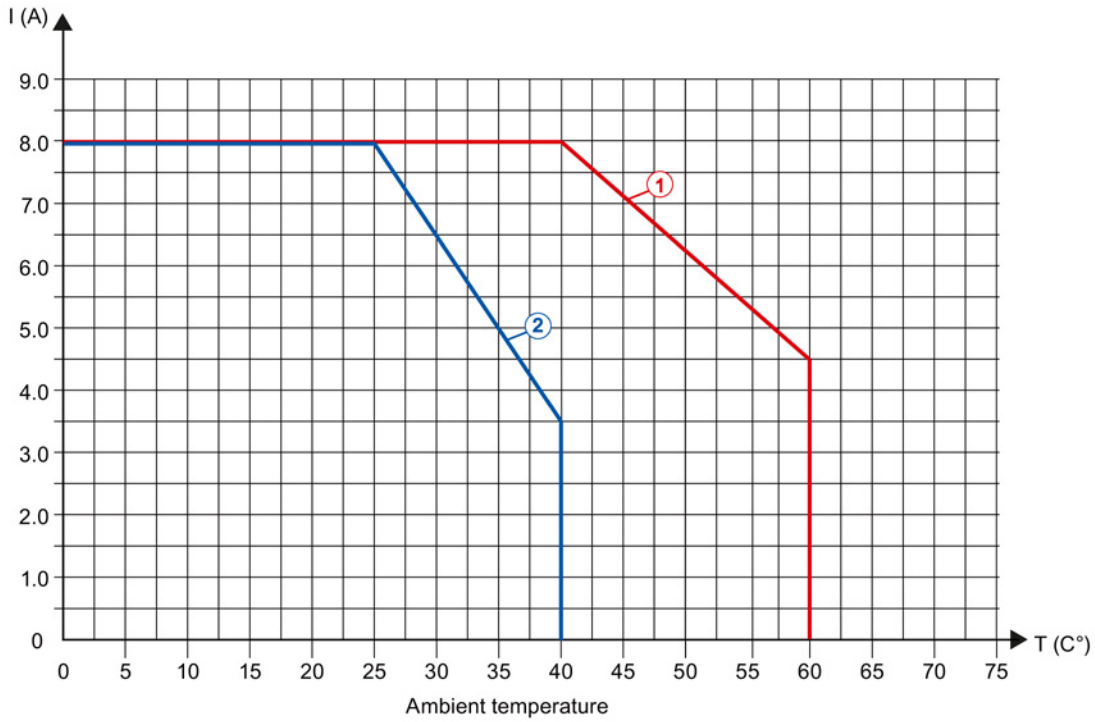
	6ES7522-1BF00-0AB0
Product type designation	DQ 8x24VDC/2A HF
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes; through internal protection with 10 A per group
Input current	
Current consumption, max.	40 mA; 20 mA per group, no output activated.
Output voltage	
Rated value (DC)	24 V
Power	
Power consumption from the backplane bus	0.9 W
Power loss	
Power loss, typ.	5.6 W

	6ES7522-1BF00-0AB0
Digital outputs	
Type of digital output	Transistor
Number of outputs	8
Switching to P potential	Yes
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic clocking
• Response threshold, typ.	3 A
Limitation of inductive shutdown voltage to	-17 V
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	4 kΩ
Output voltage	
Type of output voltage	DC
for signal "1", min.	L+ (-0.8 V)
Output current	
for signal "1" rated value	2 A
for signal "1" permissible range, max.	2.4 A
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	100 µs
"1" to "0", max.	500 µs
Parallel switching of 2 outputs	
For logic operations	Yes
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	0.5 Hz; acc. to IEC 947-5-1, DC13
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per channel	2 A; (see additional description in the manual)
Max. current per group	8 A; (see additional description in the manual)
Max. current per module	16 A; (see additional description in the manual)
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No

	6ES7522-1BF00-0AB0
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	Yes
Fuse blown	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	4
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	240 g

Power reduction (derating) to aggregate current of outputs (per group)

The following graphs show the loading capacity of the outputs in relation to the mounting position and the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Details on aggregate current of outputs (per group)

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

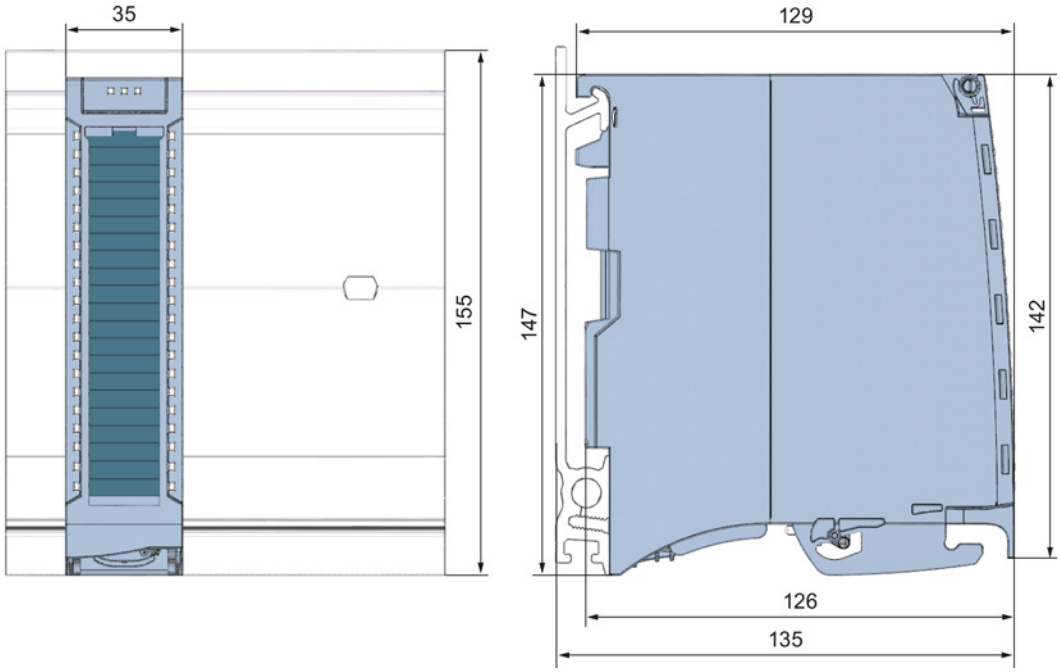


Figure A-1 Dimensional drawing of the DQ 8x24VDC/2A HF module

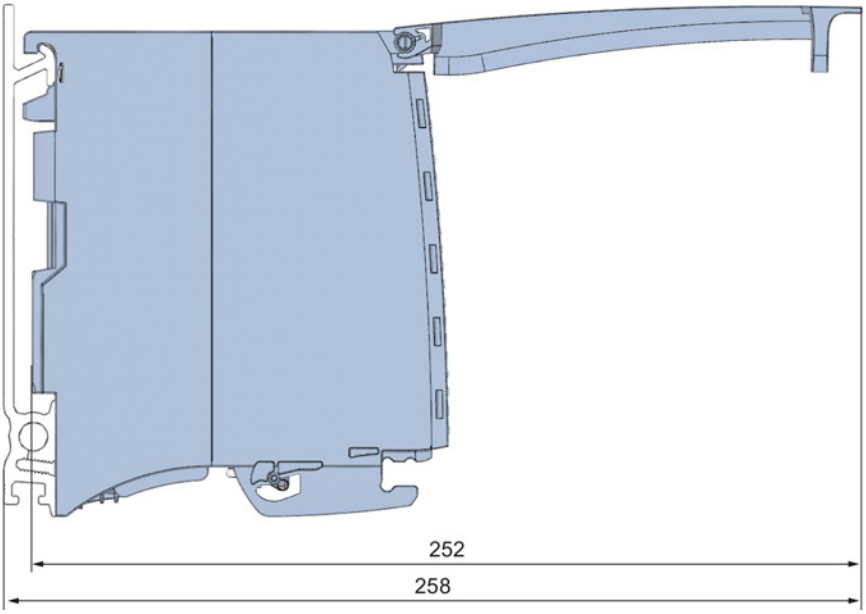


Figure A-2 Dimensional drawing of the DQ 8x24VDC/2A HF module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 71. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The channel parameters of the module are included in data records 64 to 71 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- Data record 66 for channel 2
- Data record 67 for channel 3
- Data record 68 for channel 4
- Data record 69 for channel 5
- Data record 70 for channel 6
- Data record 71 for channel 7

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

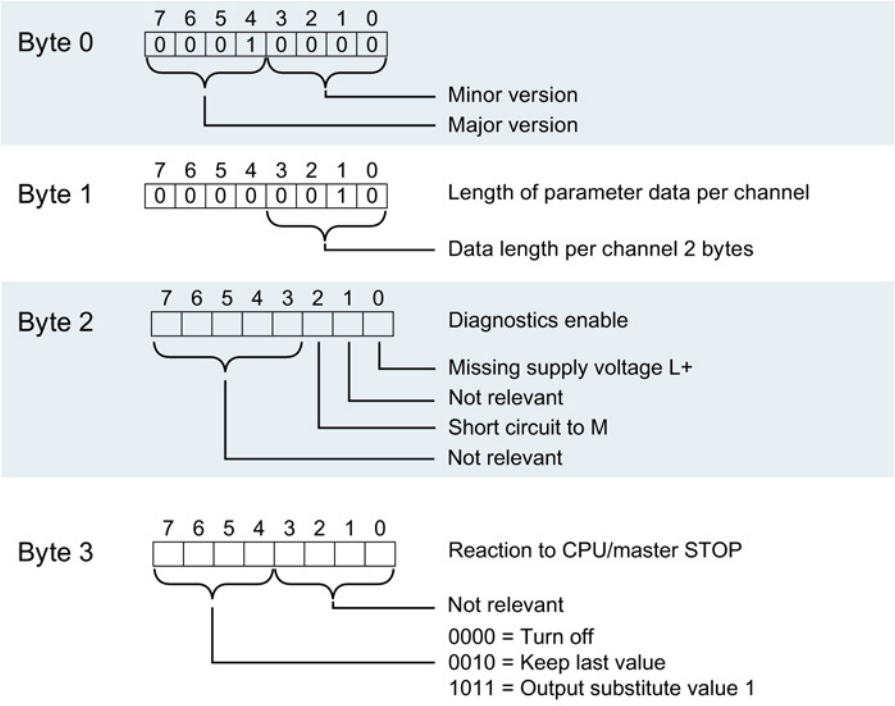


Figure B-1 Structure of data record 64: Bytes 0 to 3

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S7-1500/ET 200MP DI 16x230VAC BA Digital Input Module (6ES7521-1FH00-0AA0)

Manual

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08/2013

A5E03485975-02

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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GERMANY

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared input (MSI) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital input module DI 16x230VAC BA

The following table lists additional documentation that you will need when using the DI 16x230VAC BA digital input module.

Table 1- 1 Documentation for digital input module DI 16x230VAC BA

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7521-1FH00-0AA0

View of the module

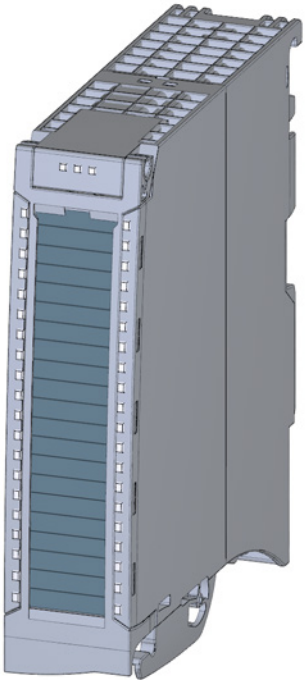


Figure 2-1 View of the DI 16x230VAC BA module

Properties

The module is characterized by the following properties:

- Technical properties
  - 16 digital inputs; electrically isolated in groups of 4
  - Rated input voltage 120/230 V AC
  - Suitable for switches and 2-/3-/4-wire AC proximity switches (alternating voltage)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Note

Do not insert the potential jumpers included with the front connector!

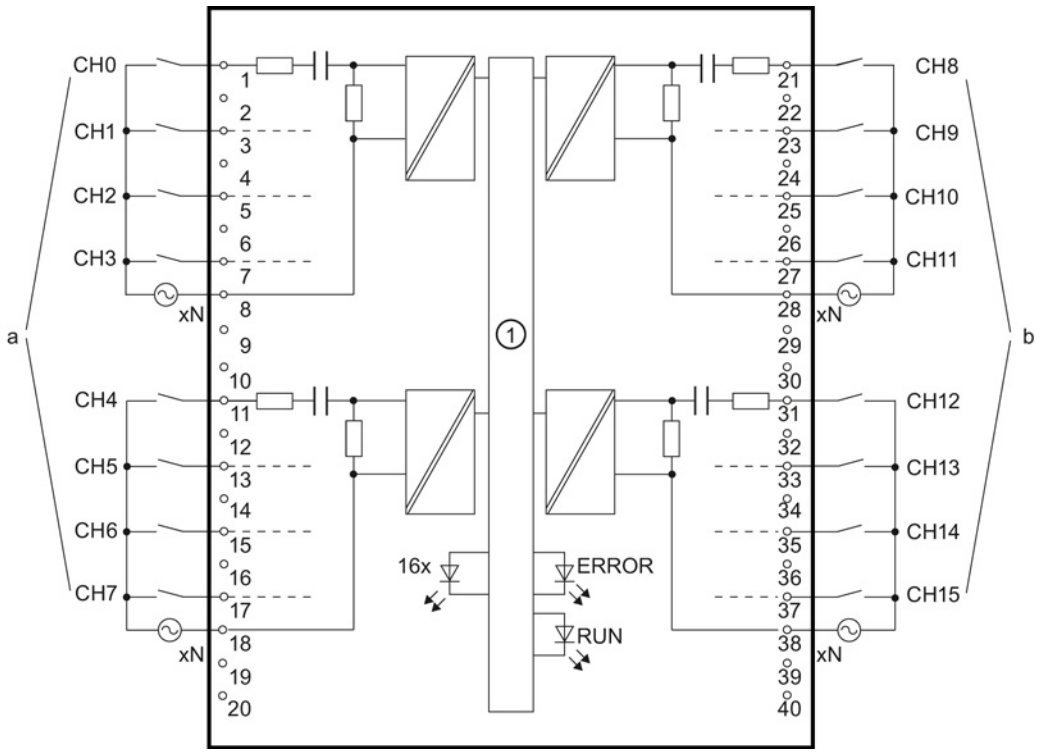
Abbreviations used

Meaning of the abbreviations used in the following figures:

xN	Supply voltage connection AC
CHx	Channel or display of the channel status

Wiring and block diagrams

The figure below shows you how to connect the module and channel addressing (input byte a to input byte b).



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Address space 4

4.1 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

The letters "a to d" are printed onto the module. "IB a" for example, stands for module start address input byte a.

Configuration options of DI 16x230VAC BA

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 1 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DI 16x230VAC BA	X	X
2 x 8-channel without value status	DI 16x230VAC BA S	X	---
1 x 16-channel with value status for module-internal Shared Input with up to 4 submodules	DI 16x230VAC BA MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the DI 16x230VAC BA MSI module:

An additional bit is assigned to each channel for the value status. In contrast to the modules with diagnostics capability, the module indicates only information regarding the parameter assignment of the first submodule (basic submodule) in the value status.

The module does not supply a value status for the read-in digital value.

Address space for configuration as DI 16x230VAC BA

The following figure shows the address space allocation for the configuration as 16-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

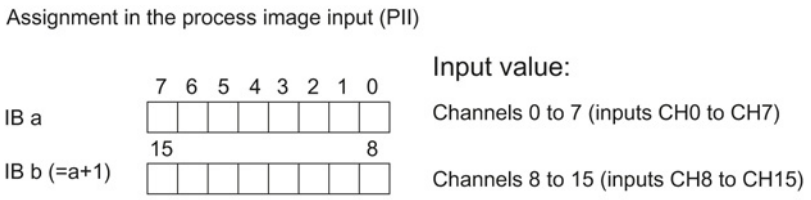


Figure 4-1 Address space for configuration as 16-channel DI 16x230VAC BA

Address space for configuration as 2 x 8-channel DI 16x230VAC BA S

For the configuration as a 2 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 16-channel module configuration, each of the two submodules has a freely assignable start address.

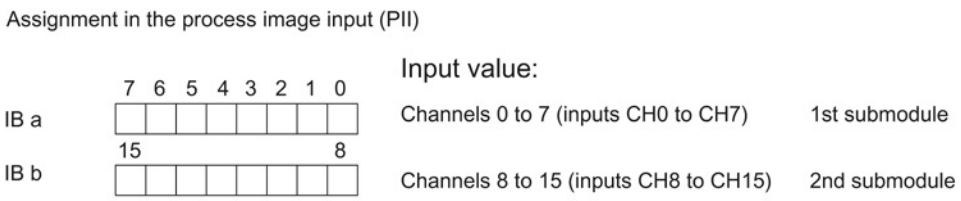


Figure 4-2 Address space for configuration as 2 x 8-channel DI 16x24VDC SRC BA S

Address space for configuration as 1 x 16-channel DI 16x230VAC BA MSI

The channels 0 to 15 of the module are copied in up to four submodules with configuration 1 x 16-channel module (Module-internal shared input, MSI). Channels 0 to 15 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basis submodule), the value status is not relevant.

For the second to fourth submodules (=MSI submodule), the value status 0 indicates that the basic submodule parameters have not yet been assigned (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

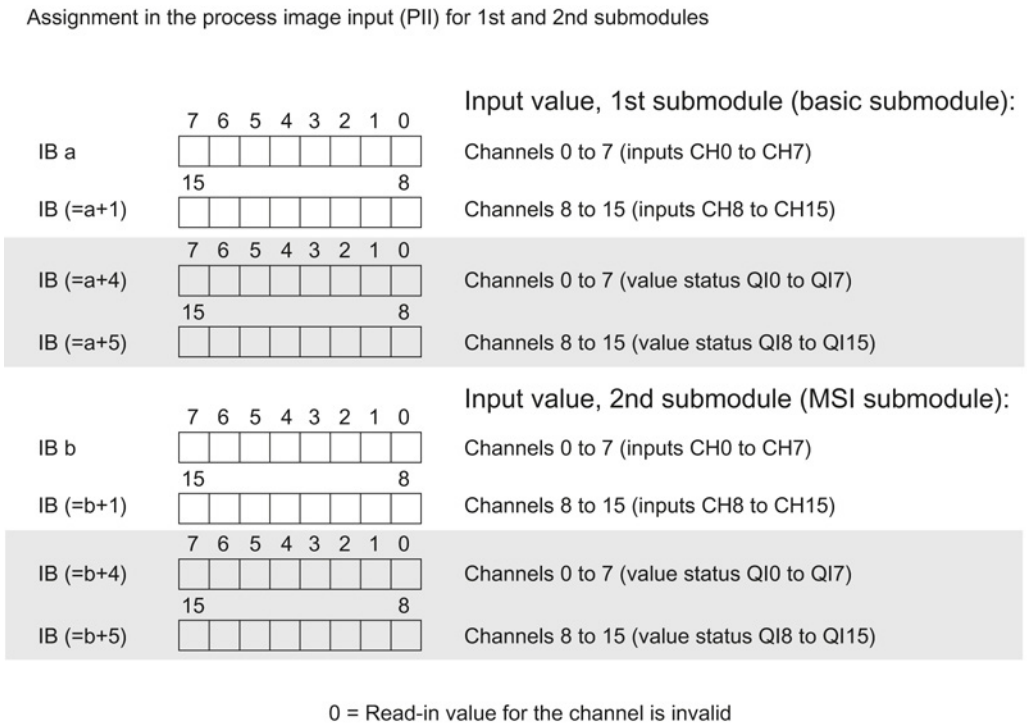


Figure 4-3 Address space for configuration as 1 x 16-channel DI 16x230VAC BA MSI

The following figure shows the assignment of the address space with submodules 3 and 4.

Assignment in the process image input (PII) for 3rd and 4th submodules

		Input value, 3rd submodule (MSI submodule):
	7 6 5 4 3 2 1 0	
IB c		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=c+1)		Channels 8 to 15 (inputs CH8 to CH15)
	7 6 5 4 3 2 1 0	
IB (=c+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=c+5)		Channels 8 to 15 (value status QI8 to QI15)
		Input value, 4th submodule (MSI submodule):
	7 6 5 4 3 2 1 0	
IB d		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=d+1)		Channels 8 to 15 (inputs CH8 to CH15)
	7 6 5 4 3 2 1 0	
IB (=d+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=d+5)		Channels 8 to 15 (value status QI8 to QI15)

0 = Read-in value for the channel is invalid

Figure 4-4 Address space for configuration as 1 x 16-channel DI 16x230VAC BA MSI

Diagnostic alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LEDs (status and error displays) of the DI 16x230VAC BA.

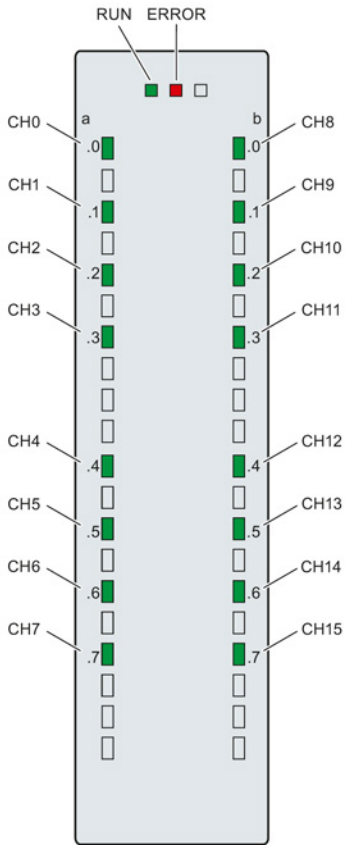


Figure 5-1 LED displays of the module DI 16x230VAC BA

Meaning of the LED displays

The following table explains the meaning of the status and error displays.

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	Module starts up	---
On	Off	Module is ready	
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 CHx status display

LED CHx	Meaning	To correct or avoid errors
Off	0 = Status of the input signal	---
On	1 = Status of the input signal	---

Technical specifications

6

Technical specifications of the DI 16x230VAC BA

	6ES7521-1FH00-0AA0
Product type designation	DI 16x230VAC BA
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
Power	
Power consumption from the backplane bus	1 W
Power loss	
Power loss, typ.	4.9 W
Digital inputs	
Number of inputs	16
reading m/p	reading p
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input voltage	
Type of input voltage	AC
Rated value, AC	230 V; 120/230 V AC; 60/50Hz
for signal "0"	0 to 40 V AC
for signal "1"	79 to 264 V AC
Input current	
for signal "1", typ.	11 mA; at 230 V AC and 5.5 mA at 120 V AC

	6ES7521-1FH00-0AA0
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	No
• with "0" to "1", max.	25 ms
• with "1" to "0", max.	25 ms
For interrupt inputs	
• Configurable	No
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	2 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	No
Hardware interrupt	No
Diagnostics alarms	
Monitoring of supply voltage	No
Wire break	No
Short-circuit	No
Fuse blown	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	No
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	4
Between the channels and the backplane bus	Yes

	6ES7521-1FH00-0AA0
Permitted potential difference	
Between different circuits	250 V AC between the channels and the backplane bus; 500 V AC between the channels
Isolation	
Isolation tested with	2500 V DC
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	300 g

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

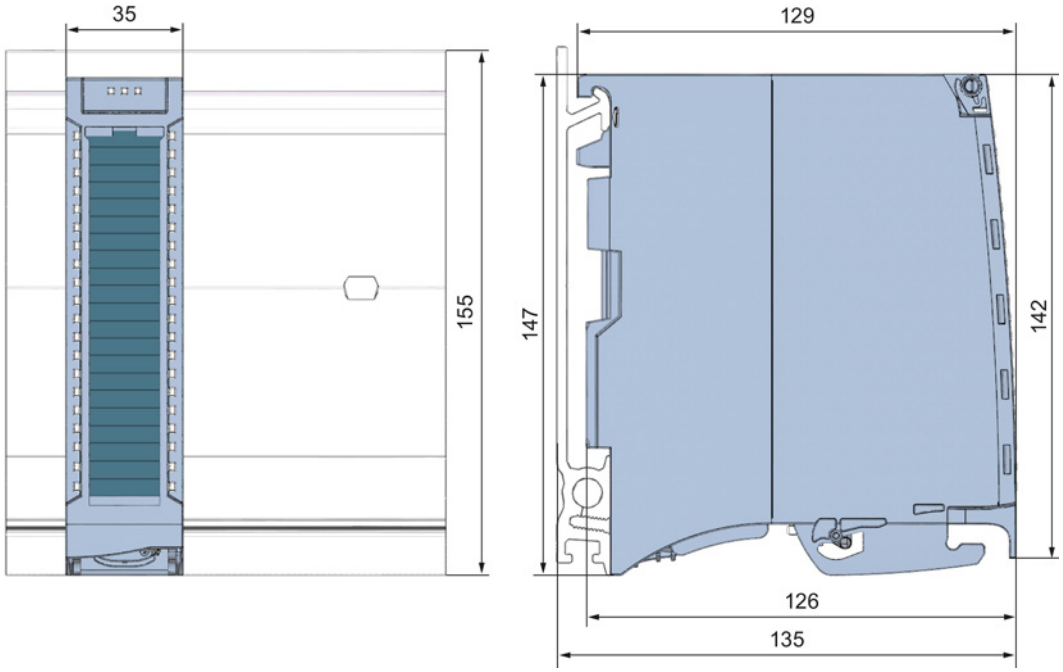


Figure A-1 Dimensional drawing of the DI 16x24VAC BA module

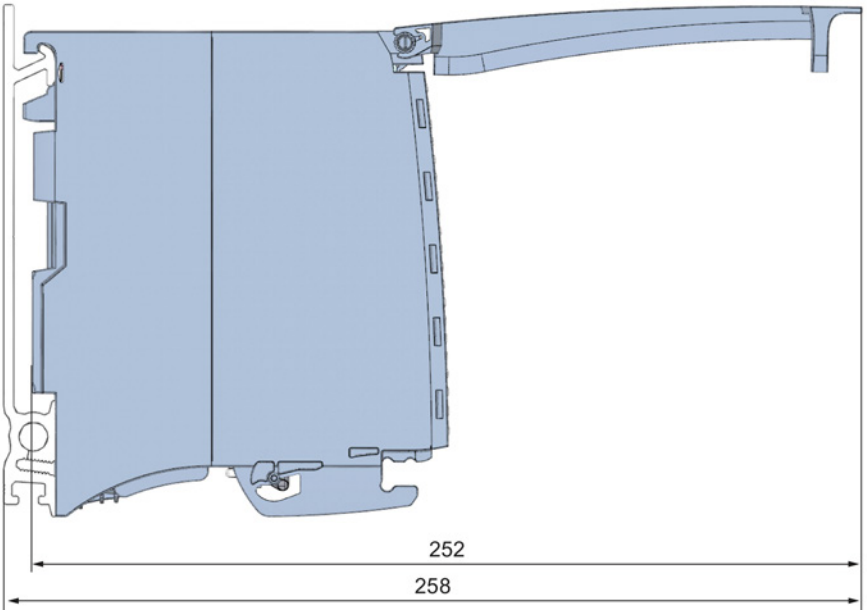


Figure A-2 Dimensional drawing of the DI 16x24VAC BA module, side view with open front cover

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S7-1500/ET 200MP DI 16x24VDC HF Digital Input Module (6ES7521-1BH00-0AB0)

Manual

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version:

- In the chapter Parameters: Input delay for isochronous mode 0.05 ms (cannot be changed) added.
- In the chapter Interrupts: Hardware interrupts; start information of organization block and structure of additional interrupt information added.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

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A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital input module DI 16x24VDC HF

The following table lists additional documentation that you will need when using the DI 16x24VDC HF digital input module.

Table 1- 1 Documentation for digital input module DI 16x24VDC HF

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number:

6ES7521-1BH00-0AB0

View of the module

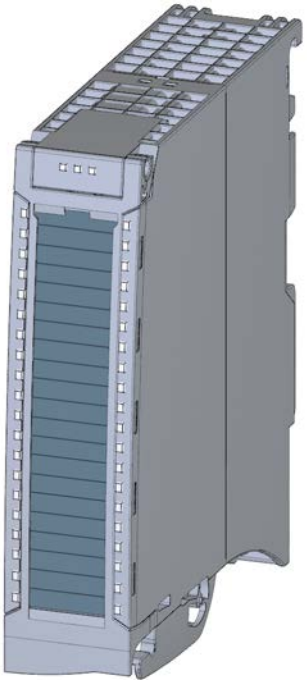


Figure 2-1 View of the DI 16x24VDC HF module

Properties

The module has the following properties:

- Technical properties
  - 16 digital inputs; electrically isolated in groups of 16
  - Rated input voltage 24 V DC
  - Configurable input delay: 0.05 ms to 20 ms
  - Configurable diagnostics (per channel)
  - Configurable hardware interrupt (per channel)
  - Suitable for switches and 2-/3-/4-wire proximity switches

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring 3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

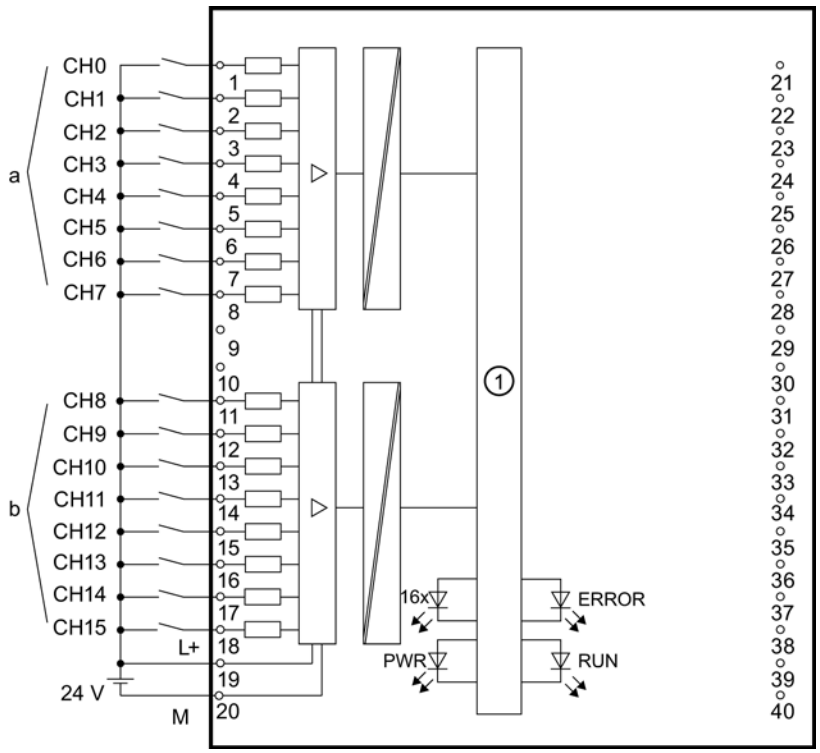
Abbreviations used

Meaning of the abbreviations used in the following figures:

L+	Supply voltage connection
M	Ground connection
CHx	Channel or display of the channel status
PWR	Display for the supply voltage (POWER)

Wiring and block diagrams

The figure below shows you how to connect the module and channel addressing (input byte a to input byte b).



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Resistor circuitry of the encoders

To detect a wire break, it is necessary that enough quiescent current is flowing even when the encoder contacts are open. Connect a resistor of 25 kΩ to 45 kΩ with 0.25 W to the encoder contacts for this reason.

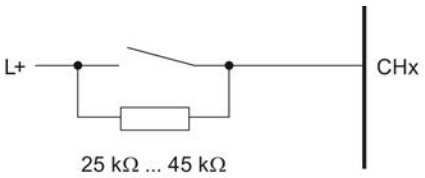


Figure 3-2 Resistor circuitry of the encoders

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to distribute the 24V DC supply voltage to a neighboring module. This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24 V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between terminals 19 and 39 (L+) and between terminals 20 and 40 (M).
3. Use the terminals 39 and 40 to distribute the potential to the next module

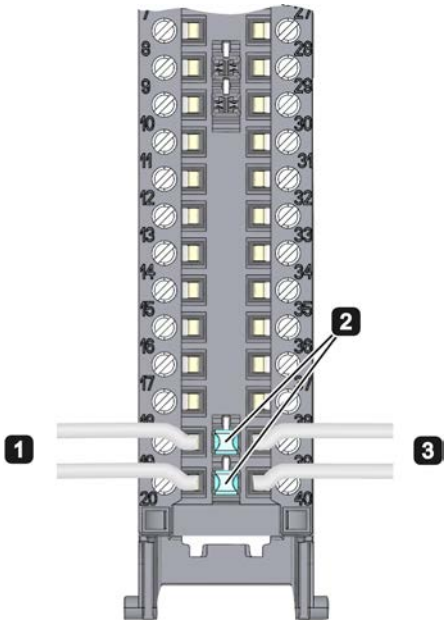


Figure 3-3 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded!

Parameters/address space 4

4.1 Parameters

DI 16x24VDC HF parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 31).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel*	Channel group**
• Wire break	Yes/No	No	Yes	Channel	Channel group**
Input delay	0.05 ms, 0.1 ms, 0.4 ms, 1.6 ms, 3.2 ms, 12.8 ms, 20 ms	3.2 ms; for isochronous mode 0.05 ms (cannot be changed)	Yes	Channel	Channel group**

Parameters	Range of values	Default	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt					
• Positive edge	Yes/No	No	Yes	Channel	Channel
• Negative edge	Yes/No	No	Yes	Channel	Channel
• Positive and negative edge	Yes/No	No	Yes	Channel	Channel

* If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

** The scope can be assigned for each channel during parameter assignment in RUN.

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

The letters "a to d" are printed onto the module. "IB a" for example, stands for module start address input byte a.

Configuration options of DI 16x24VDC HF

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DI 16x24VDC HF	X	X
1 x 16-channel with value status	DI 16x24VDC HF QI	X	X
2 x 8-channel without value status	DI 16x24VDC HF S	X	---
2 x 8-channel with value status	DI 16x24VDC HF QI S	X	---
1 x 16-channel with value status for module-internal Shared Input with up to 4 submodules	DI 16x24VDC HF MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DI 16x24VDC HF QI,
- DI 16x24VDC HF QI S
- DI 16x24VDC HF MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space for configuration as 16-channel DI 16x24VDC HF

The following figure shows the assignment of the address space for the configuration as a 32-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

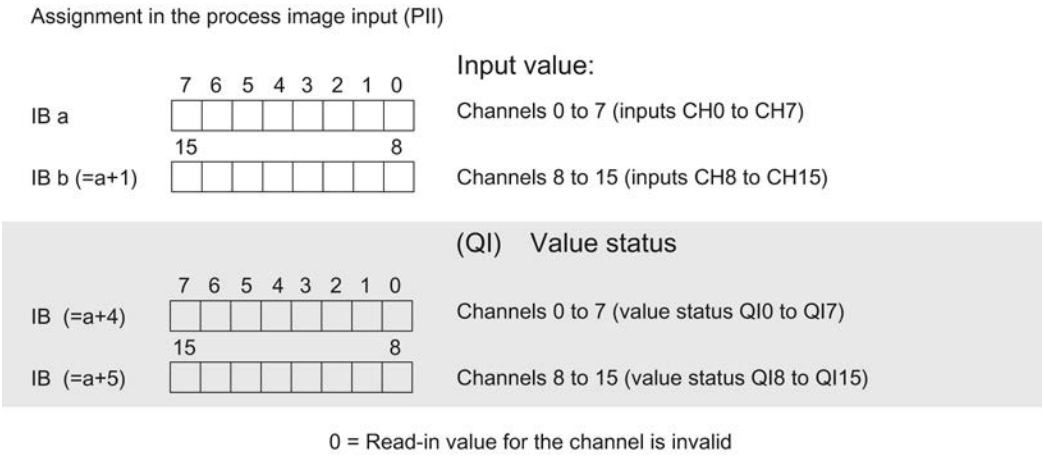


Figure 4-1 Address space for configuration as 16-channel DI 16x24VDC HF with value status

Address space for configuration as 2 x 8-channel DI 16x24VDC HF QI S

For the configuration as a 2 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 16-channel module configuration, each of the two submodules has a freely assignable start address.

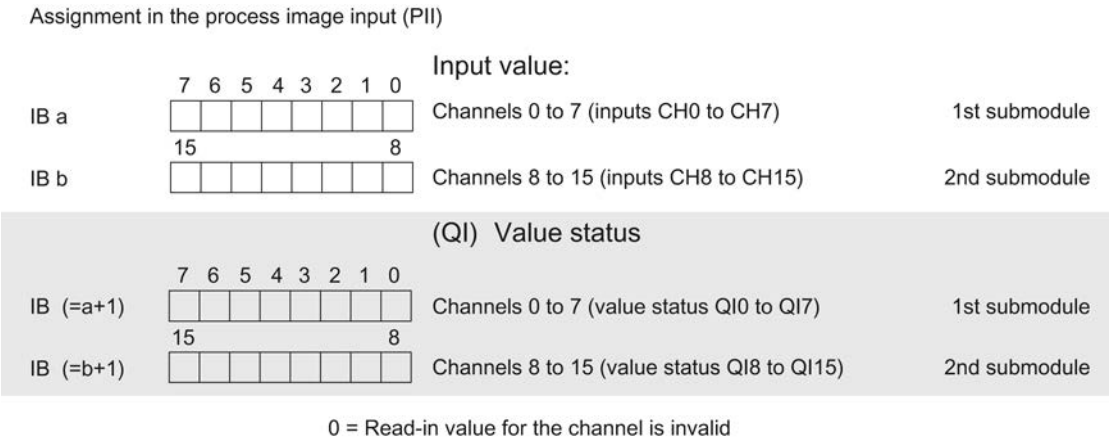


Figure 4-2 Address space for configuration as 2 x 8-channel DI 16x24VDC HF QI S

Address space for configuration as 1 x 16-channel DI 16x24VDC HF MSI

The channels 0 to 15 of the module are copied in up to four submodules with configuration 1 x 16-channel module (Module-internal shared input, MSI). Channels 0 to 15 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2 and the value status.

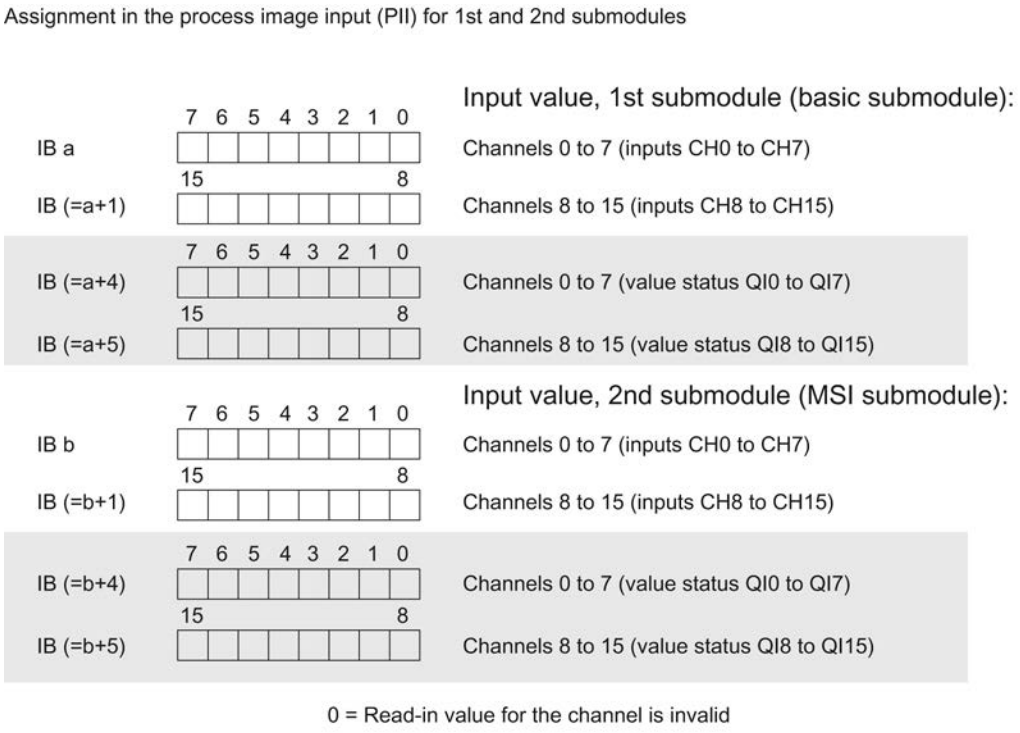


Figure 4-3 Address space for configuration as 1 x 16-channel DI 16x24VDC HF MSI

The following figure shows the assignment of the address space with submodules 3 and 4 and the value status.

Assignment in the process image input (PII) for 3rd and 4th submodules

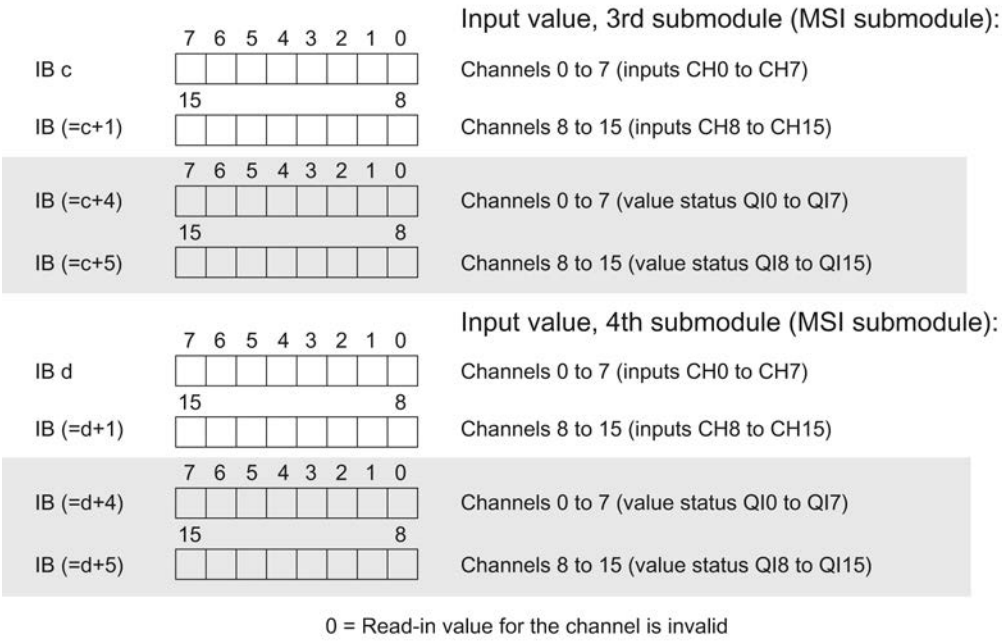


Figure 4-4 Address space for configuration as 1 x 16-channel DI 16x24VDC HF MSI

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED displays (status and error displays) of DI 16x24VDC HF.

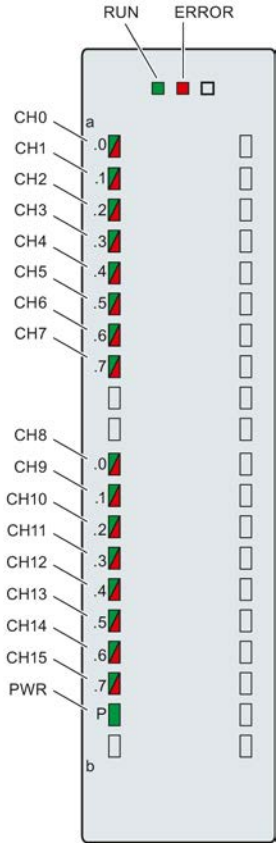


Figure 5-1 LED displays of the module DI 16x24VDC HF

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in chapter Diagnostics alarms (Page 24).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (there is an error on at least one channel, for example, a wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	To correct or avoid errors
Off	Supply voltage L+ too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	To correct or avoid errors
Off	0 = Status of the input signal	---
On	1 = Status of the input signal	---
On	Diagnostics: Wire break	Check the wiring. When using simple switches, deactivate diagnostics or connect a resistor (25 kΩ … 45 kΩ) to the encoder contacts.
	Supply voltage L+ too low or missing	Check supply voltage L+.

5.2 Interrupts

Digital input module DI 16x24VDC HF supports diagnostic and hardware interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Positive edge
- Negative edge
- Positive and negative edge

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt information) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

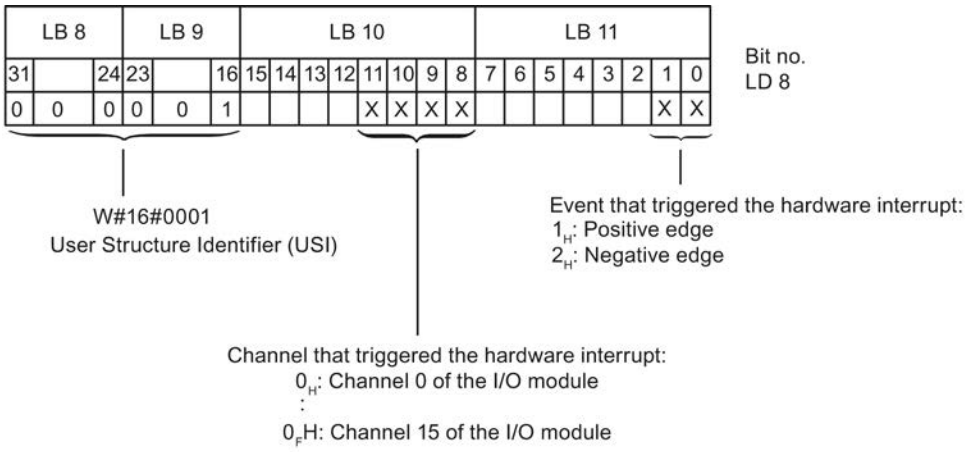


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#0F	Number of the event-triggering channel (channel 0 to channel 15 of the module)	1
It follows the error event that triggered the hardware interrupt.				
	Event	B#16#01	Positive edge	1
		B#16#02	Negative edge	

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kΩ to 45 kΩ to the encoder contacts
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel
Hardware interrupt lost	16_H	The module cannot trigger an interrupt because the previous interrupt was not acknowledged; possibly a configuration error	• Change interrupt processing in the CPU and, if necessary, edit the module parameters. • The error persists until the module is assigned new parameters

Technical specifications

6

Technical specifications of the DI 16x24VDC HF

	6ES7521-1BH00-0AB0
Product type designation	DI 16x24VDC HF
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	20 mA; (with 24 V DC supply)
Power	
Power consumption from the backplane bus	1.1 W
Power loss	
Power loss, typ.	2.6 W
Digital inputs	
Number of inputs	16
reading m/p	reading p
Input characteristic curve acc. to IEC 61131, type 3	Yes

	6ES7521-1BH00-0AB0
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
for signal "0"	-30 to +5 V
for signal "1"	11 to 30 V
Permissible voltage at input, max.	30 V
Permissible voltage at input, min.	-30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 1.6 / 3.2 / 12.8 / 20 ms
• with "0" to "1", min.	0.05 ms
• with "0" to "1", max.	20 ms
• with "1" to "0", min.	0.05 ms
• with "1" to "0", max.	20 ms
For interrupt inputs	
• Configurable	Yes
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	80 µs; with 50 µs filter time
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Hardware interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; to I < 350 µA
Short-circuit	No
Fuse blown	No

	6ES7521-1BH00-0AB0
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	16
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	240 g

Tolerances of the programmable input delay

Table 6- 1 Tolerances of the programmable input delay

Input delay	Tolerance range
0.05 ms	43 µs to 57 µs
0.1 ms	86 µs to 114 µs
0.4 ms	344 µs to 456 µs
1.6 ms	1.5 ms to 1.9 ms
3.2 ms (preset)	3 ms to 4 ms
12.8 ms	12 ms to 15 ms
20 ms	19 ms to 23 ms

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

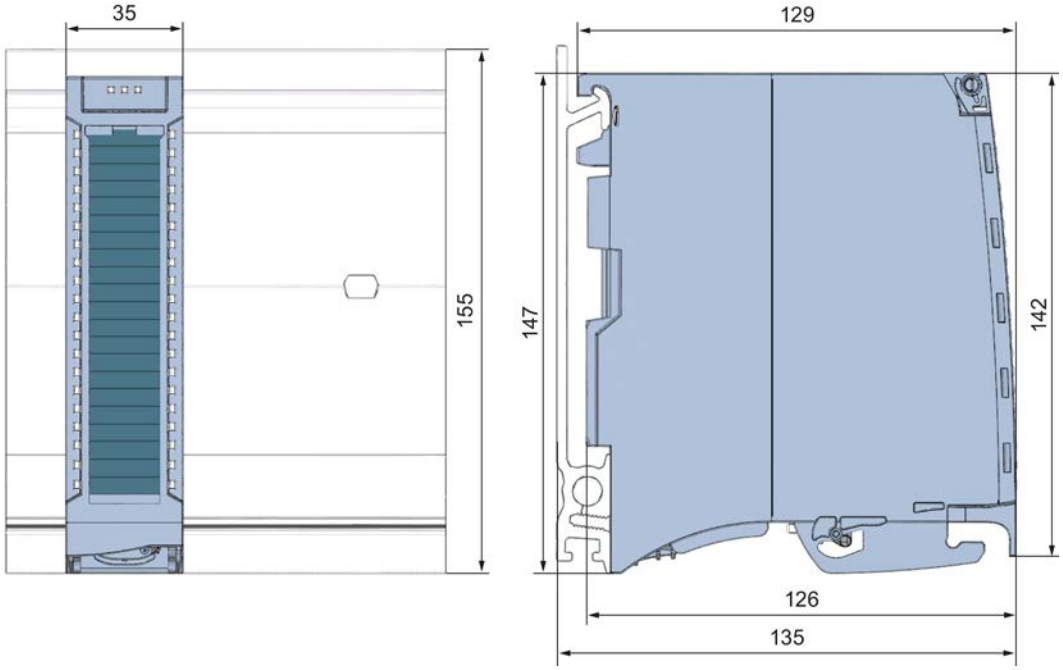


Figure A-1 Dimensional drawing of the DI 16x24VDC HF module

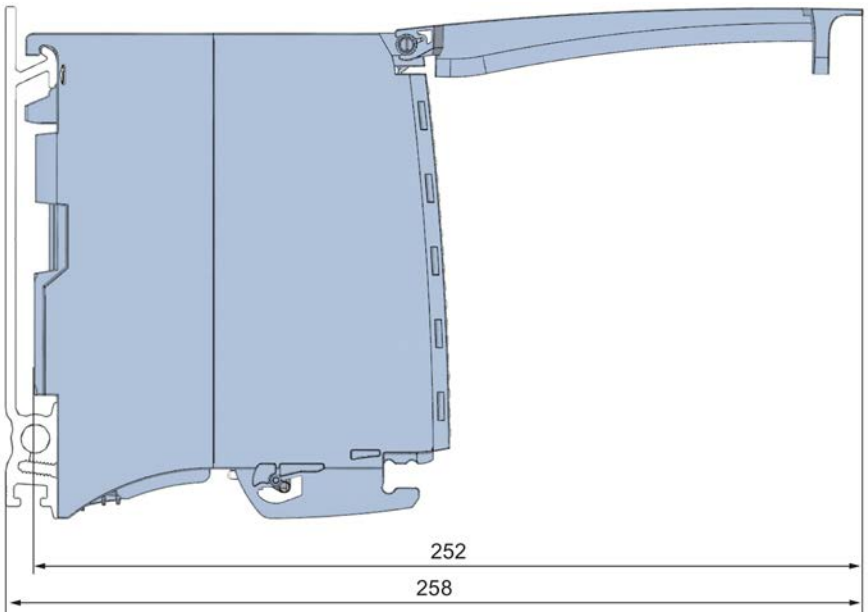


Figure A-2 Dimensional drawing of the DI 16x24VDC HF module, side view with open front cover

Parameter data records B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the input delay values of selected channels can be edited without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 15. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

For the configuration as a 1 x 16-channel module, the parameters are located in data records 0 to 15 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 14 for channel 14
- Data record 15 for channel 15

For the configuration as a 2 x 8-channel module, the module has 2 submodules with eight channels each. The parameters for the channels are located in data records 0 to 7 and are assigned as follows:

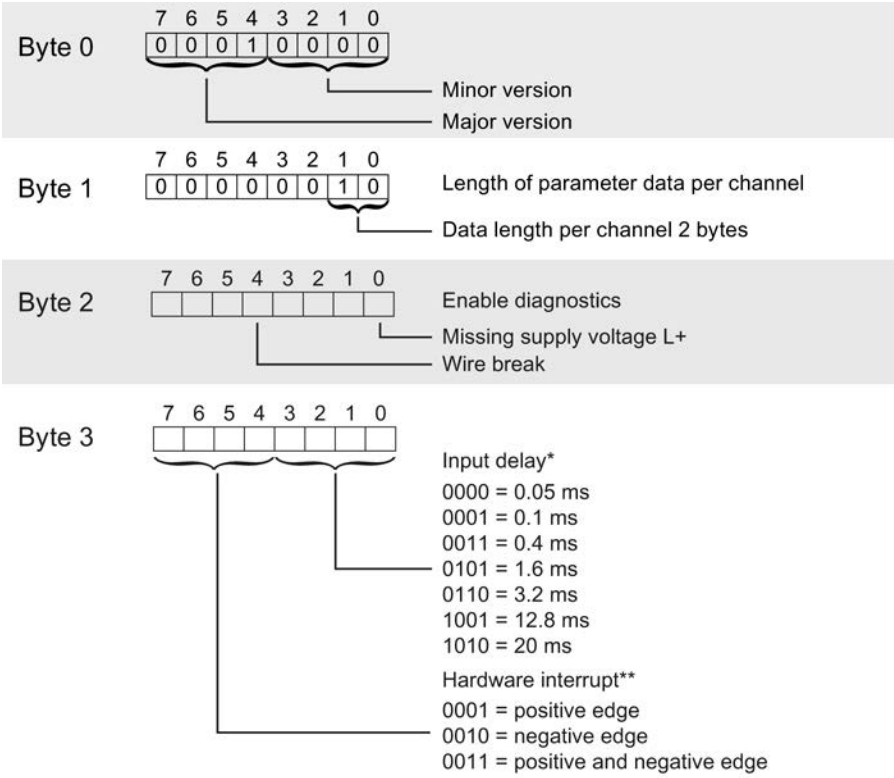
- Data records 0 to 7 for channels 0 to 7 (submodule 1)
- Data records 0 to 7 for channels 8 to 15 (submodule 2)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 0 for channel 0. The structure of channels 1 to 15 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".



* For isochronous mode 0.05 ms (cannot be changed)

** Hardware interrupts can only be activated using the data record if a hardware interrupt OB is assigned to the channel in STEP 7

Figure B-1 Structure of data record 0: Bytes 0 to 3

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S7-1500/ET 200MP DI 16x24VDC SRC BA Digital Input Module (6ES7521-1BH50-0AA0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared input (MSI) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital input module DI 16x24VDC SRC BA

The following table lists additional documentation that you will need when using the DI 16x24VDC SRC BA digital input module.

Table 1- 1 Documentation for digital input module DI 16x24VDC SRC BA

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7521-1BH50-0AA0

View of the module

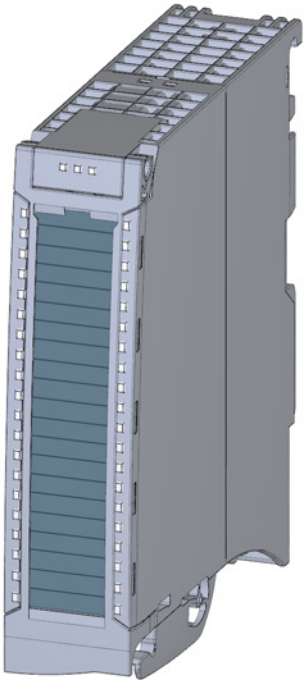


Figure 2-1 View of the DI 16x24VDC SRC BA module

Properties

The module is characterized by the following properties:

- Technical properties
  - 16 digital inputs; electrically isolated in groups of 16
  - Reading M
  - Rated input voltage 24 V DC
  - Suitable for switches and 2-/3-/4-wire proximity switches

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring 3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

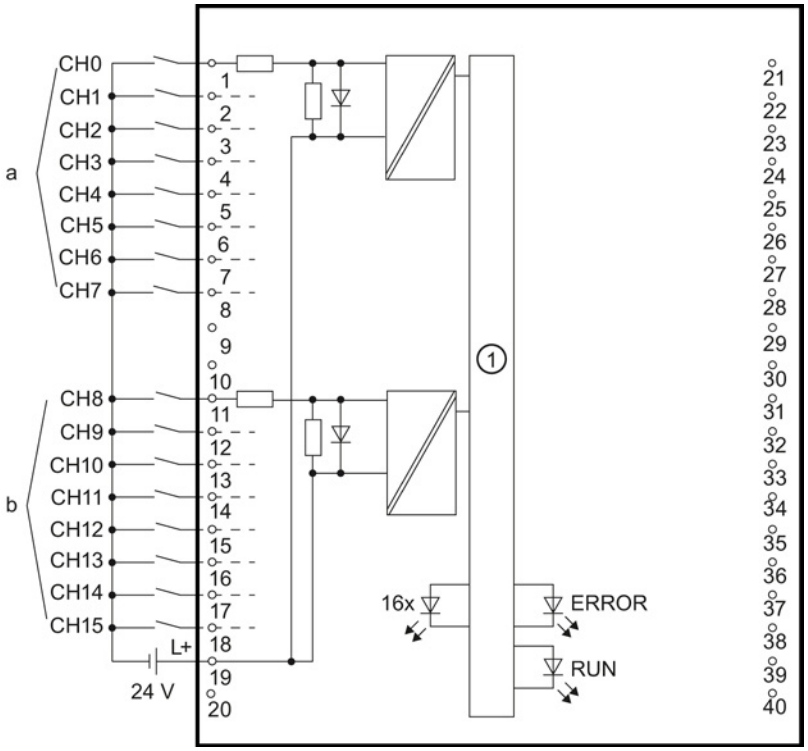
Abbreviations used

Meaning of the abbreviations used in the following figures:

L+	Supply voltage connection
CHx	Channel or display of the channel status

Wiring and block diagrams

The figure below shows you how to connect the module and channel addressing (input byte a to input byte b)



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to distribute the 24V DC supply voltage to a neighboring module. This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24 V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between terminals 19 and 39 (L+) and between terminals 20 and 40 (M).
3. Use the terminals 39 and 40 to distribute the potential to the next module

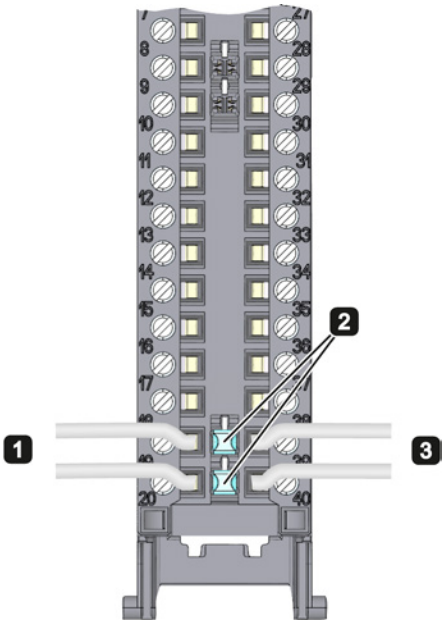


Figure 3-2 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded!

Address space 4

4.1 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 16x24VDC SRC BA

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 1 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DI 16x24VDC SRC BA	X	X
2 x 8-channel without value status	DI 16x24VDC SRC BA S	X	---
1 x 16-channel with value status for module-internal Shared Input with up to 4 submodules	DI 16x24VDC SRC BA MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the DI 16x24VDC SRC BA MSI module:

An additional bit is assigned to each channel for the value status. In contrast to the modules with diagnostics capability, the module indicates only information regarding the parameter assignment of the first submodule (basic submodule) in the value status.

The module does not supply a value status for the read-in digital value.

Address space for configuration as DI 16x24VDC SRC BA

The following figure shows the address space allocation for the configuration as 16-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "IB a" for example, stands for module start address input byte a.

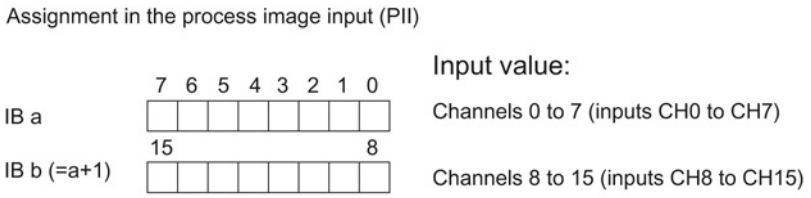


Figure 4-1 Address space for configuration as 16-channel DI 16x24VDC SRC BA

Address space for configuration as 2 x 8-channel DI 16x24VDC SRC BA S

For the configuration as a 2 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 16-channel module configuration, each of the two submodules has a freely assignable start address.

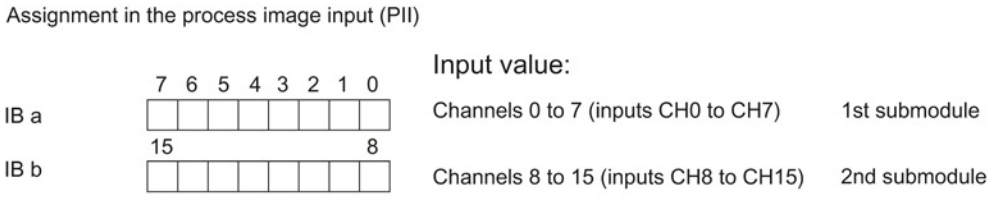


Figure 4-2 Address space for configuration as 2 x 8-channel DI 16x24VDC SRC BA

Address space for configuration as 1 x 16-channel DI 16x24VDC SRC BA MSI

The channels 0 to 15 of the module are copied in up to four submodules with configuration 1 x 16-channel module (Module-internal shared input, MSI). Channels 0 to 15 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basis submodule), the value status is not relevant.

For the second to fourth submodules (=MSI submodule), the value status 0 indicates that the basic submodule parameters have not yet been assigned (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

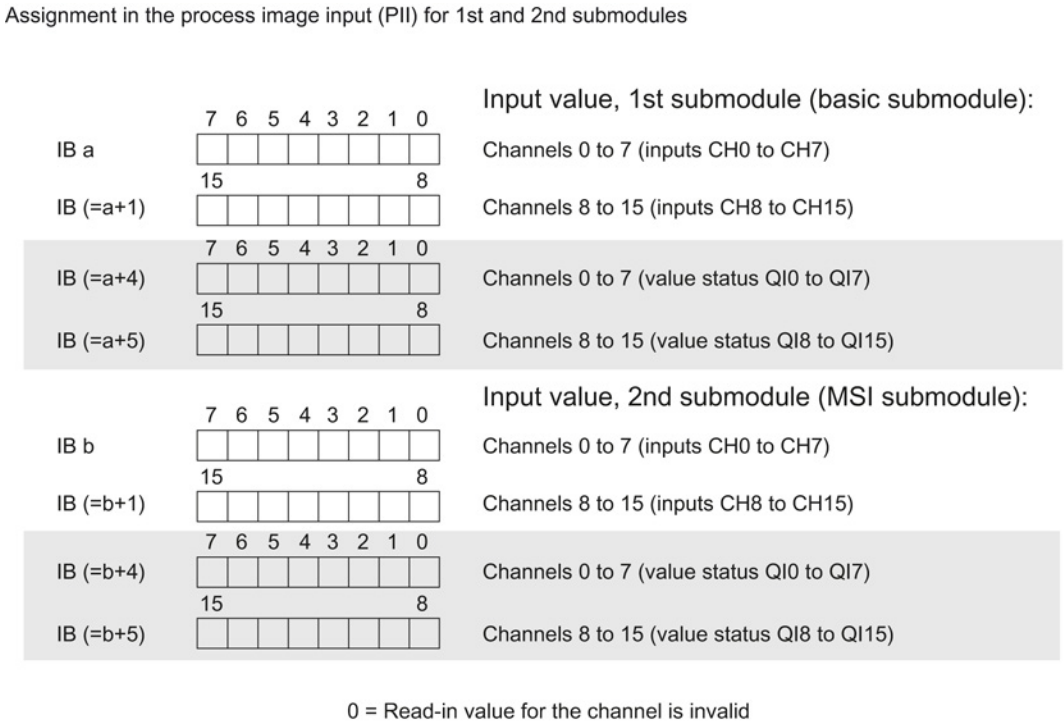


Figure 4-3 Address space for configuration as 1 x 16-channel DI 16x24VDC SRC BA MSI

The following figure shows the assignment of the address space with submodules 3 and 4.

Assignment in the process image input (PII) for 3rd and 4th submodules

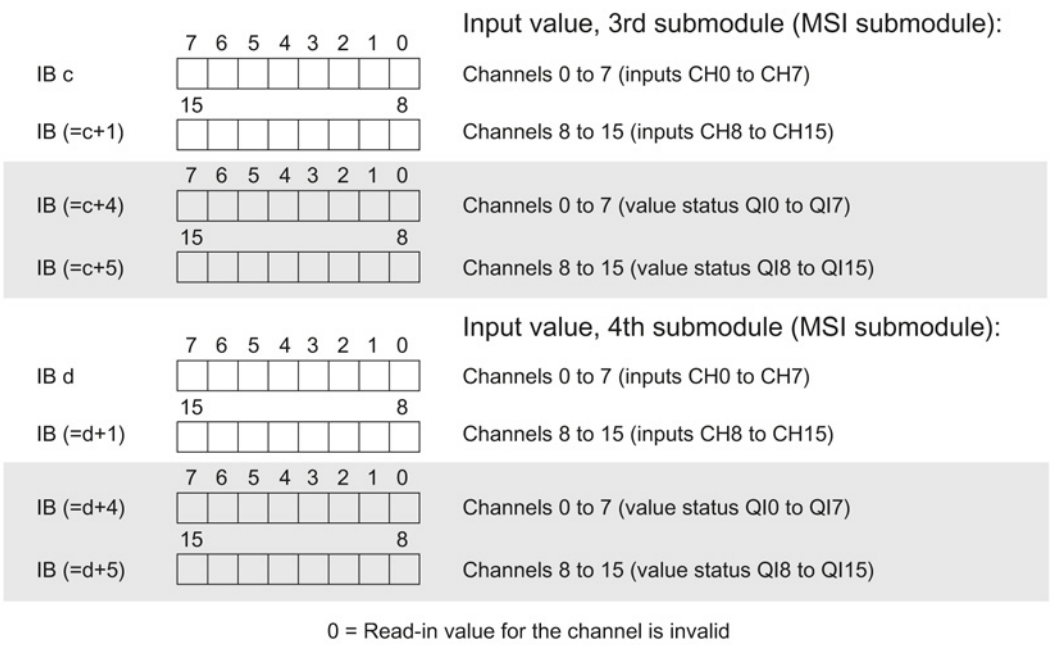


Figure 4-4 Address space for configuration as 1 x 16-channel DI 16x24VDC SRC BA MSI

Diagnostic alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED displays (status and error displays) of DI 16x24VDC SRC BA.

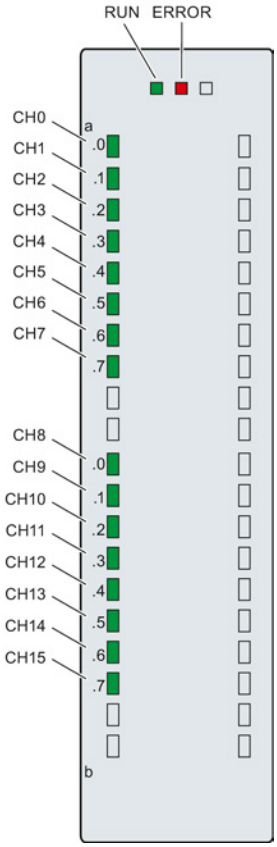


Figure 5-1 LED displays of the module DI 16x24VDC SRC BA

Meaning of the LED displays

The following table explains the meaning of the status and error displays.

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	Module starts up.	---
On	Off	Module is ready.	
Flashes	Flashes	Hardware defective.	Replace the module.

Table 5- 2 CHx status display

LED CHx	Meaning	To correct or avoid errors
Off	0 = Status of the input signal	---
On	1 = Status of the input signal	---

Technical specifications

6

Technical specifications of the DI 16x24VDC SRC BA

	6ES7521-1BH50-0AA0
Product type designation	DI 16x24VDC SRC BA
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
Power	
Power consumption from the backplane bus	0.9 W
Power loss	
Power loss, typ.	2.8 W
Digital inputs	
Number of inputs	16
reading m/p	reading m
Input characteristic curve acc. to IEC 61131, type 3	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
for signal "0"	30 to -5 V
for signal "1"	-11 to -30 V
Permissible voltage at input, max.	30 V
Permissible voltage at input, min.	-30 V
Input current	
for signal "1", typ.	4.5 mA

	6ES7521-1BH50-0AA0
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	No
• with "0" to "1", min.	3 ms
• with "0" to "1", max.	4 ms
• with "1" to "0", min.	3 ms
• with "1" to "0", max.	4 ms
For interrupt inputs	
• Configurable	No
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	No
Hardware interrupt	No
Diagnostics alarms	
Diagnostics	No
Monitoring of supply voltage	No
Wire break	No
Short-circuit	No
Fuse blown	No
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	No
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	No

	6ES7521-1BH50-0AA0
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	16
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	230 g

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

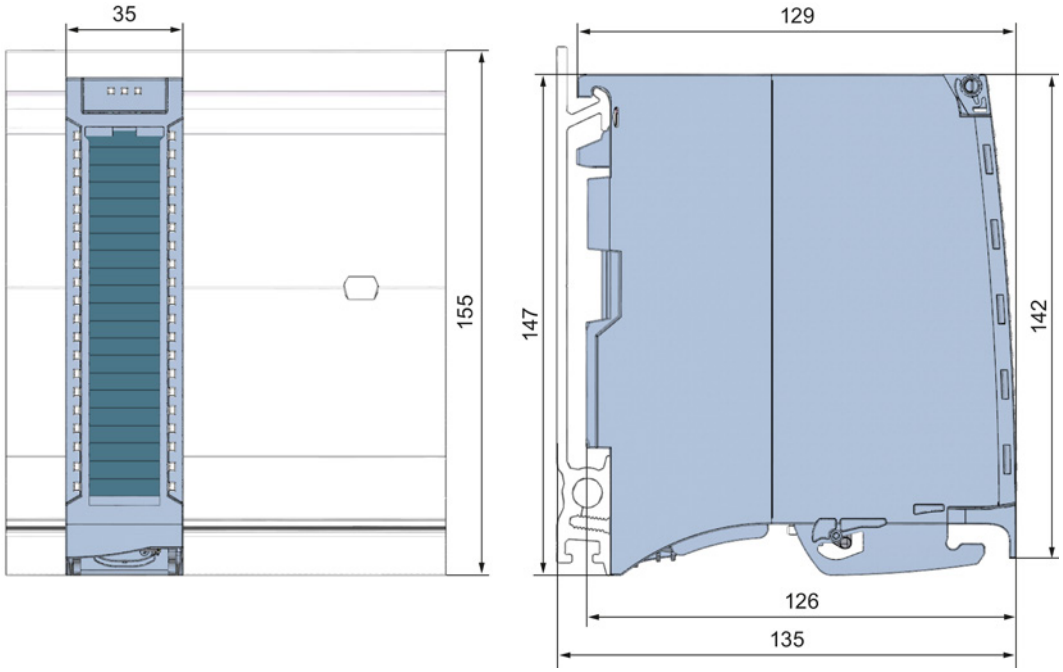


Figure A-1 Dimensional drawing of the DI 16x24VDC SRC BA module

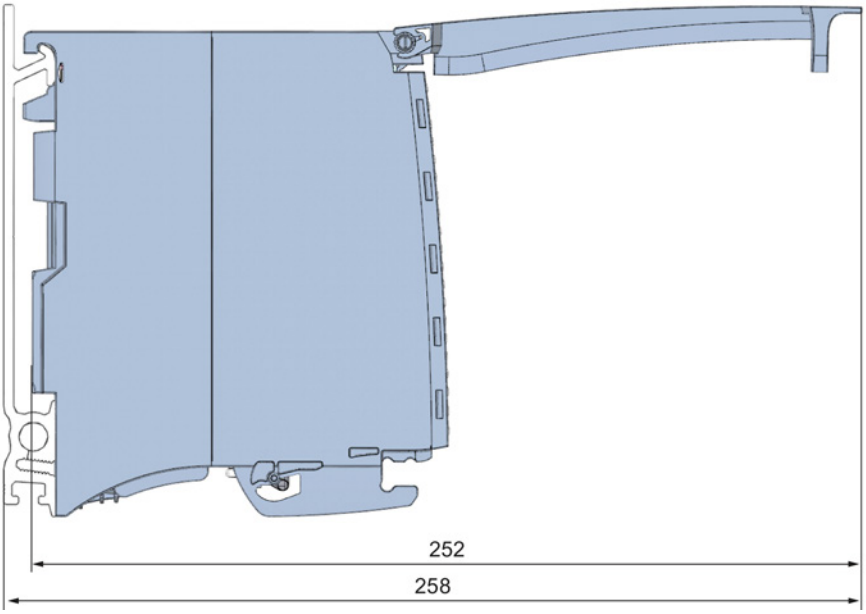


Figure A-2 Dimensional drawing of the DI 16x24VDC SRC BA module, side view with open front cover

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S7-1500/ET 200MP DI 32x24VDC HF digital input module (6ES7521-1BL00-0AB0)

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version:

- In the chapter Parameters: Input delay for isochronous mode 0.05 ms (cannot be changed) added.
- In the chapter Interrupts: Hardware interrupts; start information of organization block and structure of additional interrupt information added.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation for digital input module DI 32x24VDC HF

The following table lists additional documentation that you will need when using the DI 32x24VDC HF digital input module.

Table 1- 1 Documentation for digital input module DI 32x24VDC HF

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number:

6ES7521-1BL00-0AB0

View of the module

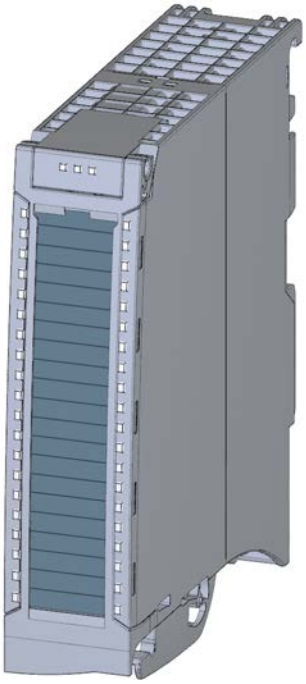


Figure 2-1 View of the DI 32x24VDC HF module

Properties

The module has the following properties:

- Technical properties
  - 32 digital inputs; electrically isolated in groups of 16
  - Rated input voltage 24 V DC
  - Configurable input delay: 0.05 ms to 20 ms
  - Configurable diagnostics (per channel)
  - Configurable hardware interrupt (per channel)
  - Suitable for switches and 2-/3-/4-wire proximity switches
  - Hardware compatible with digital input module DI 16x24VDC HF (6ES7521-1BH00-0AB0)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

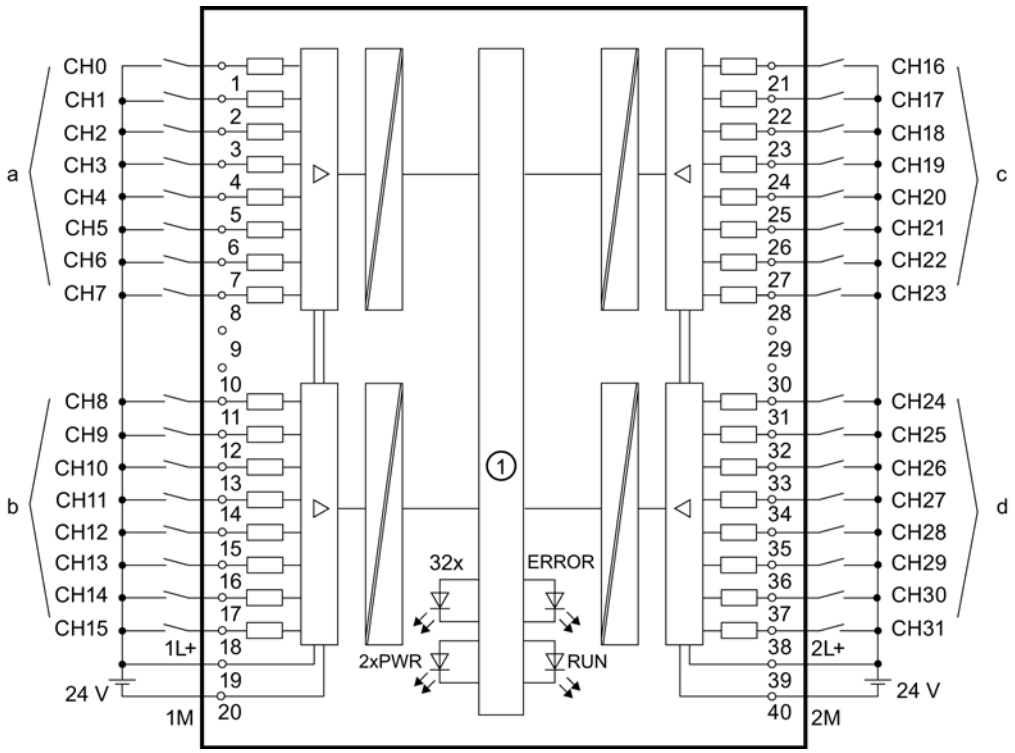
Abbreviations used

Meaning of the abbreviations used in the following figures:

xL+	Supply voltage connection
xM	Ground connection
CHx	Channel or display of the channel status
PWRx	Display for the supply voltage (POWER)

Wiring and block diagrams

The figure below shows how to wire the module and assign channel addresses (input byte a up to input byte d).



① Backplane bus interface

Figure 3-1 Block diagram and terminal assignment

Resistor circuitry of the encoders

To detect a wire break, it is necessary that enough quiescent current is flowing even when the encoder contacts are open. Connect a resistor of 25 kΩ to 45 kΩ with 0.25 W to the encoder contacts for this reason.

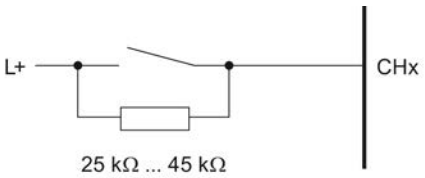


Figure 3-2 Resistor circuitry of the encoders

Tip: Using the potential jumpers

Use the potential jumpers supplied with the front connector if you want to connect both load groups to the same potential (non-isolated). This helps you to avoid having to terminate two wires to one terminal.

Proceed as follows:

1. Connect the 24 V DC supply voltage to terminals 19 and 20.
2. Insert the potential jumpers between terminals 19 and 39 (xL+) and between terminals 20 and 40 (xM).
3. Use the terminals 39 and 40 to distribute the potential to the next module

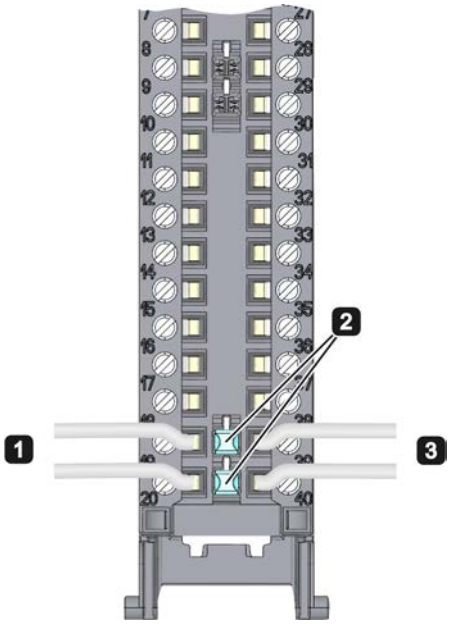


Figure 3-3 Using the potential jumpers

Note

Ensure that the maximum current load of 8 A per potential jumper is not exceeded!

Parameters/address space 4

4.1 Parameters

DI 32x24VDC HF parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

For parameter assignment in the user program, the parameters are transferred to the module using the WRREC instruction (parameter reassignment in RUN) and data records; see chapter Parameter assignment and structure of the parameter data records (Page 31).

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel*	Channel group**
• Wire break	Yes/No	No	Yes	Channel	Channel group**
Input delay	0.05 ms, 0.1 ms, 0.4 ms, 1.6 ms, 3.2 ms, 12.8 ms, 20 ms	3.2 ms; for isochronous mode 0.05 ms (cannot be changed)	Yes	Channel	Channel group**

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuring software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt***					
• Positive edge	Yes/No	No	Yes	Channel	Channel
• Negative edge	Yes/No	No	Yes	Channel	Channel
• Positive and negative edge	Yes/No	No	Yes	Channel	Channel

* If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

** The scope can be assigned for each channel during parameter assignment in RUN.

*** For the configuration as a 4 x 8-channel module, a maximum of 16 hardware interrupts can be configured (channels 0 to 15).

4.2 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 32x24VDC HF

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 32-channel without value status	DI 32x24VDC HF	X	X
1 x 32-channel with value status	DI 32x24VDC HF QI	X	X
4 x 8-channel without value status	DI 32x24VDC HF S	X	---
4 x 8-channel with value status	DI 32x24VDC HF QI S	X	---
1 x 32-channel with value status for module-internal Shared Input with up to 4 submodules	DI 32x24VDC HF MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DI 32x24VDC HF QI
- DI 32x24VDC HF QI S
- DI 32x24VDC HF MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space for configuration as 32-channel DI 32x24VDC HF

The following figure shows the assignment of the address space for the configuration as a 32-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

The letters "a to d" are printed onto the module. "IB a" for example, stands for module start address input byte a.

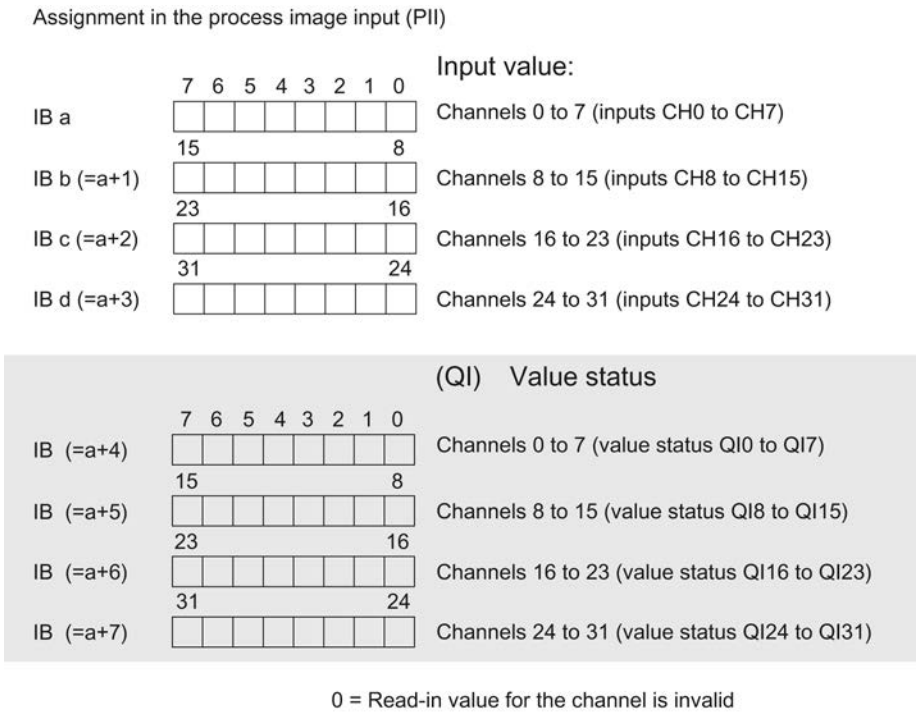


Figure 4-1 Address space for configuration as 32-channel DI 32x24VDC HF with value status

Address space for configuration as 4 x 8-channel DI 32x24VDC HF QI S

For the configuration as a 4 x 8-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 32-channel module configuration, each of the four submodules has a freely assignable start address.

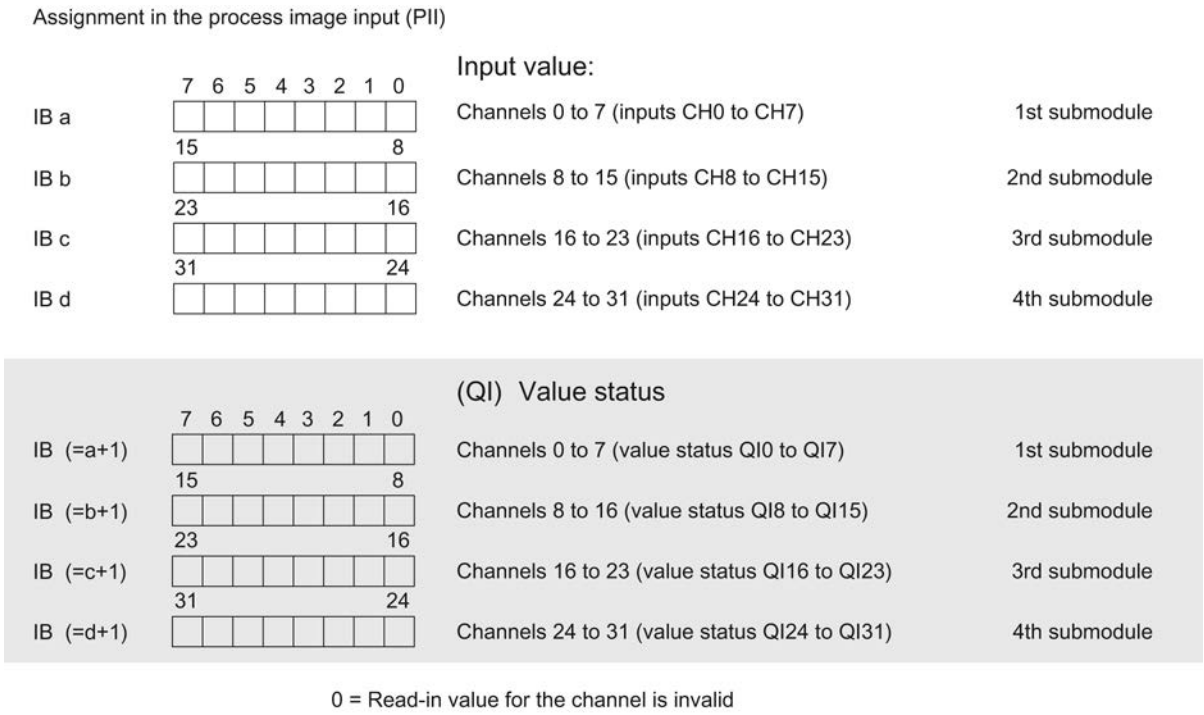


Figure 4-2 Address space for configuration as 4 x 8-channel DI 32x24VDC HF QI S

Address space for configuration as 1 x 32-channel DI 32x24VDC HF MSI

The channels 0 to 31 of the module are copied in up to four submodules with configuration 1 x 32-channel module (Module-internal shared input, MSI). Channels 0 to 31 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2 and the value status.

Assignment in the process image input (PII) for 1st and 2nd submodules

		Input value, 1st submodule (basic submodule):
	7 6 5 4 3 2 1 0	
IB a		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=a+1)		Channels 8 to 15 (inputs CH8 to CH15)
	23 16	
IB (=a+2)		Channels 16 to 23 (inputs CH16 to CH23)
	31 24	
IB (=a+3)		Channels 24 to 31 (inputs CH24 to CH31)
	7 6 5 4 3 2 1 0	
IB (=a+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=a+5)		Channels 8 to 15 (value status QI8 to QI15)
	23 16	
IB (=a+6)		Channels 16 to 23 (value status QI16 to QI23)
	31 24	
IB (=a+7)		Channels 24 to 31 (value status QI24 to QI31)

		Input value, 2nd submodule (MSI submodule):
	7 6 5 4 3 2 1 0	
IB b		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=b+1)		Channels 8 to 15 (inputs CH8 to CH15)
	23 16	
IB (=b+2)		Channels 16 to 23 (inputs CH16 to CH23)
	31 24	
IB (=b+3)		Channels 24 to 31 (inputs CH24 to CH31)
	7 6 5 4 3 2 1 0	
IB (=b+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=b+5)		Channels 8 to 15 (value status QI8 to QI15)
	23 16	
IB (=b+6)		Channels 16 to 23 (value status QI16 to QI23)
	31 24	
IB (=b+7)		Channels 24 to 31 (value status QI24 to QI31)

0 = Read-in value for the channel is invalid

Figure 4-3 Address space for configuration as 1 x 32-channel DI 32x24VDC HF MSI

The following figure shows the assignment of the address space with submodules 3 and 4 and the value status.

Assignment in the process image input (PII) for 3rd and 4th submodules

Input value, 3rd submodule (MSI submodule):

	7 6 5 4 3 2 1 0	
IB c		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=c+1)		Channels 8 to 15 (inputs CH8 to CH15)
	23 16	
IB (=c+2)		Channels 16 to 23 (inputs CH16 to CH23)
	31 24	
IB (=c+3)		Channels 24 to 31 (inputs CH24 to CH31)
	7 6 5 4 3 2 1 0	
IB (=c+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=c+5)		Channels 8 to 15 (value status QI8 to QI15)
	23 16	
IB (=c+6)		Channels 16 to 23 (value status QI16 to QI23)
	31 24	
IB (=c+7)		Channels 24 to 31 (value status QI24 to QI31)

Input value, 4th submodule (MSI submodule):

	7 6 5 4 3 2 1 0	
IB d		Channels 0 to 7 (inputs CH0 to CH7)
	15 8	
IB (=d+1)		Channels 8 to 15 (inputs CH8 to CH15)
	23 16	
IB (=d+2)		Channels 16 to 23 (inputs CH16 to CH23)
	31 24	
IB (=d+3)		Channels 24 to 31 (inputs CH24 to CH31)
	7 6 5 4 3 2 1 0	
IB (=d+4)		Channels 0 to 7 (value status QI0 to QI7)
	15 8	
IB (=d+5)		Channels 8 to 15 (value status QI8 to QI15)
	23 16	
IB (=d+6)		Channels 16 to 23 (value status QI16 to QI23)
	31 24	
IB (=d+7)		Channels 24 to 31 (value status QI24 to QI31)

0 = Read-in value for the channel is invalid

Figure 4-4 Address space for configuration as 1 x 32-channel DI 32x24VDC HF MSI

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED displays (status and error displays) of DI 32x24VDC HF.

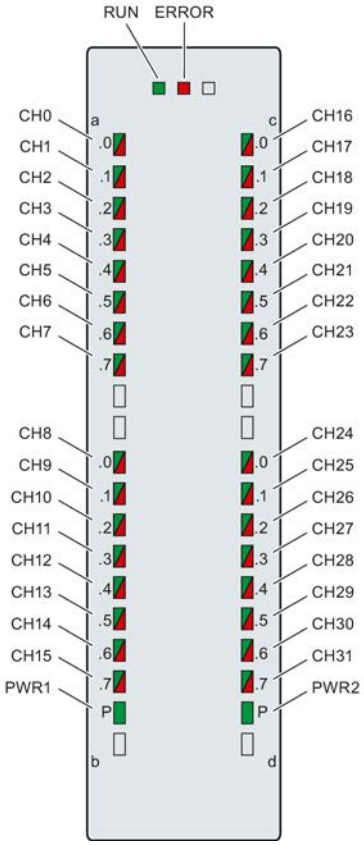


Figure 5-1 LED displays of the module DI 32x24VDC HF

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in chapter Diagnostics alarms (Page 24).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (there is an error on at least one channel, for example, a wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR1 / PWR2 status display

LED PWR1 / PWR2	Meaning	To correct or avoid errors
Off	Supply voltage L+ too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	To correct or avoid errors
Off	0 = Status of the input signal	---
On	1 = Status of the input signal	---
On	Diagnostics: Wire break	Check the wiring. When using simple switches, deactivate diagnostics or connect a resistor (25 kΩ … 45 kΩ) to the encoder contacts.
	Supply voltage L+ too low or missing	Check supply voltage L+

5.2 Interrupts

Digital input module DI 32x24VDC HF supports diagnostic and hardware interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Positive edge
- Negative edge
- Positive and negative edge

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

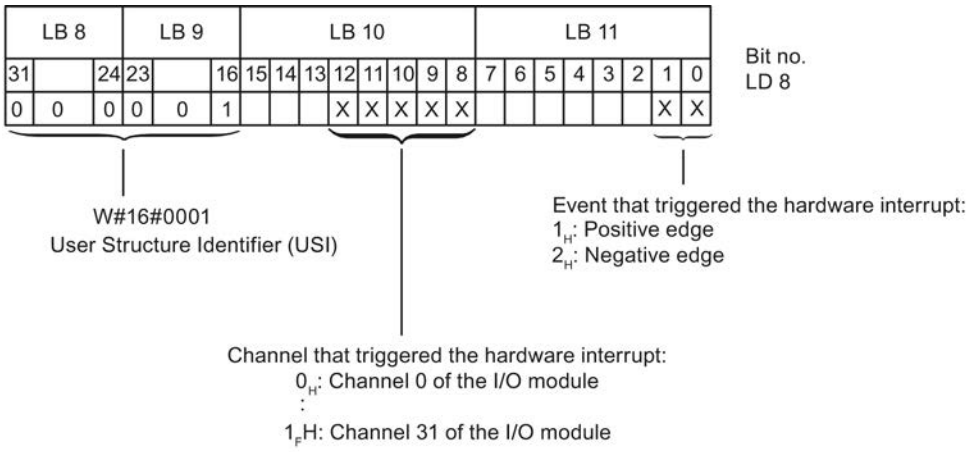


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#1F	Number of the event-triggering channel (channel 0 to channel 31 of the module)	1
It follows the error event that triggered the hardware interrupt.				
	Event	B#16#01	Positive edge	1
		B#16#02	Negative edge	

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the ERROR-LED flashes for each diagnostics event on the module. The diagnostics alarms can, for example, be read out in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kΩ to 45 kΩ to the encoder contacts
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel
Hardware interrupt lost	16_H	The module cannot trigger an interrupt because the previous interrupt was not acknowledged; possibly a configuration error	• Change interrupt processing in the CPU and, if necessary, edit the module parameters. • The error persists until the module is assigned new parameters

Technical specifications

6

Technical specifications of the DI 32x24VDC HF

	6ES7521-1BL00-0AB0
Product type designation	DI 32x24VDC HF
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	40 mA; (20 mA per group with 24 V DC supply)
Power	
Power consumption from the backplane bus	1.1 W
Power loss	
Power loss, typ.	4.2 W
Digital inputs	
Number of inputs	32
reading m/p	reading p
Input characteristic curve acc. to IEC 61131, type 3	Yes

	6ES7521-1BL00-0AB0
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
for signal "0"	-30 to +5 V
for signal "1"	11 to 30 V
Permissible voltage at input, max.	30 V
Permissible voltage at input, min.	-30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 1.6 / 3.2 / 12.8 / 20 ms
• with "0" to "1", min.	0.05 ms
• with "0" to "1", max.	20 ms
• with "1" to "0", min.	0.05 ms
• with "1" to "0", max.	20 ms
For interrupt inputs	
• Configurable	Yes
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	80 µs; with 50 µs filter time
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Hardware interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; to I < 350 µA
Short-circuit	No
Fuse blown	No

	6ES7521-1BL00-0AB0
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels, in groups of	16
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	260 g

Tolerances of the programmable input delay

Table 6- 1 Tolerances of the programmable input delay

Input delay	Tolerance range
0.05 ms	43 µs to 57 µs
0.1 ms	86 µs to 114 µs
0.4 ms	344 µs to 456 µs
1.6 ms	1.5 ms to 1.9 ms
3.2 ms (preset)	3 ms to 4 ms
12.8 ms	12 ms to 15 ms
20 ms	19 ms to 23 ms

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front cover, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

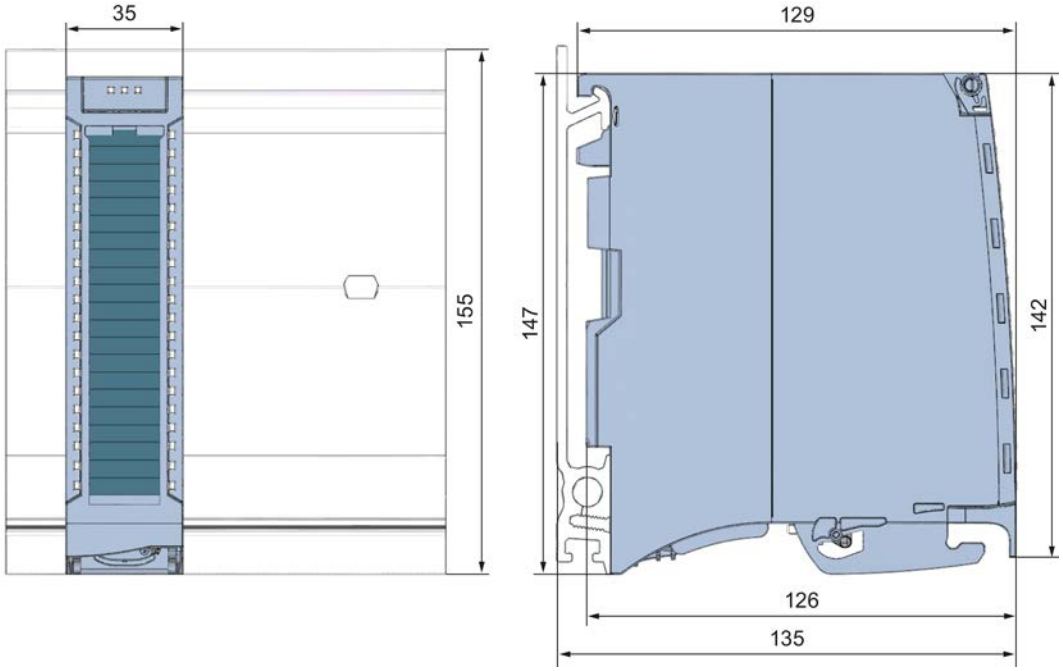


Figure A-1 Dimensional drawing of the DI 32x24VDC HF module

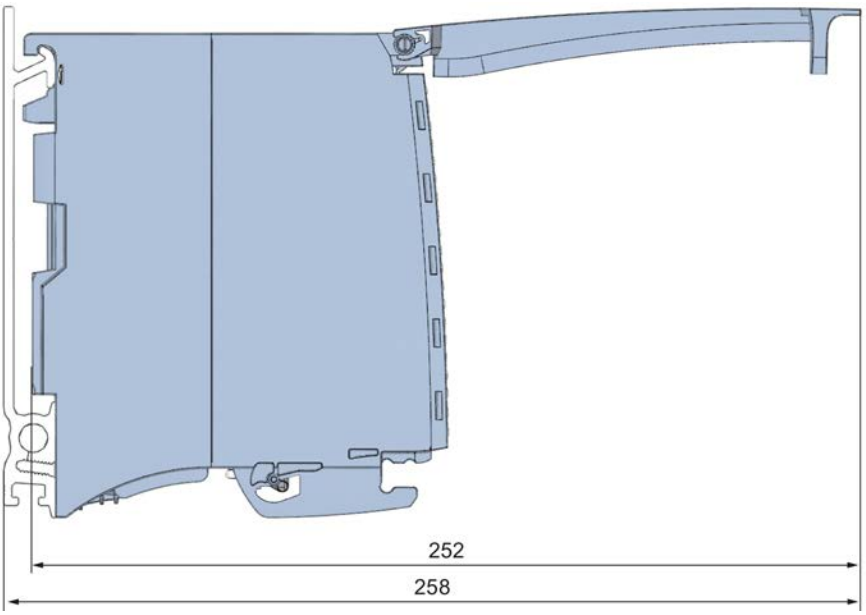


Figure A-2 Dimensional drawing of the DI 32x24VDC HF module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When a GSD file is used to configure a module, dependencies can arise when "assigning the parameters".

There are no dependencies for this module. You can assign the individual parameters in any combination.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the input delay values of selected channels can be edited without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 31. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

For the configuration as a 1 x 32-channel module, the parameters are located in data records 0 to 31 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 30 for channel 30
- Data record 31 for channel 31

For the configuration as a 4 x 8-channel module, the module has 4 submodules with eight channels each. The parameters for the channels are located in data records 0 to 7 and are assigned as follows:

- Data records 0 to 7 for channels 0 to 7 (submodule 1)
- Data records 0 to 7 for channels 8 to 15 (submodule 2)
- Data records 0 to 7 for channels 16 to 23 (submodule 3)
- Data records 0 to 7 for channels 24 to 31 (submodule 4)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 0 for channel 0. The structure of channels 1 to 31 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

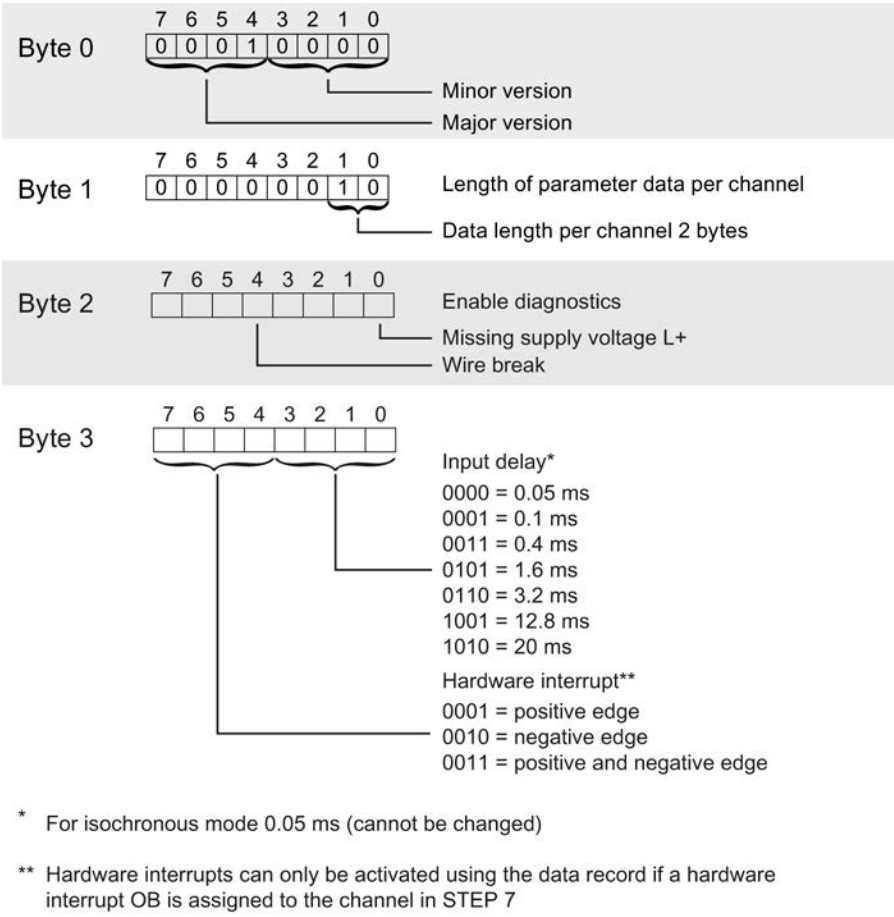


Figure B-1 Structure of data record 0: Bytes 0 to 3

SIEMENS

SIMATIC

S7-1500/ET 200MP
Analog output module AQ 8xU/I HS
(6ES7532-5HF00-0AB0)

Manual

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08/2013

A5E03484776-02

Legal information

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation provided for analog output module AQ 8xU/I HS

The following table lists further documentation that you will need when using the AQ 8xU/I HS analog output module.

Table 1- 1 Documentation for analog output module AQ 8xU/I HS

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Most important contents
Analog value processing	Function manual Analog Value Processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology), etc. • Description/explanation of meanings, e.g. conversion and cycle time, basic and operation limits, etc.
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7532-5HF00-0AB0

View of the module

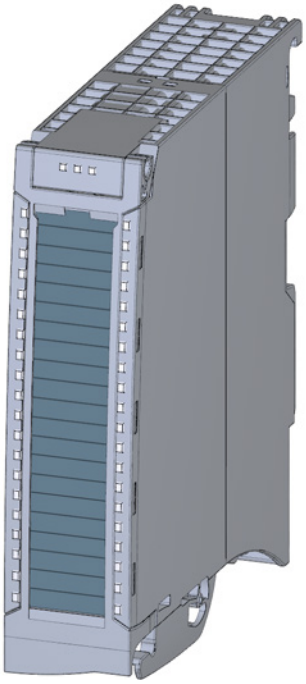


Figure 2-1 View of the AQ 8xU/I HS module

Properties

The module has the following properties:

- Technical properties
  - Channel-based selection of 8 analog outputs
  - Selection of channels for current output
  - Selection of channels for voltage output
  - Resolution: 16 bits including sign
  - Configurable diagnostics (per channel)
  - Fast updating of the output values

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Calibration in runtime	V1.0.0 or higher	X	X
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Note

You may use and combine the different wiring options for all channels.

Note

Do not insert the potential jumpers included with the front connector!

Abbreviations used

Meaning of the abbreviations used in the figures below:

QV_n	Voltage output channel
QI_n	Current output channel
Sn+/Sn-	Sense line channel
L+	Supply voltage connection
M	Ground connection
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status
PWR	Display for the supply voltage

Pin assignment for the power supply element

The power supply element is plugged onto the front connector for powering the analog module. Wire the supply voltage to terminals 41 (L+) and 44 (M). Use terminals 42 (L+) and 43 (M) to loop the potential to the next module.

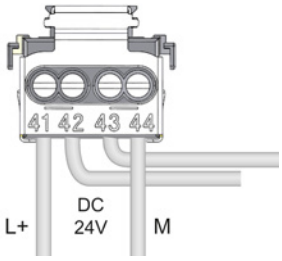
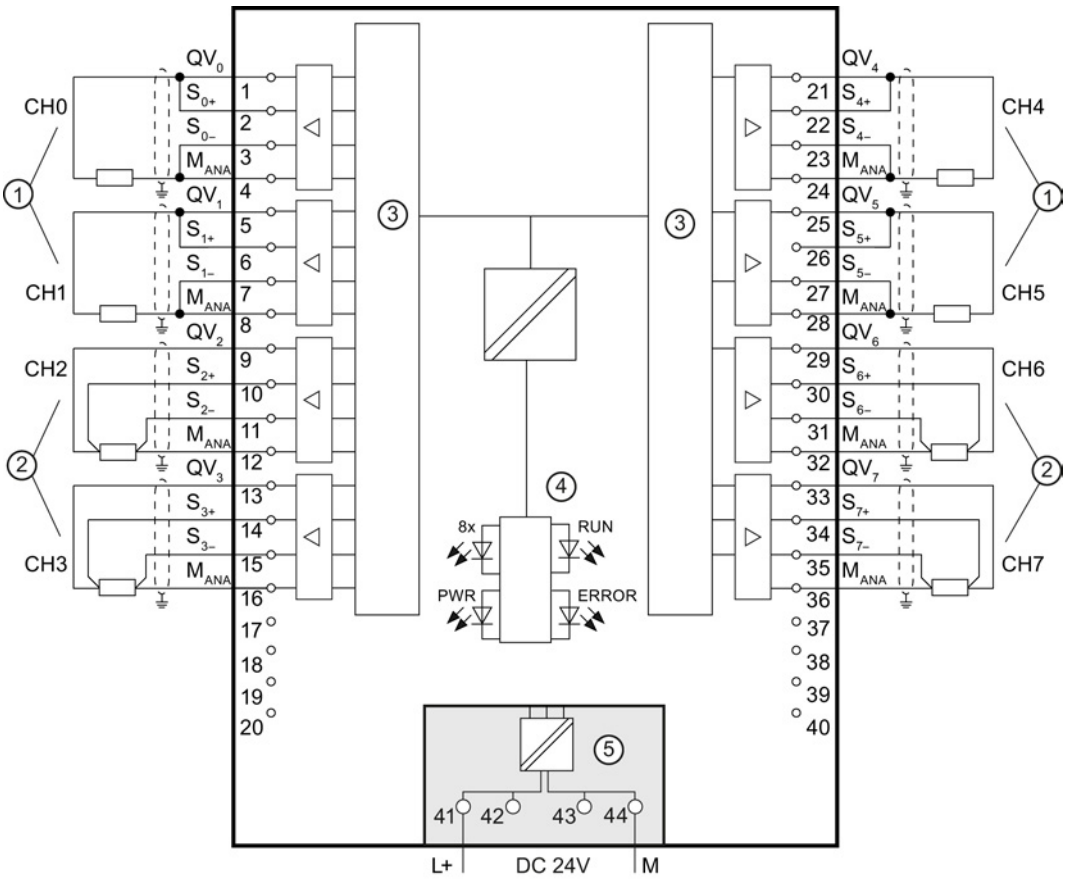


Figure 3-1 Power supply element wiring

Block diagram and terminal assignment for the voltage output

The example in the figure below shows the terminal assignment for a voltage measurement.

- 2-wire connection, no compensation for line impedance.
- 4-wire connection with compensation for line impedance is displayed.

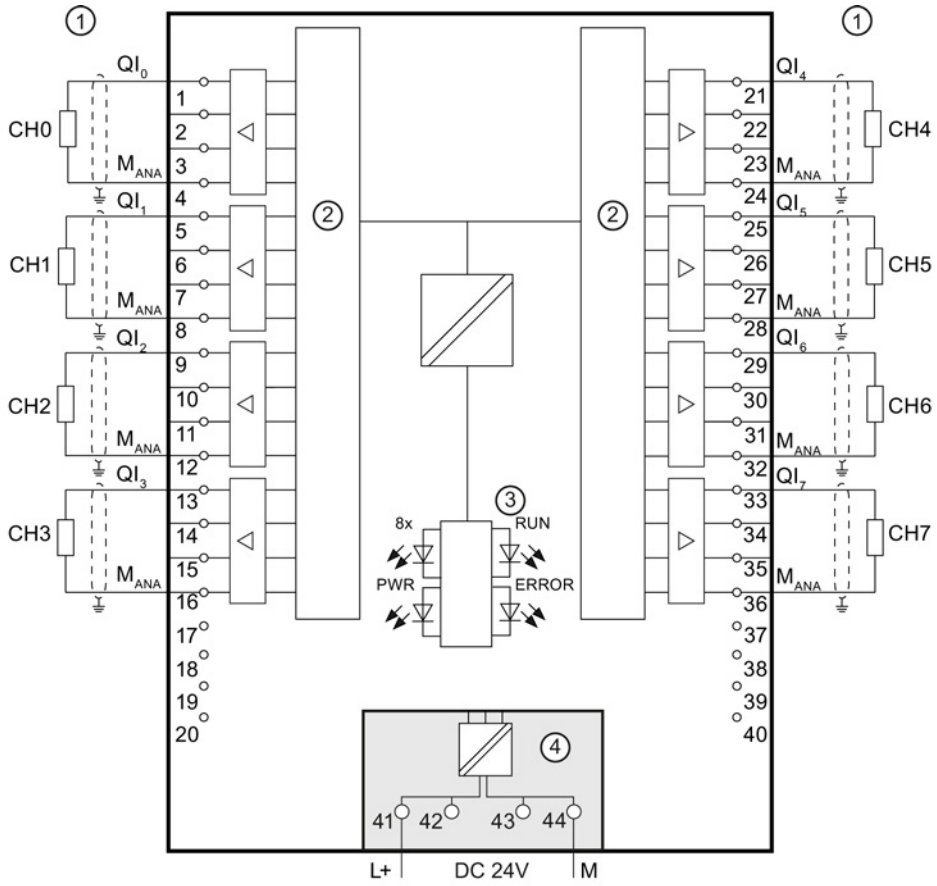


① 2-wire connection (jumper at the front connector)
② 4-wire connection
③ Digital Analog Converter (DAC)
④ Backplane bus interface
⑤ Supply voltage via power supply element

Figure 3-2 Block diagram and terminal assignment for the voltage output

Block diagram and terminal assignment for a current output

The following figure shows an example of the terminal assignment for current output circuitry.



① Load on current outputs

② Digital Analog Converter (DAC)

③ Backplane bus interface

④ Supply voltage via power supply element

Figure 3-3 Block diagram and terminal assignment for a current output

Parameters/address space 4

4.1 Output ranges

The module is set to voltage output type by default with output range ±10 V. You need to edit the module parameters with STEP 7 if you want to use a different output range or output type.

Output type and output ranges

Output type	Output range
Voltage	1 V to 5 V 0 V to 10 V ±10 V
Current	0 mA to 20 mA 4 mA to 20 mA ±20 mA
Disabled	-

The tables of the output ranges, overflow, overshoot range, etc. are available in the appendix Representation of analog values (Page 43).

4.2 Parameters

AQ 8xU/I HS parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to chapter Parameter assignment and structure of the parameter data records (Page 39).

Table 4- 1 Configurable parameters and their defaults

Parameters	Value range	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	No	Channel*	Module**
• Wire break	Yes/No	No	No	Channel	Module**
• Short circuit to M	Yes/No	No	No	Channel	Module**
• Overflow	Yes/No	No	No	Channel	Module**
• Underflow	Yes/No	No	No	Channel	Module**
Output					
• Output type	Voltage/current	Voltage	Yes	Channel	Channel
• Output range	See chapter output ranges (Page 17)	±10 V	Yes	Channel	Channel
• Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Channel*** • Turn off • Keep last value

Parameters	Value range	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
• Substitute value	See Table B-4 Valid substitute value for the output range (Page 42)	0	Yes	Channel	---***

* If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

** You can set the effective range of the diagnostics for each channel in the user program with data records 64 to 71.

*** You can configure the setting "Output substitute value" and the substitute value in the user program by means of data records 64 to 71.

Short-circuit detection

The diagnostics for short circuit to ground can be configured for the voltage output type. A short-circuit detection is not possible for small output values; the output voltages must therefore be below -0.5 V or above +0.5 V.

Open-circuit detection

The diagnostics for open circuit can be configured for the current output type. An open-circuit detection is not possible for small output values; the output voltages must therefore be below -3 mA or above +3 mA.

4.3 Declaration of parameters

Missing supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the output to M_{ANA} occurs.

Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Underflow

Enabling of the diagnostics when the output value violates the underrange.

Reaction to CPU STOP

Determines the reaction of the output to the CPU going into STOP state.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of AQ 8xU/I HS

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	AQ 8xU/I HS	X	X
1 x 8-channel with value status	AQ 8xU/I HS QI	X	X
8 x 1-channel without value status	AQ 8xU/I HS S	X	---
8 x 1-channel with value status	AQ 8xU/I HS S QI	X	---
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	AQ 8xU/I HS MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AQ 8xU/I HS QI
- AQ 8xU/I HS S QI
- AQ 8xU/I HS MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space of AQ 8xU/I HS

The following figure shows the address space allocation for the configuration as 8-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"QB x" represents the module start address output byte x.

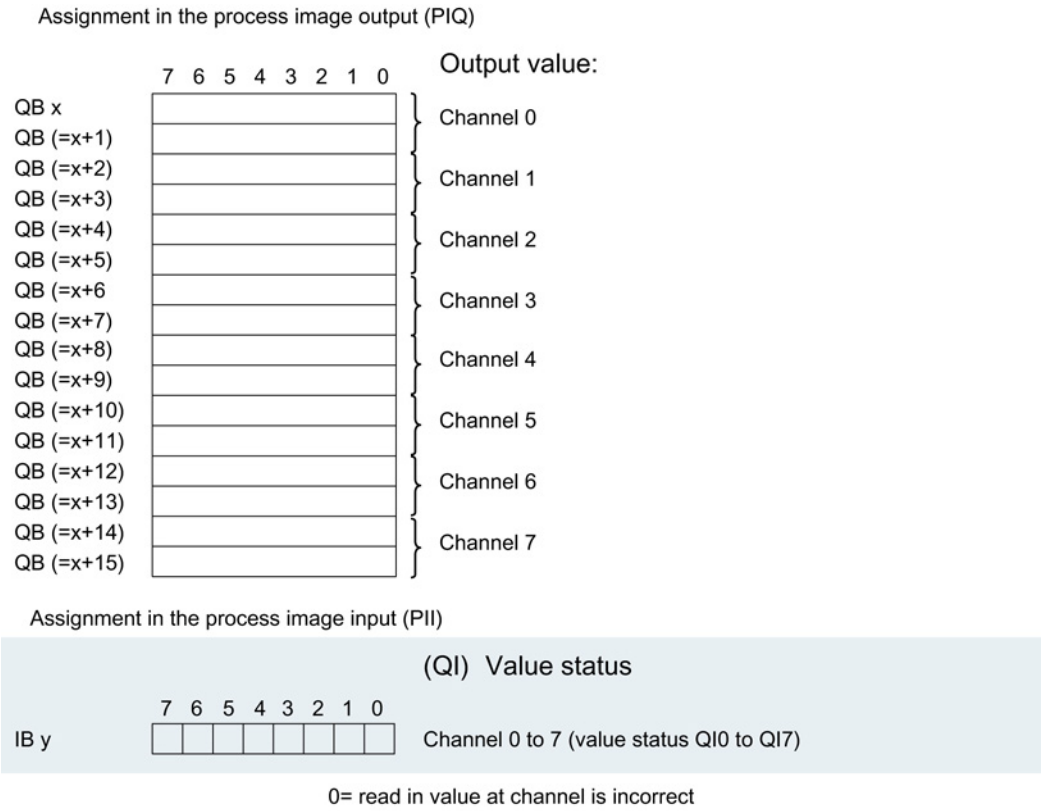


Figure 4-1 Address space for configuration as 1 x 8-channel AQ 8xU/I HS with value status

Address space for configuration as 8 x 1-channelAQ 8xU/I HS S QI

For the configuration as a 8 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 8-channel module configuration, each of the eight submodules has a freely assignable start address.

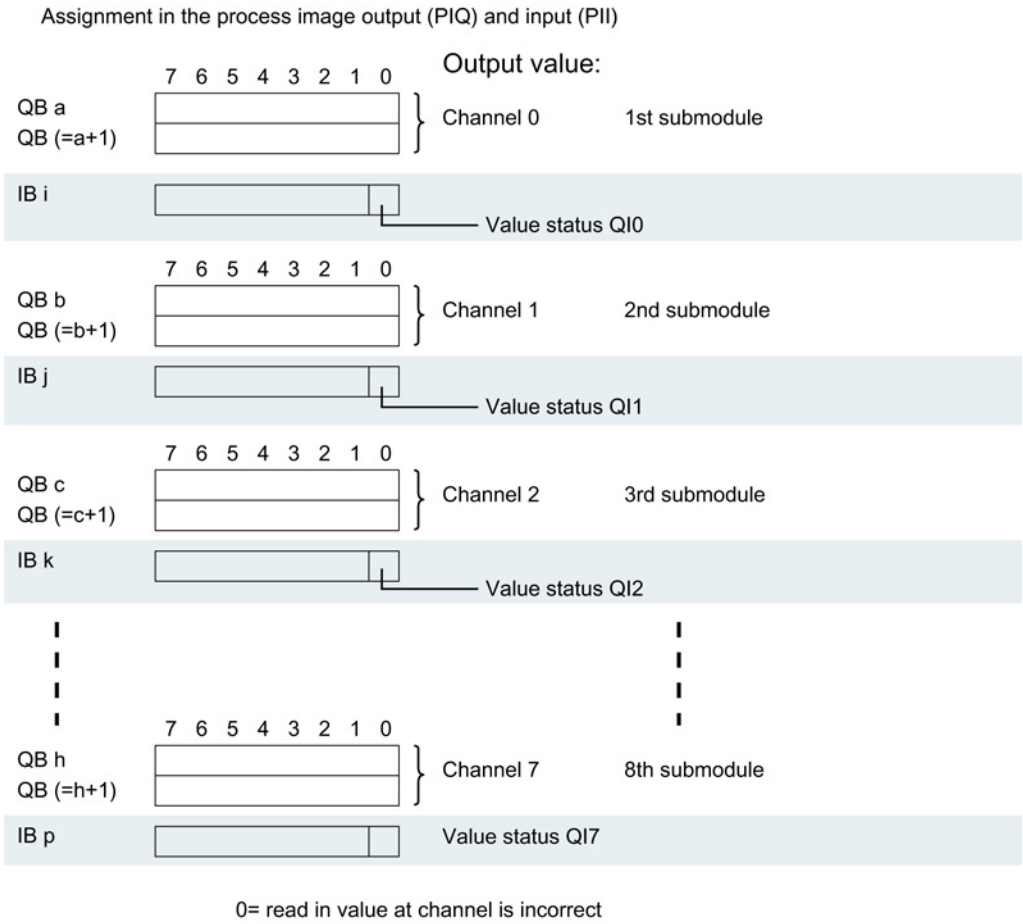


Figure 4-2 Address space for configuration as 8 x 1-channel AQ 8xU/I HS S QI with value status

Address space for configuration as 1 x 8-channelAQ 8xU/I HS MSO

For the configuration as a 1 x 8-channel module (module-internal shared output, MSO), channels 0 to 7 of the module are copied to multiple submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device.

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space with submodules 1 and 2.

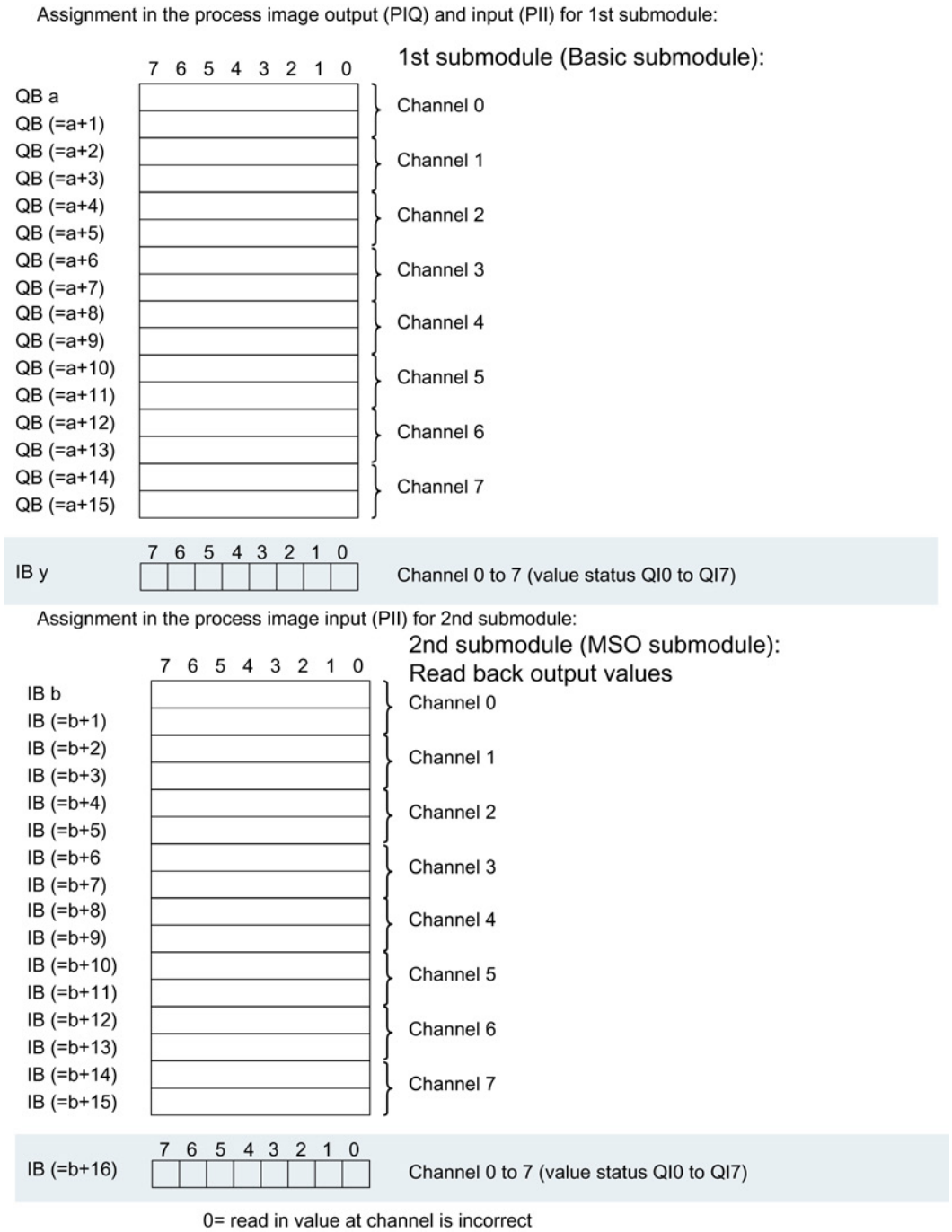


Figure 4-3 Address space for configuration as 1 x 8-channel AQ 8xU/I HS MSO with value status

The following figure shows the assignment of the address space with submodules 3 and 4.

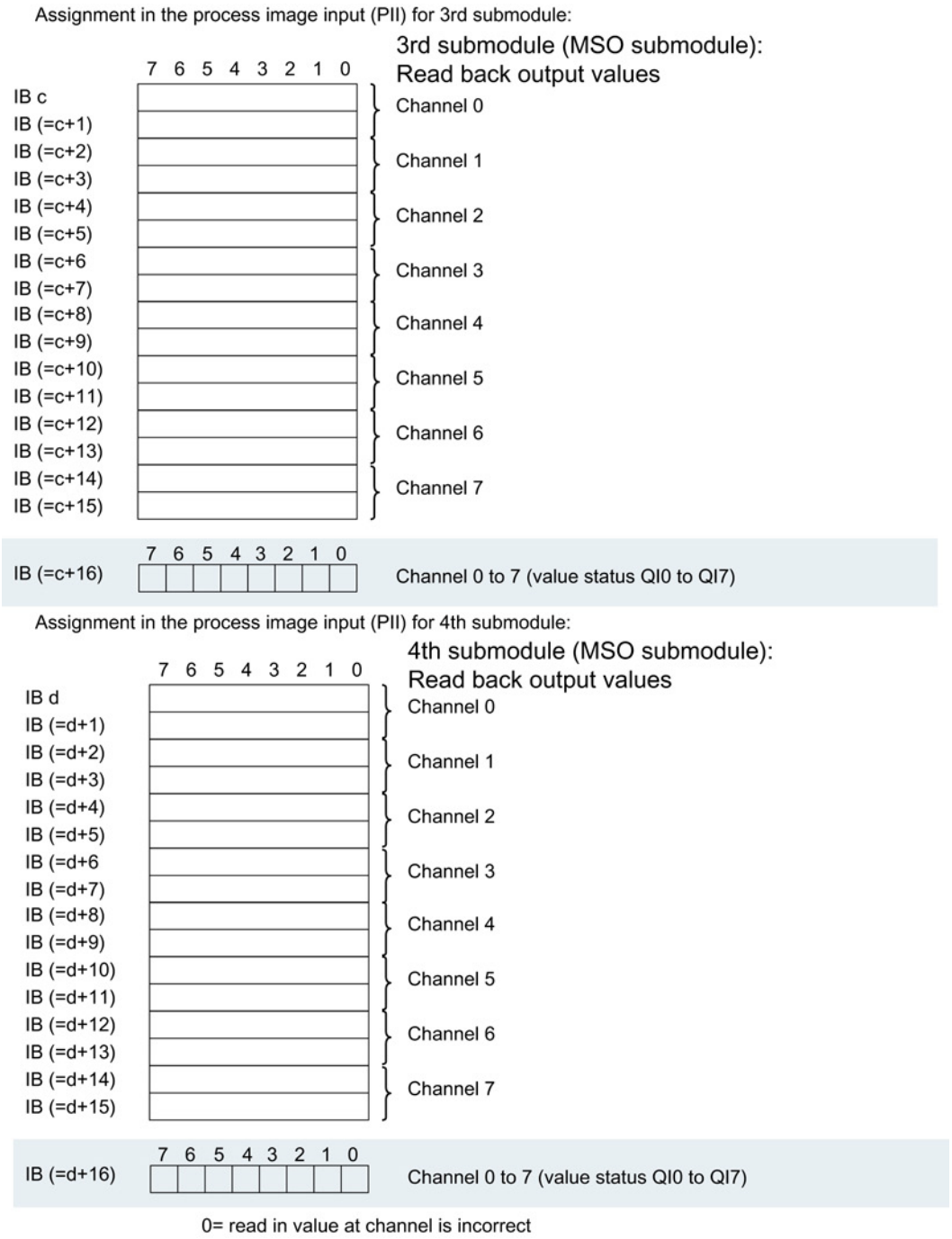


Figure 4-4 Address space for configuration as 1 x 8-channel AQ 8xU/I HS MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the AQ 8xU/I HS.

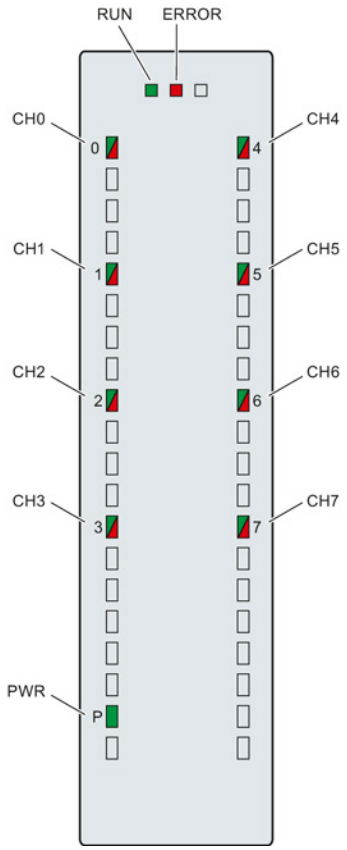


Figure 5-1 LED displays of the AQ 8xU/I HS module

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in section Diagnostic alarms (Page 30).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (there is an error on at least one channel, for example a wire break).	Evaluate the diagnostic data and eliminate the error (e.g. wire break).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	Remedy
Off	Supply voltage L+ too low or missing	Check the L+ supply voltage.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
Off	Channel deactivated	---
On	Channel configured and OK	---
On	Diagnostic alarm: e.g., wire break, overflow, underflow	Check the wiring. Disable diagnostics.

5.2 Interrupts

The analog output module AQ 8xU/I HS supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Short-circuit to ground
- Wire break
- Overflow
- Underflow

For more information on the error event, refer to the error OB with the RALRM instruction (read additional interrupt information) and to the STEP 7 online help.

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit to ground	1_H	Overload at output	Eliminate overload
		Short-circuit of output Q_V to M_{ANA}	Eliminate the short-circuit
Wire break	6_H	Encoder circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wirebreak between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
Overflow	7_H	The output value set by the user program exceeds the valid rated range/overshoot range.	Correct the output value
Underflow	8_H	The output value set by the user program undershoots the valid rated range/undershoot range.	Correct the output value
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module

Technical specifications 6

Technical specifications of the AQ 8xU/I HS

	6ES7532-5HF00-0AB0
Product type designation	AQ 8xU/I HS
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
CiR Configuration in RUN	
Parameter assignment in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	260 mA; (with 24 V DC supply)
Power	
Power consumption from the backplane bus	1.15 W
Power loss	
Power loss, typ.	7 W
Analog outputs	
Number of analog outputs	8
Voltage output, short-circuit protection	Yes
Voltage output, short-circuit current, max.	45 mA
Current output, open-circuit voltage, max.	20 V
Cycle time (all channels) min.	125 µs; (regardless of the number of activated channels)

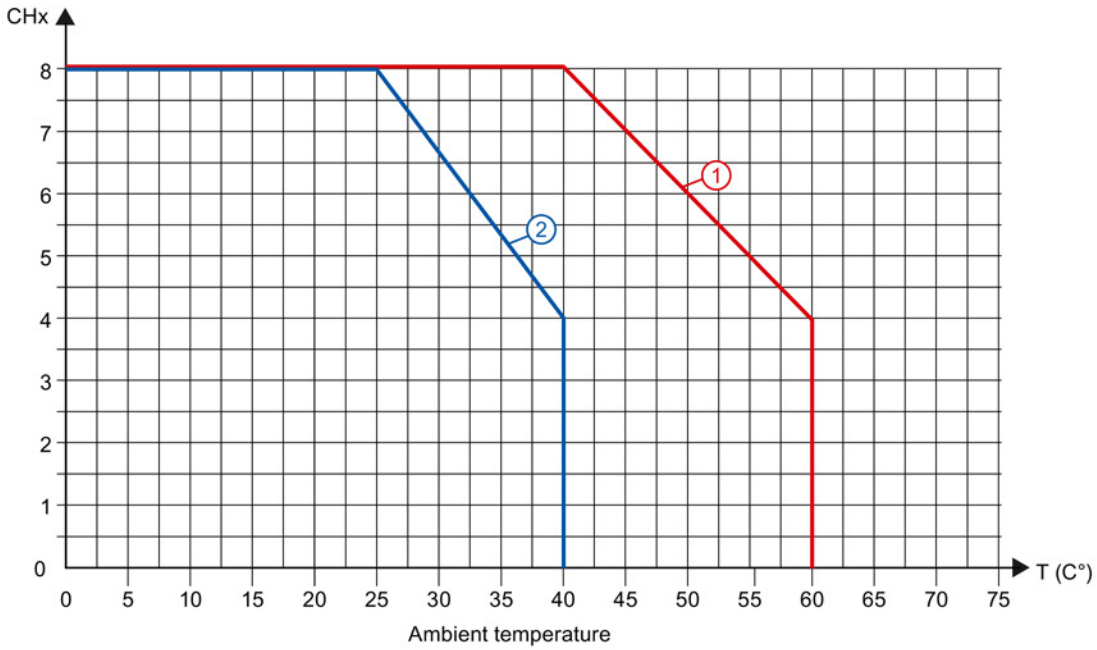
	6ES7532-5HF00-0AB0
Output ranges, voltage	
0 V to 10 V	Yes
1 V to 5 V	Yes
-10 V to +10 V	Yes
Output ranges, current	
0 mA to 20 mA	Yes
-20 mA to +20 mA	Yes
4 mA to 20 mA	Yes
Connection of actuators	
for voltage output 2-wire connection	Yes
for voltage output 4-wire connection	Yes
for current output 2-wire connection	Yes
Load resistance (in the rated output range)	
for voltage outputs, min.	1 kΩ
for voltage outputs, capacitive load, max.	100 nF
for current outputs, max.	500 Ω
for current outputs, inductive load, max.	1 mH
Cable length	
Cable length shielded, max.	200 m
Analog value formation	
Integration and conversion time / resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Conversion time (per channel)	50 µs
Settling time	
for resistive load	30 µs; (see additional description in the manual)
for capacitive load	100 µs; (see additional description in the manual)
for inductive load	100 µs; (see additional description in the manual)
Errors/accuracies	
Output ripple (referenced to the output range, bandwidth 0 to 50 kHz)	± 0.02 %
Linearity error (referenced to the output range)	± 0,15 %
Temperature error (referenced to the output range)	± 0,002 %
Crosstalk between outputs, max.	-100 dB
Repetition accuracy in settled state at 25 °C (referenced to the output range)	± 0,05 %
Operational limit in overall temperature range	
Voltage, referenced to the output range	± 0.3 %
Current, referenced to the output range	± 0.3 %

	6ES7532-5HF00-0AB0
Basic error limit (operational limit at 25 °C)	
Voltage, referenced to the output range	± 0.2 %
Current, referenced to the output range	± 0.2 %
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	100 µs
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; only for output type current
Short-circuit	Yes; only for output type voltage
Overflow/underflow	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	8
Between the channels and the backplane bus	Yes
Between the channels and the load voltage L+	Yes
Permitted potential difference	
Between MANA and M internal (UISO)	75 V DC / 60 V AC (basic isolation)
between S- and MANA (UCM)	+/- 8 V
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	No

	6ES7532-5HF00-0AB0
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	325 g

Derating in dependence on overall length, ambient temperature and output type (per module)

The following curves show the number of channels (CHx) that can be used simultaneously in horizontal and vertical installation depending on the ambient temperature.



① Horizontal mounting position

② Vertical mounting position

Figure 6-1 Information on channels used simultaneously (per module) for output type: Current and voltage

Note

All eight channels can be used in the case of voltage outputs with load resistances > 5 kΩ and ambient temperatures up to 40° (vertical installation) or up to 60° (horizontal installation).

Settling times for voltage outputs

The settling time for voltage outputs is influenced mainly by the capacitive load.

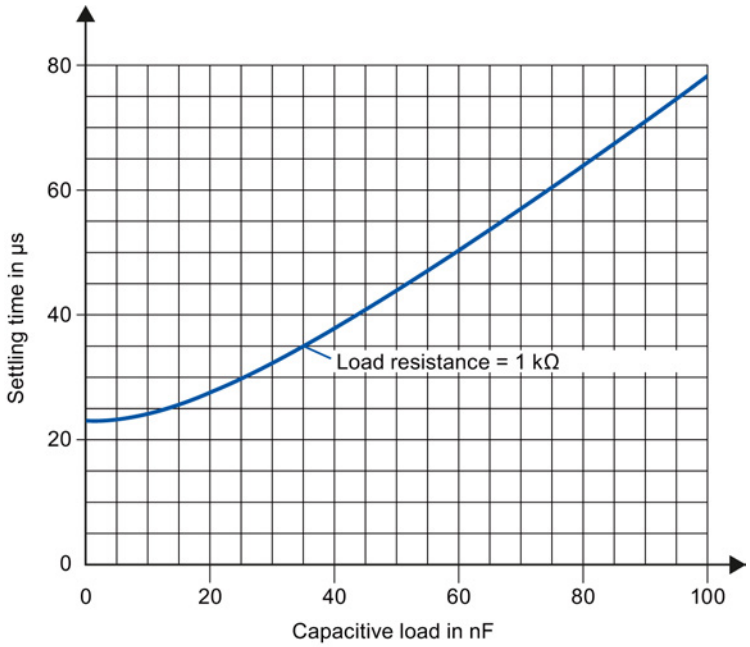


Figure 6-2 Typical settling times for voltage outputs

Settling times for current outputs

The settling time for current outputs increases when the load impedance rises.

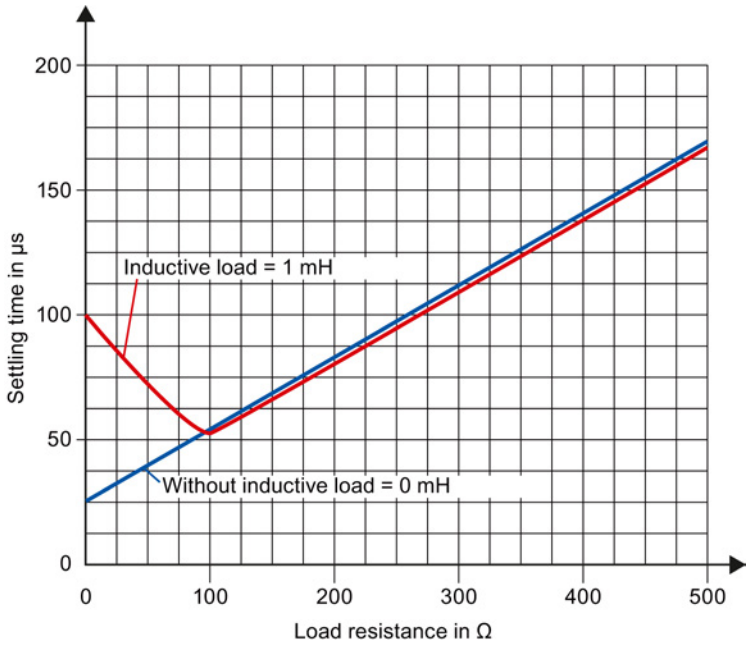


Figure 6-3 Typical settling times for current outputs

Dimensional drawing

A

This appendix contains the dimensional drawing of the module installed on a mounting rail and with a shield bracket. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

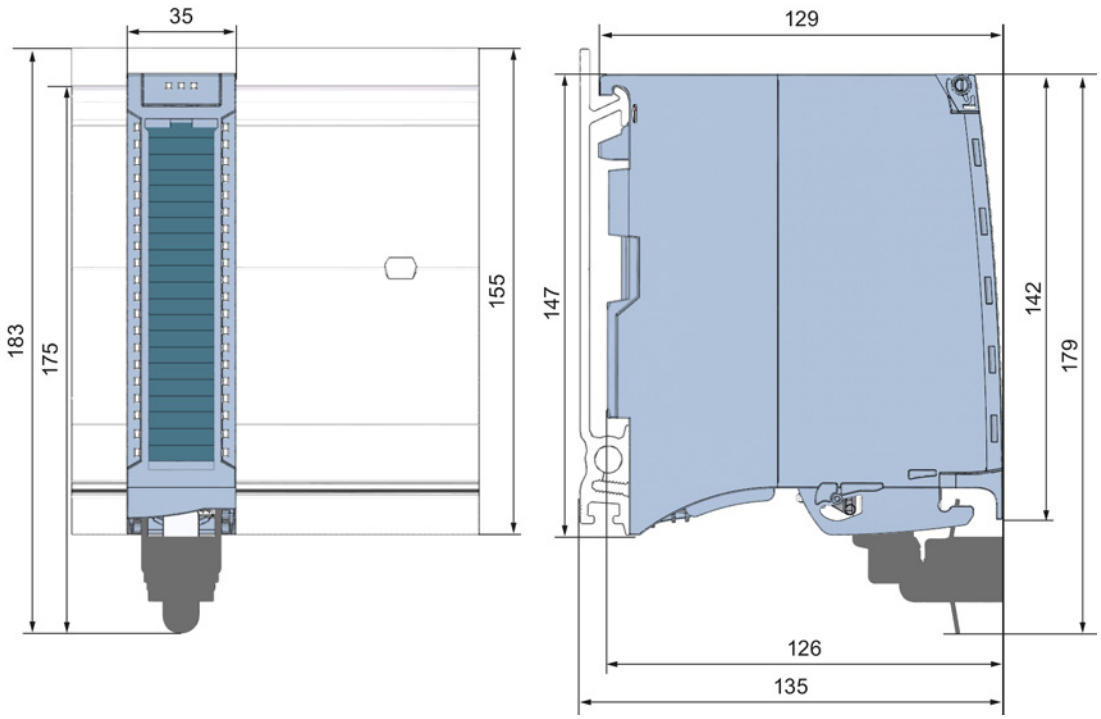


Figure A-1 Dimensional drawing of the AQ 8xU/I HS module

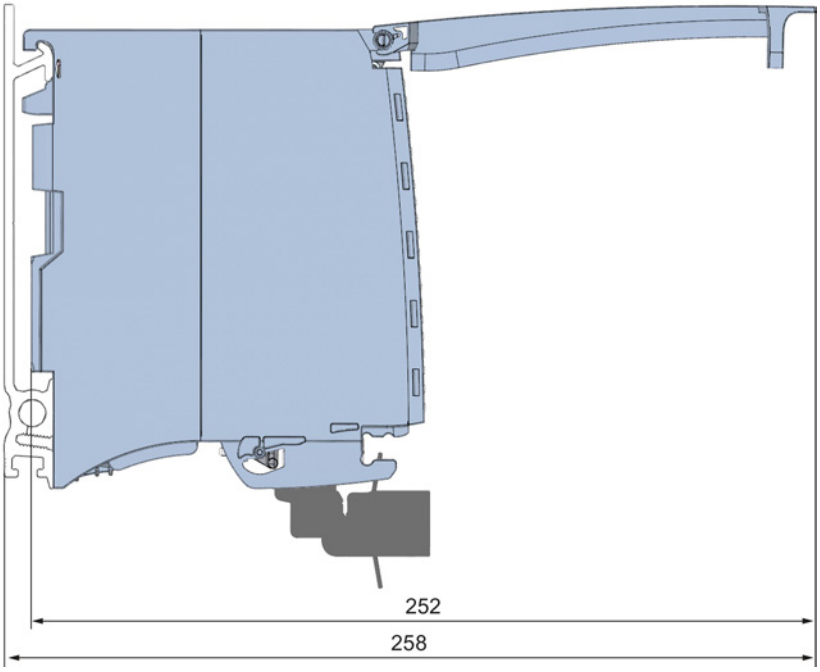


Figure A-2 Dimensional drawing of the AQ 8xU/I HS module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

Note for configuration of the module with GSD file that the settings of some parameters are dependent on each other, see the table below.

The parameters are only checked for plausibility by the module after the transfer.

If errors occur during the transfer of parameters with the GSD file, the module continues operation with the previous parameter assignment.

Table B- 1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Short circuit to M	With **output type** voltage only
Wire break	With **output type** current only
Substitute value	Only if **Reaction to CPU STOP** -> **Output substitute value** is configured

Parameter assignment in the user program

You have the option to assign module parameters in RUN (e.g., the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 71. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The channel parameters in data records 64 to 71 are available for 1x 8-channel configuration and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- ...
- Data record 70 for channel 6
- Data record 71 for channel 7

For configuration 8 x 1-channel, the module has 8 submodules with one channel each. The parameters for the channel are available in data record 64 and are assigned as follows:

- Data record 64 for channel 0 (submodule 1)
- Data record 64 for channel 1 (submodule 2)
- ...
- Data record 64 for channel 5 (submodule 6)
- Data record 64 for channel 6 (submodule 7)
- Data record 64 for channel 7 (submodule 8)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

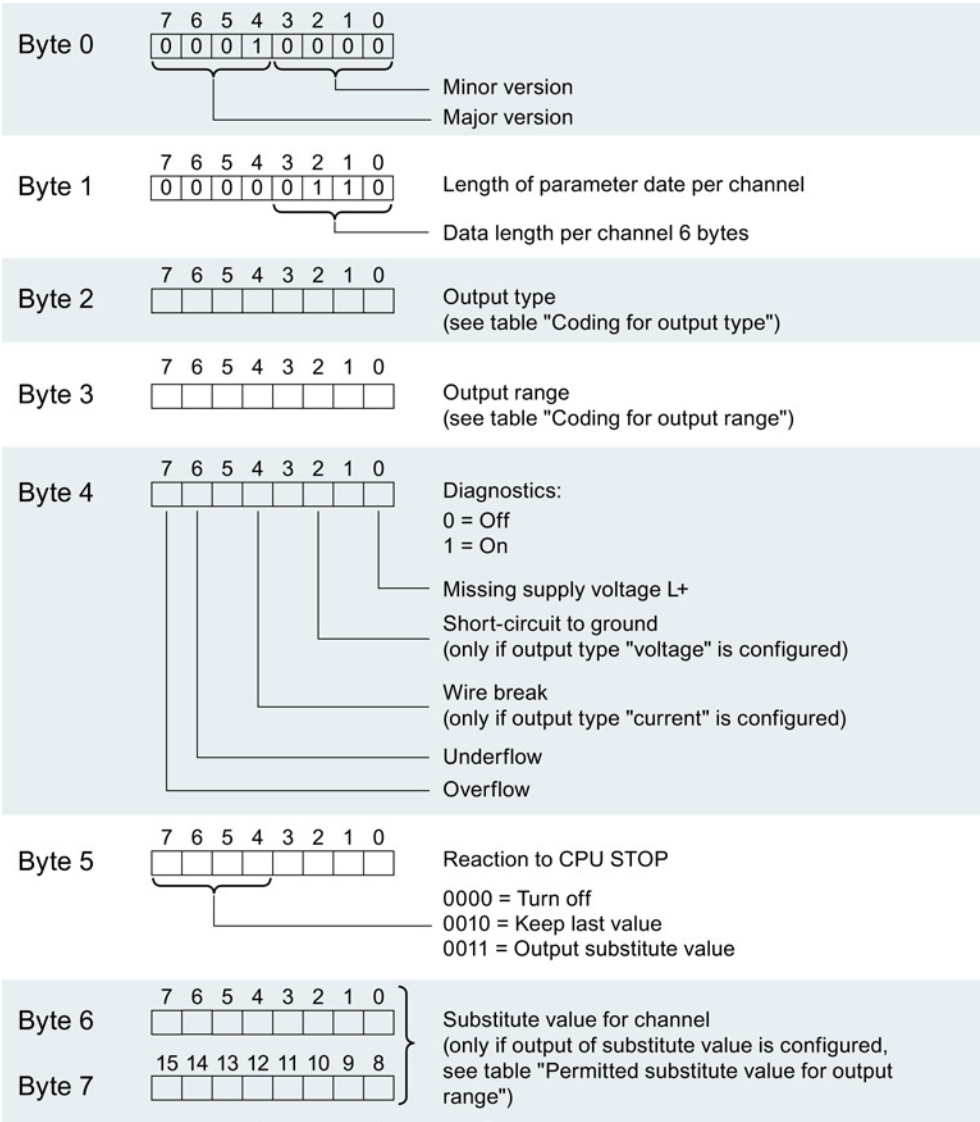


Figure B-1 Data record structure: Bytes 0 to 7

Output type codes

The following table lists all output types of the analog output module along with their codes. Enter these codes at byte 2 of the data record for the corresponding channel (see the previous figure).

Table B- 2 Code for the output type

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0010

Codes for the output ranges

The table below contains all output ranges of the analog output module with their codes. Enter these codes at byte 3 of the data record for the corresponding channel (see the previous figure).

Table B- 3 Output range code

Output range for voltage	Code
1 V to 5 V	0000 0011
0 V to 10 V	0000 0010
±10 V	0000 0000
Output range for current	**Code**
0 mA to 20 mA	0000 0001
4 mA to 20 mA	0000 0010
±20 mA	0000 0000

Valid substitute values

The following table lists all output ranges for the valid substitute values. Enter these substitute values at bytes 6 and 7 of the data record for the corresponding channel (see the previous figure). You can find the binary representation of the output ranges in section Representation of analog values (Page 43).

Table B- 4 Valid substitute value for the output range

Output range	Valid substitute value
±10 V	-32512 ... +32511
1 V to 5 V	-6912 ... +32511
0 V to 10 V	0 ... +32511
±20 mA	-32512 ... +32511
4 mA to 20 mA	-6912 ... +32511
0 mA to 20 mA	0 ... +32511

Representation of analog values

C

Introduction

This appendix describes the analog values for all output ranges supported by the AQ 8xU/I HS analog module.

Measured value resolution

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table C- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	dec	hex	high byte	low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.1 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Table C- 2 Bipolar output ranges

Value dec.	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100,004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100,000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0,003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0,003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100,000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100,004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117,593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117,593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < -32512 are specified, the output value is limited to -117.593%.

Table C- 3 Unipolar output ranges

Value dec.	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117,589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100,004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100,000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0,003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < 0 are specified, the output value is limited to 0%.

C.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table C- 4 Voltage output range ±10 V

Values			Voltage output range	Range
	dec	hex	±10 V	
>117.589 %	>32511	>7EFF	11.76 V	Maximum output value
117.589 %	32511	7EFF	11.76 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	10 V	Rated range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
	-1	FFFF	-361.7 µV	
-75 %	-20736	AF00	-7.5 V	
-100 %	-27648	9400	-10 V	
	-27649	93FF		Undershoot range
-117.593 %	-32512	8100	-11.76 V	
<-117.593 %	<-32512	<8100	-11.76 V	Minimum output value

Table C- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	dec	hex	0 V to 10 V	
>117.589 %	>32511	>7EFF	11.76 V	Maximum output value
117.589 %	32511	7EFF	11.76 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	10 V	Rated range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
<0 %	<0	<0	0 V	Minimum output value

Table C- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	dec	hex	1 V to 5 V	
>117.589 %	>32511	>7EFF	5.70 V	Maximum output value
117.589 %	32511	7EFF	5.70 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	5 V	Rated range
75 %	20736	5100	4 V	
0.003617 %	1	1	1 V +144.7 µV	
0 %	0	0	1 V	
	-1	FFFF	1 V -144.7 µV	Undershoot range
-25 %	-6912	E500	0 V	
<-25 %	<-6912	<E500	0 V	Minimum output value

C.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table C- 7 Current output range ±20 mA

Values			Current output range	Range
	dec	hex	±20 mA	
>117.589 %	>32511	>7EFF	23.52 mA	Maximum output value
117.589 %	32511	7EFF	23.52 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75 %	-20736	AF00	-15 mA	
-100 %	-27648	9400	-20 mA	
	-27649	93FF		Undershoot range
-117.593 %	-32512	8100	-23.52 mA	
<-117.593 %	<-32512	<8100	-23.52 mA	Minimum output value

Table C- 8 Current output range 0 to 20 mA

Values			Current output range	Range
	dec	hex	0 mA to 20 mA	
>117.589 %	>32511	>7EFF	23.52 mA	Maximum output value
117.589 %	32511	7EFF	23.52 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
<0 %	<0	<0	0 mA	Minimum output value

Table C- 9 Current output range 4 to 20 mA

Values			Current output range	Range
	dec	hex	4 mA to 20 mA	
>117.589 %	>32511	>7EFF	22.81 mA	Maximum output value
117.589 %	32511	7EFF	22.81 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	16 mA	
0.003617 %	1	1	4 mA	
0 %	0	0	4 mA	
	-1	FFFF		Undershoot range
-25 %	-6912	E500	0 mA	
<-25 %	<-6912	<E500	0 mA	Minimum output value

SIEMENS

SIMATIC

S7-1500/ET 200MP
Analog output module AQ 4xU/I ST
(6ES7532-5HD00-0AB0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared output (MSO) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation provided for analog output module AQ 4xU/I ST

The following table lists further documentation that you will need when using the AQ 4xU/I ST analog output module.

Table 1- 1 Documentation for analog output module AQ 4xU/I ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP distributed I/O System (http://support.automation.siemens.com/WW/view//68052815)	
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Most important contents
Analog value processing	Function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology), etc. • Description/explanation of meanings, e.g. conversion and cycle time, basic and operation limits, etc.
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

See also

ET 200MP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/59193214)

Product overview

2

2.1 Properties

Order number

6ES7532-5HD00-0AB0

View of the module

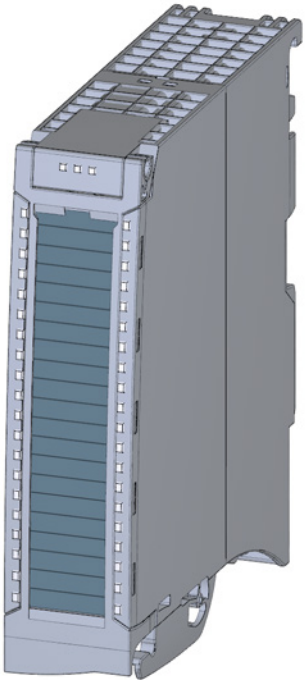


Figure 2-1 View of the AQ 4xU/I ST module

Properties

The module has the following properties:

- Technical properties
  - 4 analog outputs
  - Selection of channels for voltage output
  - Selection of channels for current output
  - Resolution: 16 bits including sign
  - Configurable diagnostics (per channel)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Calibration in runtime	V1.0.0 or higher	X	X
Module-internal shared output (MSO)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Note

You may use and combine the different wiring options for all channels.

Note

Do not insert the potential jumpers included with the front connector!

Abbreviations used

QV_n	Voltage output channel
QI_n	Current output channel
S_n+/S_n-	Sense line channel
L+	Supply voltage connection
M	Ground connection
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status
PWR	Display for the supply voltage

Pin assignment for the power supply element

The power supply element is plugged onto the front connector for powering the analog module. Wire the supply voltage to terminals 41 (L+) and 44 (M). Use terminals 42 (L+) and 43 (M) to loop the potential to the next module.

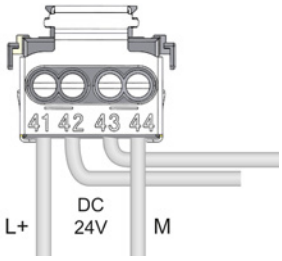
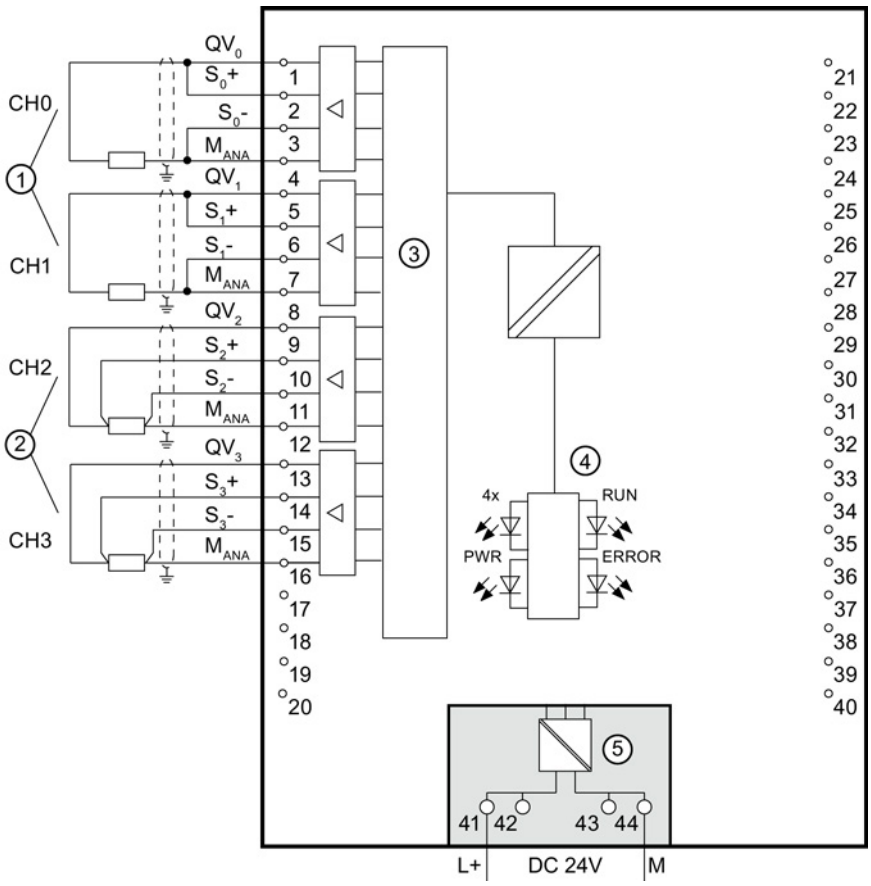


Figure 3-1 Power supply element wiring

Block diagram and terminal assignment for the voltage output

The following figure shows an example of the wiring options:

- 2-wire connection, without compensation for line resistances.
- 4-wire connection, with compensation for line resistances.

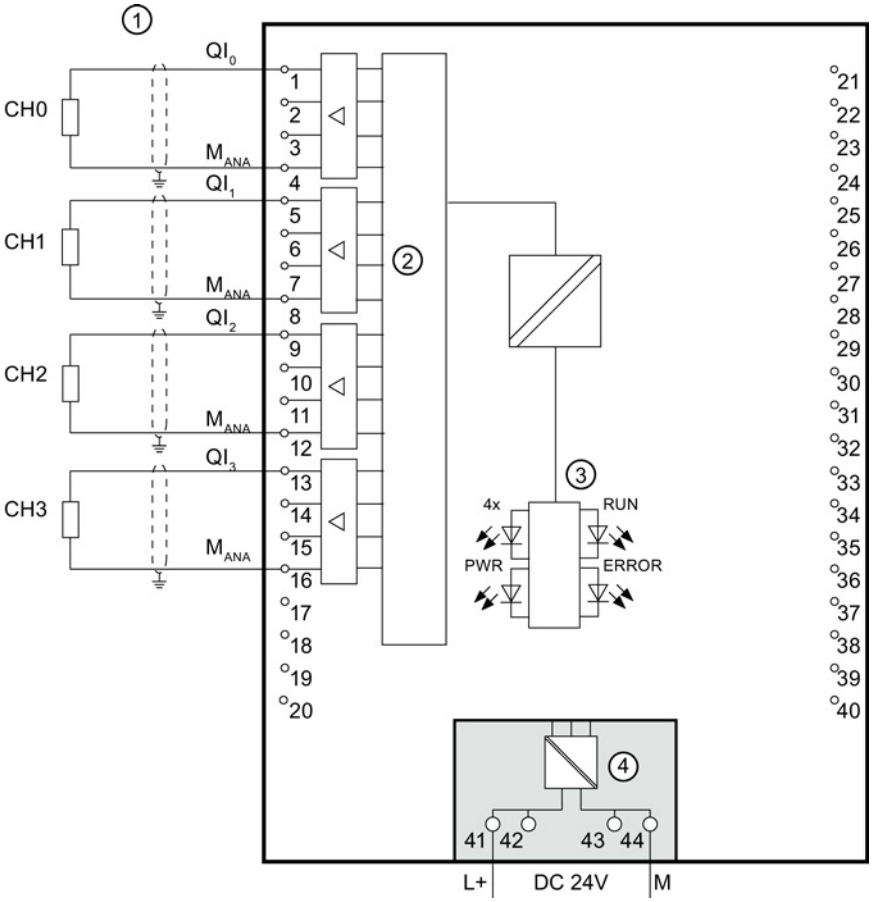


① 2-wire connection (jumper at the front connector)
② 4-wire connection
③ Digital Analog Converter (DAC)
④ Backplane bus interface
⑤ Power via supply module

Figure 3-2 Block diagram and terminal assignment for the voltage output

Block diagram and terminal assignment for the current output

The following figure shows an example of the terminal assignment for current output circuitry.



① Load on current outputs
② Digital Analog Converter (DAC)
③ Backplane bus interface
④ Power via supply module

Figure 3-3 Block diagram and terminal assignment for the current output

Parameters/address space 4

4.1 Output ranges

The module is set to voltage output type by default with output range ±10 V. You need to edit the module parameters with STEP 7 if you want to use a different output range or output type.

Output type and output ranges

The following table shows the output type and the respective output ranges.

Table 4- 1 Output type and output ranges

Output type	Output range
Voltage	1 V to 5 V 0 V to 10 V ±10 V
Current	0 to 20 mA 4 to 20 mA ±20 mA
Disabled	-

The tables of the output ranges, overflow, overshoot range, etc. are available in the appendix Representation of analog values (Page 43).

4.2 Parameters

AQ 4xU/I ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; see chapter Parameter assignment and structure of the parameter data record. (Page 37)

Table 4- 2 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel*	Module**
• Wire break	Yes/No	No	Yes	Channel	Module**
• Short circuit to M	Yes/No	No	Yes	Channel	Module**
• Underflow	Yes/No	No	Yes	Channel	Module**
• Overflow	Yes/No	No	Yes	Channel	Module**
Output					
• Output type	Current/voltage	Voltage	Yes	Channel	Channel
• Output range	See chapter Output ranges (Page 17)	±10 V	Yes	Channel	Channel
• Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Channel

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
• Substitute value	See Table B-4 Valid substitute value for the output range (Page 41)	0	Yes	Channel	Channel

* If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault. You can prevent this message burst by assigning the diagnostics function to one channel only.

** You can set the effective range of the diagnostics for each channel in the user program with data records 64 to 67.

Short-circuit detection

The diagnostics for short circuit to ground can be configured for the voltage output type. A short-circuit detection is not possible for small output values; the output voltages must therefore be below -0,1 V or above +0,1 V.

Open-circuit detection

The diagnostics for open circuit can be configured for the current output type. An open-circuit detection is not possible for small output values; the output voltages must therefore be below -0.2 mA or above +0.2 mA.

4.3 Declaration of parameters

Missing supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the output to M_{ANA} occurs.

Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Underflow

Enabling of the diagnostics when the output value violates the underrange.

Reaction to CPU STOP

Determines the reaction of the output to the CPU going into STOP state.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Configuration options of AQ 4xU/I ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 3 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	AQ 4xU/I ST	X	X
1 x 4-channel with value status	AQ 4xU/I ST QI	X	X
4 x 1-channel without value status	AQ 4xU/I ST S	X	---
4 x 1-channel with value status	AQ 4xU/I ST S QI	X	---
1 x 4-channel with value status for module-internal Shared Output with up to 4 submodules	AQ 4xU/I ST MSO	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AQ 4xU/I ST QI
- AQ 4xU/I ST S QI
- AQ 4xU/I ST MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space of the AQ 4xU/I ST

The following figure shows the address space allocation for the configuration as 4-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"QB x" represents the module start address output byte x.

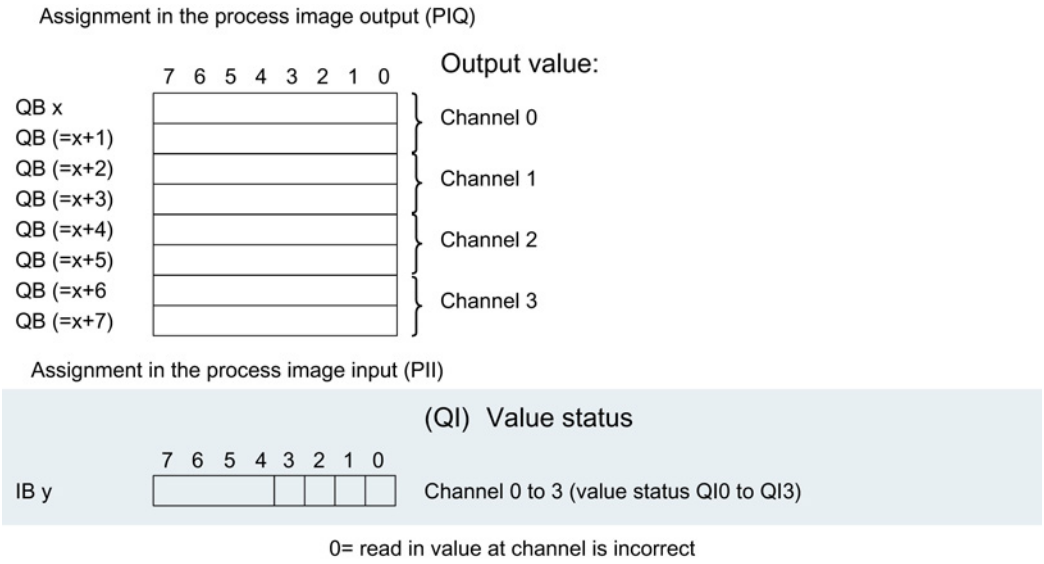


Figure 4-1 Address space for configuration as 1 x 4-channel AQ 4xU/I ST with value status

Address space for configuration as 4 x 1-channel AQ 4xU/I ST S QI

For the configuration as a 4 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 4-channel module configuration, each of the four submodules has a freely assignable start address.

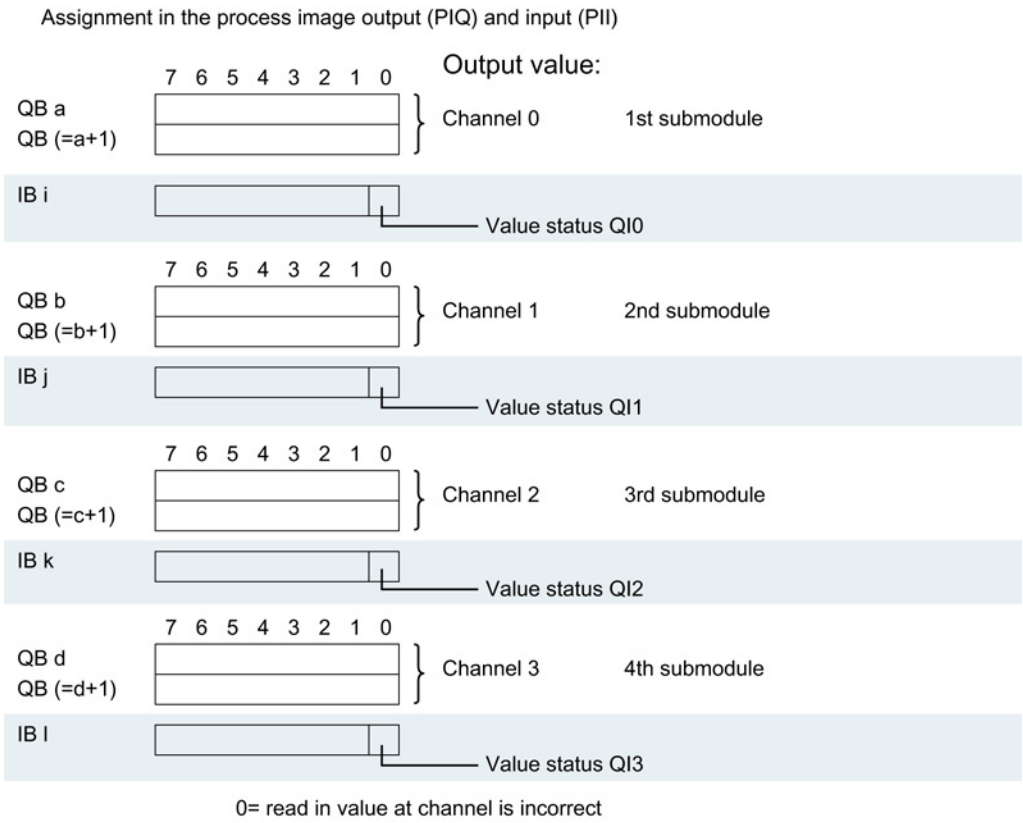


Figure 4-2 Address space for configuration as 4 x 1-channel AQ 4xU/I ST S QI with value status

Address space for configuration as 1 x 4-channel AQ 4xU/I ST MSO

For the configuration as a 1 x 4-channel module (module-internal shared output, MSO), channels 0 to 3 of the module are copied to multiple submodules. Channels 0 to 3 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device.

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 3.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 3.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space with submodules 1 and 2.

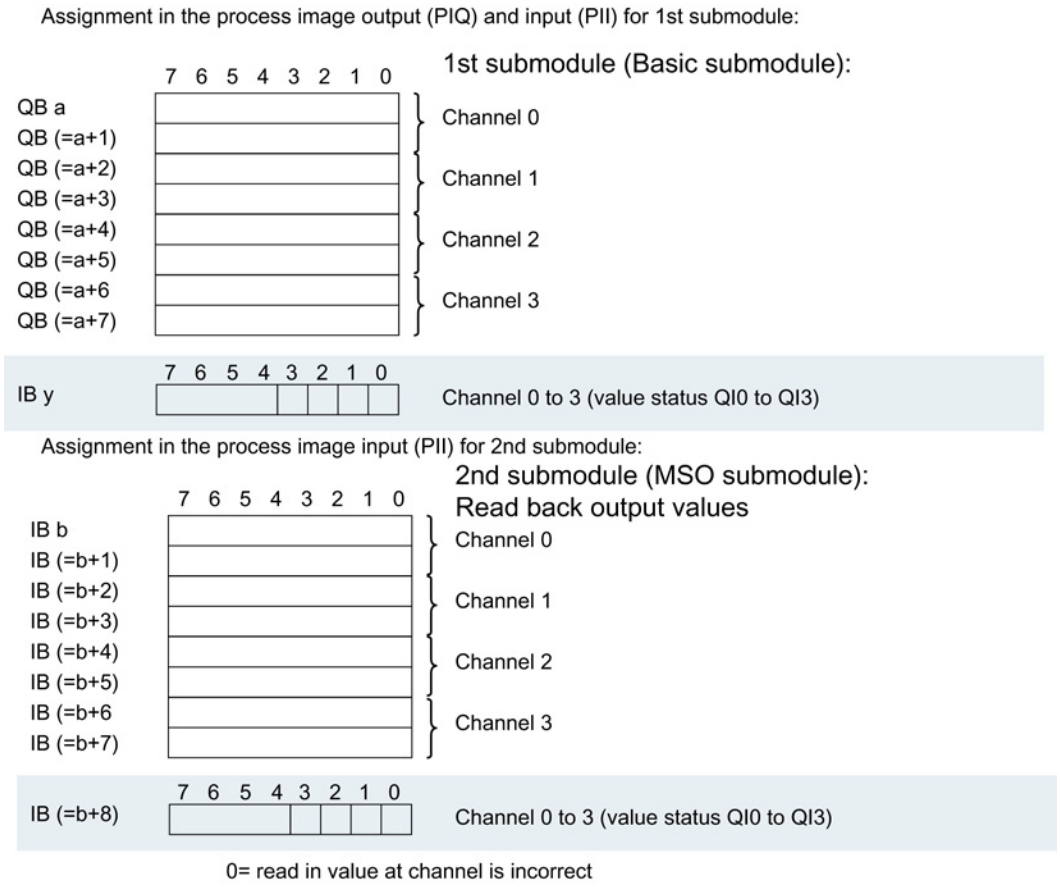


Figure 4-3 Address space for configuration as 1 x 4-channel AQ 4xU/I ST MSO with value status

The following figure shows the assignment of the address space with submodules 3 and 4.

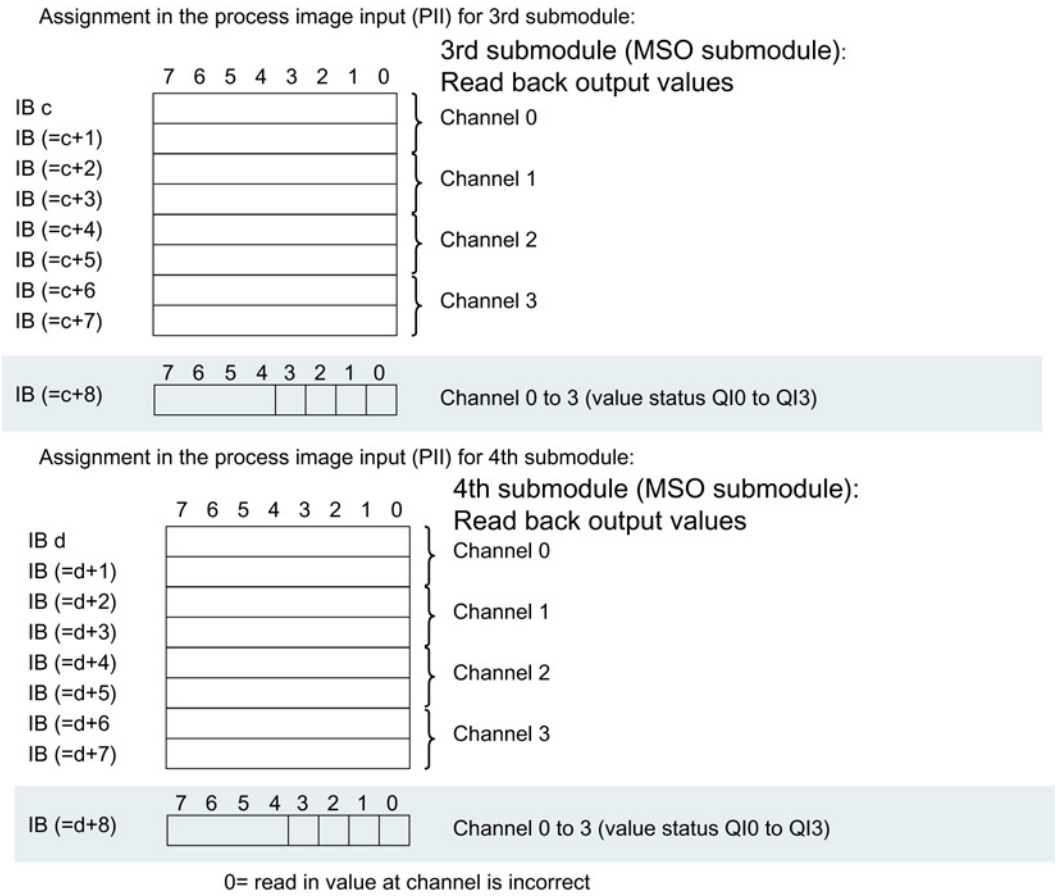


Figure 4-4 Address space for configuration as 1 x 4-channel AQ 4xU/I ST MSO with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED displays (status and error displays) of AQ 4xU/I ST.

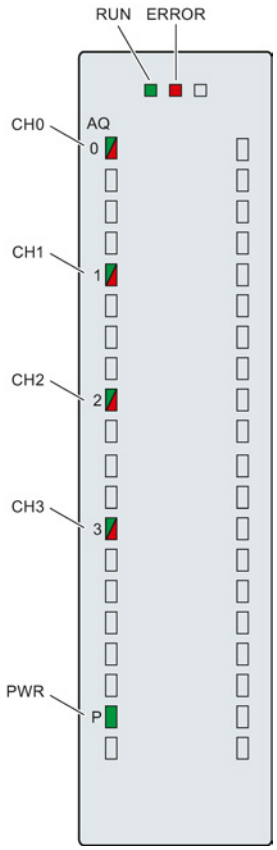


Figure 5-1 LED displays of the module AQ 4xU/I ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in chapter Diagnostics alarms (Page 30).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured	
On	Flashes	Indicates module errors (there is an error on at least one channel, for example a wire break).	Evaluate the diagnostic data and eliminate the error (e.g. wire break).
Flashes	Flashes	Hardware defective	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	Remedy
Off	Supply voltage L+ too low or missing	Check the supply voltage.
On	Supply voltage L+ is present and OK	---

Table 5- 3 CHx status display

LED CHx	Meaning	Remedy
Off	Channel deactivated	---
On	Channel configured and OK	---
On	Diagnostic alarm: e.g., wire break, overflow, underflow	Check the wiring. Disable diagnostics.

5.2 Interrupts

The analog output module AQ 4xU/I ST supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Short-circuit to ground
- Wire break
- Overflow
- Underflow

For more information on the error event, refer to the error OB with the RALRM instruction (read additional interrupt information) and to the STEP 7 online help.

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit to ground	1_H	Overload at output	Eliminate overload
		Short-circuit of output Q_V to M_{ANA}	Eliminate the short-circuit
Wire break	6_H	Encoder circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wirebreak between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
Overflow	7_H	The output value set by the user program exceeds the valid rated range/overshoot range.	Correct the output value
Underflow	8_H	The output value set by the user program undershoots the valid rated range/undershoot range.	Correct the output value
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module

Technical specifications 6

Technical specifications of the AQ 4xU/I ST

	6ES7532-5HD00-0AB0
Product type designation	AQ 4xU/I ST
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSO	Yes
CiR Configuration in RUN	
Parameter assignment in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	190 mA; (with 24 V DC supply)
Power	
Power consumption from the backplane bus	0.6 W
Power loss	
Power loss, typ.	4 W
Analog outputs	
Number of analog outputs	4
Voltage output, short-circuit protection	Yes
Voltage output, short-circuit current, max.	24 mA
Current output, open-circuit voltage, max.	22 V
Cycle time (all channels) min.	3.2 ms; (regardless of the number of activated channels)

	6ES7532-5HD00-0AB0
Output ranges, voltage	
0 V to 10 V	Yes
1 V to 5 V	Yes
-10 V to +10 V	Yes
Output ranges, current	
0 mA to 20 mA	Yes
-20 mA to +20 mA	Yes
4 mA to 20 mA	Yes
Connection of actuators	
for voltage output 2-wire connection	Yes
for voltage output 4-wire connection	Yes
for current output 2-wire connection	Yes
Load resistance (in the rated output range)	
for voltage outputs, min.	1 kOhm; 0.5 kOhm at 1 to 5 V
for voltage outputs, capacitive load, max.	1 µF
for current outputs, max.	750 Ω
for current outputs, inductive load, max.	10 mH
Cable length	
Cable length shielded, max.	800 m; for current, 200 m for voltage
Analog value formation	
Integration and conversion time / resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Conversion time (per channel)	0.5 ms
Settling time	
for resistive load	1.5 ms
for capacitive load	2.5 ms
for inductive load	2.5 ms
Errors/accuracies	
Output ripple (referenced to the output range, bandwidth 0 to 50 kHz)	± 0,02 %
Linearity error (referenced to the output range)	± 0,15 %
Temperature error (referenced to the output range)	± 0,002 %
Crosstalk between outputs, max.	-100 dB
Repetition accuracy in settled state at 25 °C (referenced to the output range)	± 0,05 %

	6ES7532-5HD00-0AB0
Operational limit in overall temperature range	
Voltage, referenced to the output range	± 0,3 %
Current, referenced to the output range	± 0,3 %
Basic error limit (operational limit at 25 °C)	
Voltage, referenced to the output range	± 0,2 %
Current, referenced to the output range	± 0,2 %
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; only for output type current
Short-circuit	Yes; only for output type voltage
Overflow/underflow	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	4
Between the channels and the backplane bus	Yes
Between the channels and the load voltage L+	Yes
Permitted potential difference	
Between MANA and M internal (UISO)	75 V DC / 60 V AC (basic isolation)
between S- and MANA (UCM)	+/- 8 V
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	No

	6ES7532-5HD00-0AB0
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	310 g

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front panel are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

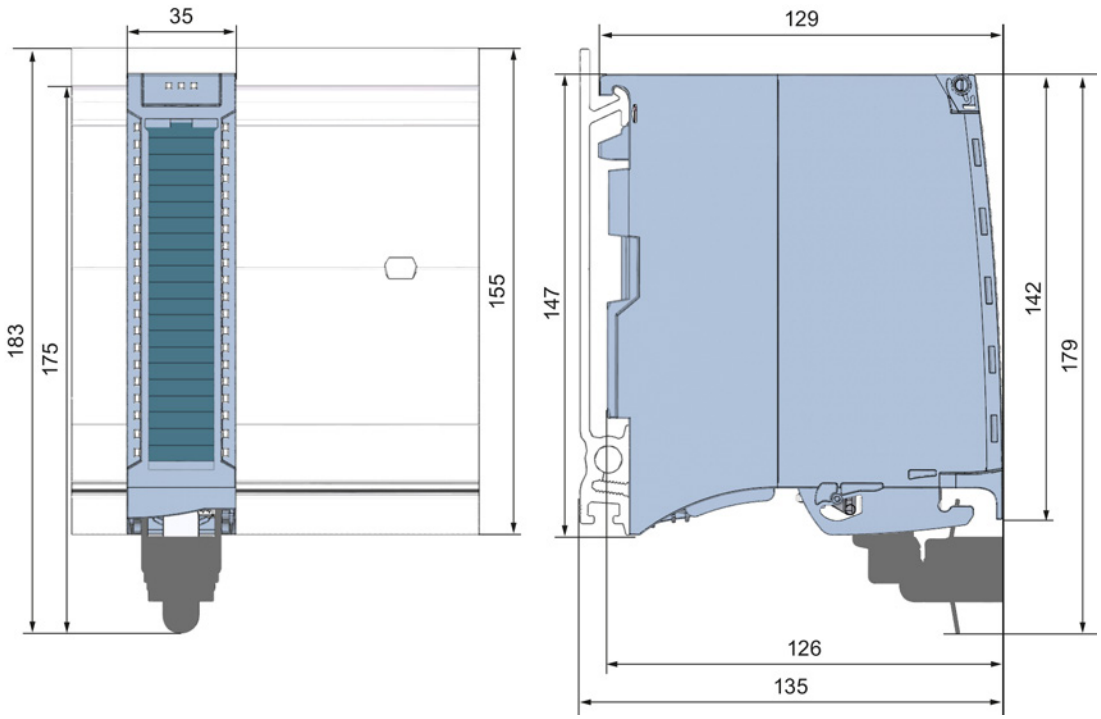


Figure A-1 Dimensional drawing of the AQ 4xU/I ST module

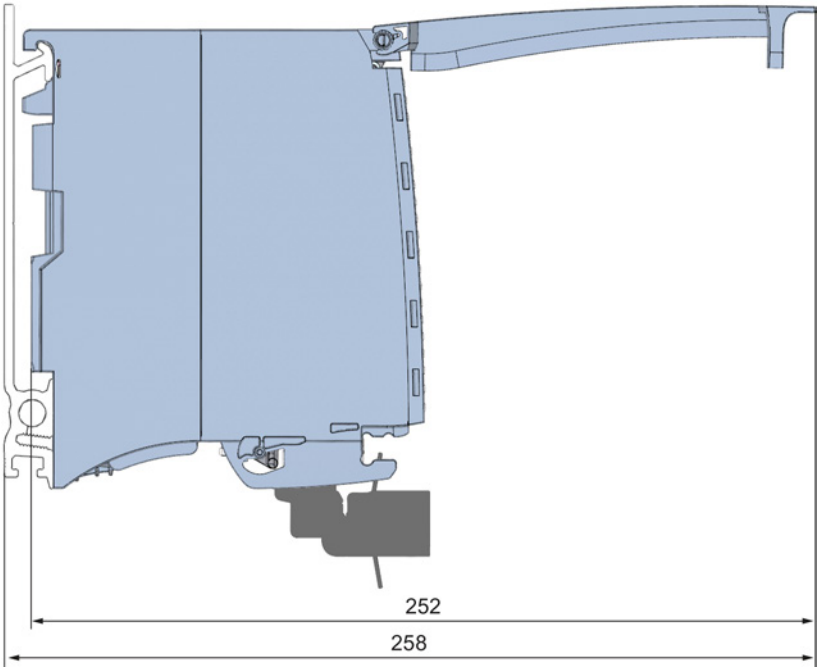


Figure A-2 Dimensional drawing of the AQ 4xU/I ST module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

Note for configuration of the module with GSD file that the settings of some parameters are dependent on each other, see the table below.

The parameters are only checked for plausibility by the module after the transfer.

If errors occur during the transfer of parameters with the GSD file, the module continues operation with the previous parameter assignment.

Table B- 1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Short circuit to M	With **output type** voltage only
Wire break	With **output type** current only
Substitute value	Only if **Reaction to CPU STOP** -> **Output substitute value** is configured

Parameter assignment in the user program

You have the option to assign module parameters in RUN (e.g., the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 64 to 67. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The channel parameters in data records 64 to 67 are available for 1x 4-channel configuration and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- Data record 66 for channel 2
- Data record 67 for channel 3

For configuration 4 x 1-channel, the module has 4 submodules with one channel each. The parameters for the channel are available in data record 64 and are assigned as follows:

- Data record 64 for channel 0 (submodule 1)
- Data record 64 for channel 1 (submodule 2)
- Data record 64 for channel 2 (submodule 3)
- Data record 64 for channel 3 (submodule 4)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 64 for channel 0. The structure of channels 1 to 3 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

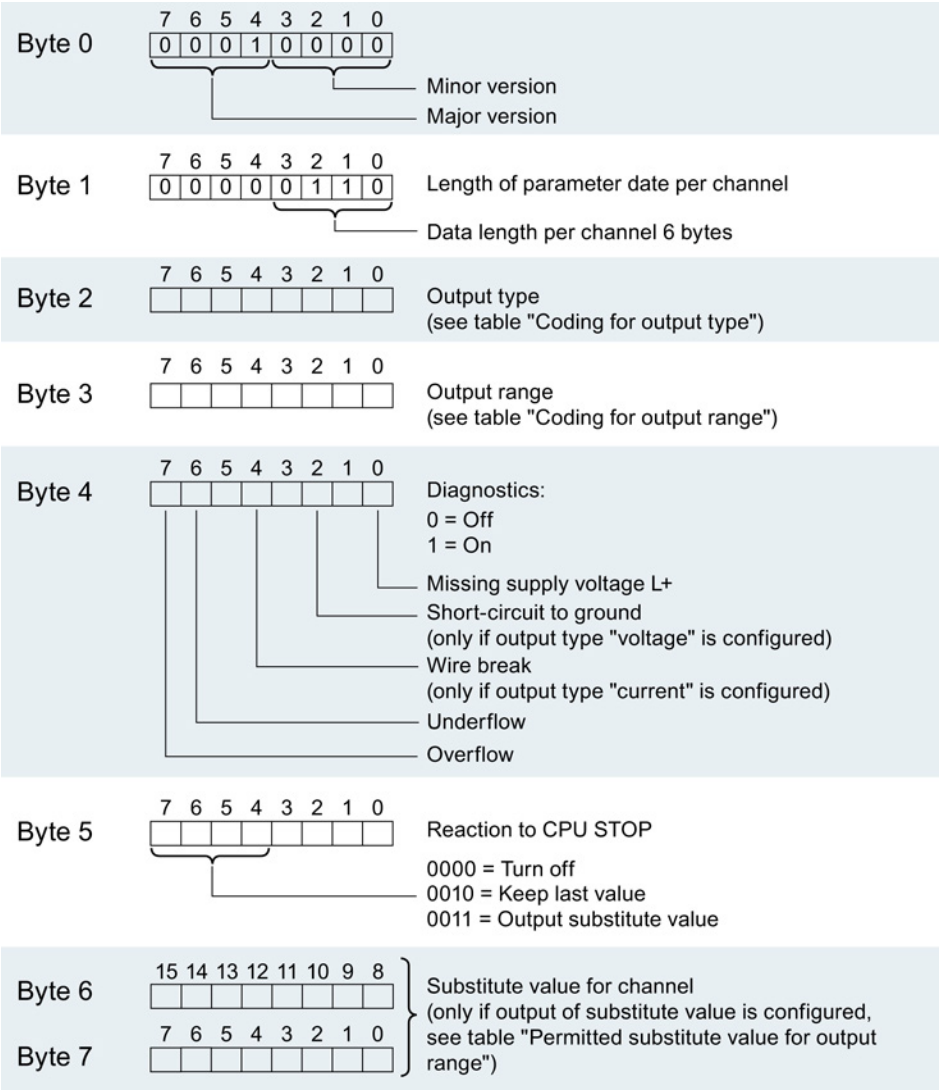


Figure B-1 Structure of data record 64: Bytes 0 to 7

Output type codes

The following table lists all output types of the analog output module along with their codes. Enter these codes at byte 2 of the data record for the corresponding channel (see the previous figure).

Table B- 2 Code for the output type

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0010

Codes for the output ranges

The following table lists all voltage and current output ranges of the analog output module along with their codes. In each case, enter these codes at byte 3 of the respective data record (see previous figure).

Table B- 3 Output range code

Output range for voltage	Code
1 V to 5 V	0000 0011
0 V to 10 V	0000 0010
±10 V	0000 0000
Output range for current	**Code**
0 mA to 20 mA	0000 0001
4 mA to 20 mA	0000 0010
±20 mA	0000 0000

Valid substitute values

The following table lists all output ranges for the valid substitute values. Enter these substitute values at bytes 6 and 7 of the data record for the corresponding channel (see the previous figure). The binary representation of output ranges is available on the Internet in Function Manual Analog value processing for SIMATIC.

Table B- 4 Valid substitute value for the output range

Output range	Valid substitute value
±10 V	-32512 ... +32511
1 V to 5 V	-6912 ... +32511
0 V to 10 V	0 ... +32511
±20 mA	-32512 ... +32511
4 mA to 20 mA	-6912 ... +32511
0 mA to 20 mA	0 ... +32511

Representation of analog values

C

Introduction

This appendix describes the analog values for all output ranges supported by the AQ 4xU/I ST analog module.

Measured value resolution

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table C- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	dec	hex	high byte	low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.1 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Table C- 2 Bipolar output ranges

Value dec.	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100,004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100,000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0,003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0,003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100,000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100,004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117,593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117,593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < -32512 are specified, the output value is limited to -117.593%.

Table C- 3 Unipolar output ranges

Value dec.	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117,589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117,589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100,004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100,000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0,003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < 0 are specified, the output value is limited to 0%.

C.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table C- 4 Voltage output range ±10 V

Values			Voltage output range	Range
	dec	hex	±10 V	
>117.589 %	>32511	>7EFF	11.76 V	Maximum output value
117.589 %	32511	7EFF	11.76 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	10 V	Rated range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
	-1	FFFF	-361.7 µV	
-75 %	-20736	AF00	-7.5 V	
-100 %	-27648	9400	-10 V	
	-27649	93FF		Undershoot range
-117.593 %	-32512	8100	-11.76 V	
<-117.593 %	<-32512	< 8100	-11.76 V	Minimum output value

Table C- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	dec	hex	0 V to 10 V	
>117.589 %	>32511	>7EFF	11.76 V	Maximum output value
117.589 %	32511	7EFF	11.76 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	10 V	Rated range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
<0 %	<0	<0	0 V	Minimum output value

Table C- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	dec	hex	1 V to 5 V	
>117.589 %	>32511	>7EFF	5.70 V	Maximum output value
117.589 %	32511	7EFF	5.70 V	Overshoot range
	27649	6C01		
100 %	27648	6C00	5 V	Rated range
75 %	20736	5100	4 V	
0.003617 %	1	1	1 V +144.7 µV	
0 %	0	0	1 V	
	-1	FFFF	1 V -144.7 µV	Undershoot range
-25 %	-6912	E500	0 V	
<-25 %	<-6912	< E500	0 V	Minimum output value

C.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table C- 7 Current output range ±20 mA

Values			Current output range	Range
	dec	hex	±20 mA	
>117.589 %	>32511	>7EFF	23.52 mA	Maximum output value
117.589 %	32511	7EFF	23.52 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75 %	-20736	AF00	-15 mA	
-100 %	-27648	9400	-20 mA	
	-27649	93FF		Undershoot range
-117.593 %	-32512	8100	-23.52 mA	
<-117.593 %	<-32512	<8100	-23.52 mA	Minimum output value

Table C- 8 Current output range 0 to 20 mA

Values			Current output range	Range
	dec	hex	0 mA to 20 mA	
>117.589 %	>32511	>7EFF	23.52 mA	Maximum output value
117.589 %	32511	7EFF	23.52 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
<0 %	<0	<0	0 mA	Minimum output value

Table C- 9 Current output range 4 to 20 mA

Values			Current output range	Range
	dec	hex	4 mA to 20 mA	
>117.589 %	>32511	>7EFF	22.81 mA	Maximum output value
117.589 %	32511	7EFF	22.81 mA	Overshoot range
	27649	6C01		
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	16 mA	
0.003617 %	1	1	4 mA	
0 %	0	0	4 mA	
	-1	FFFF		Undershoot range
-25 %	-6912	E500	0 mA	
<-25 %	<-6912	<E500	0 mA	Minimum output value

SIEMENS

SIMATIC

S7-1500/ET 200MP
Analog Input Module AI 8xU/I HS
(6ES7531-7NF10-0AB0)

Manual

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08/2013

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared input (MSI) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation provided for analog input module AI 8xU/I HS

The following table lists further documentation that you will need when using the AI 8xU/I HS analog input module.

Table 1- 1 Documentation for analog input module AI 8xU/I HS

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Most important contents
Analog value processing	Function manual Analog Value Processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology), etc. • Description/explanation of meanings, e.g. conversion and cycle time, basic and operation limits, etc.
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7531-7NF10-0AB0

View of the module

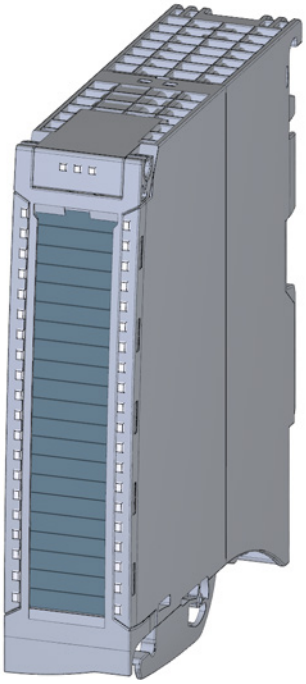


Figure 2-1 View of the AI 8xU/I HS module

Properties

The analog input module has the following properties:

- Technical properties
  - 8 analog inputs
  - Voltage or current measuring type can be set per channel
  - Resolution 16 bits including sign
  - Configurable diagnostics (per channel)
  - Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)
  - High-speed update of measured values

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Calibration in runtime	V1.0.0 or higher	X	X
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.
For more information on front connector wiring and creating cable shields, for example, refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Note

You may use and combine the different wiring options for all channels.

Note

Do not insert the potential jumpers included with the front connector!

Abbreviations used

Meaning of the abbreviations used in the following figures:

U_n+/U_n-	Voltage input channel n (voltage only)
I_n+/I_n-	Current input channel n (current only)
U_{Vn}	Supply voltage at channel n for 2-wire transmitters (2WT)
L+	Connection for supply voltage
M	Connection for ground
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status
PWR	Display for the supply voltage

Pin assignment for the power supply element

The power supply element is plugged onto the front connector for powering the analog module. Wire the supply voltage to terminals 41 (L+) and 44 (M). Use terminals 42 (L+) and 43 (M) to loop the potential to the next module.

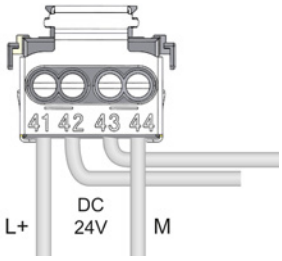
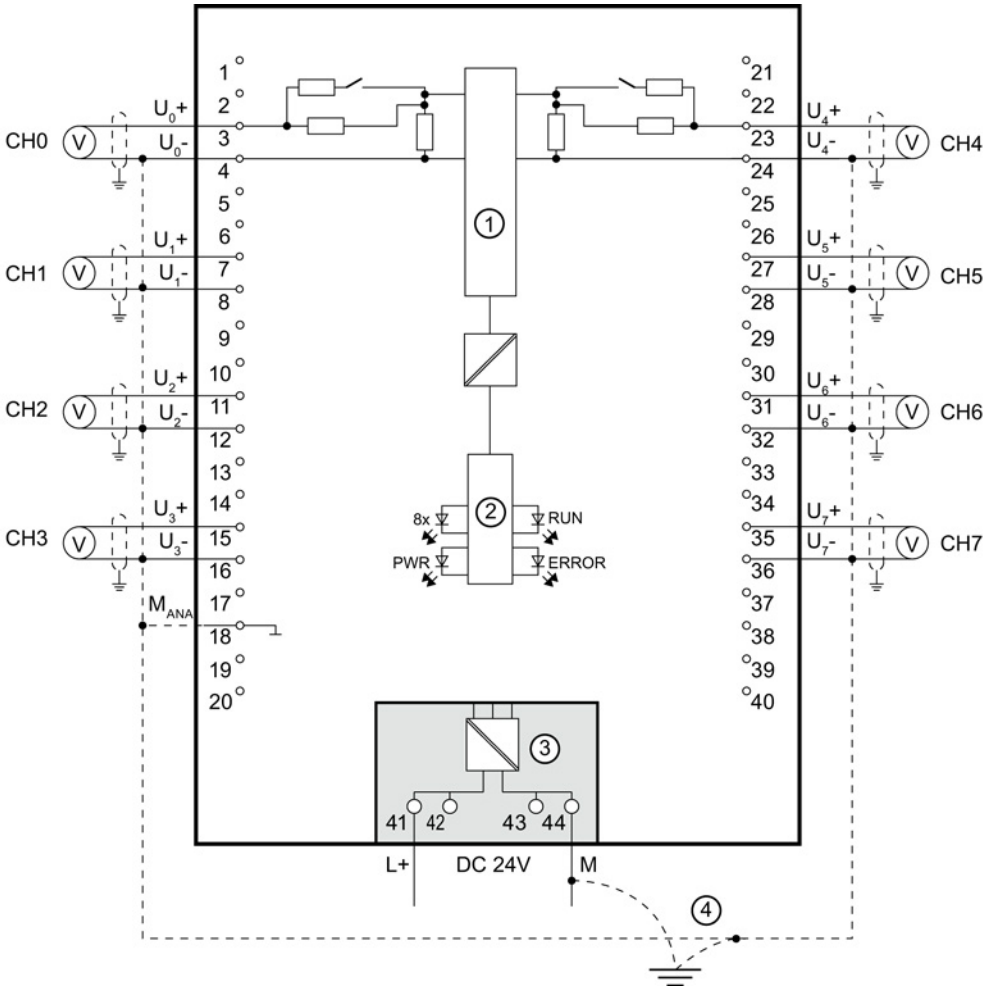


Figure 3-1 Power supply element wiring

Block diagram and pin assignment for voltage measurement

The example in the following figure shows the pin assignment for a voltage measurement.

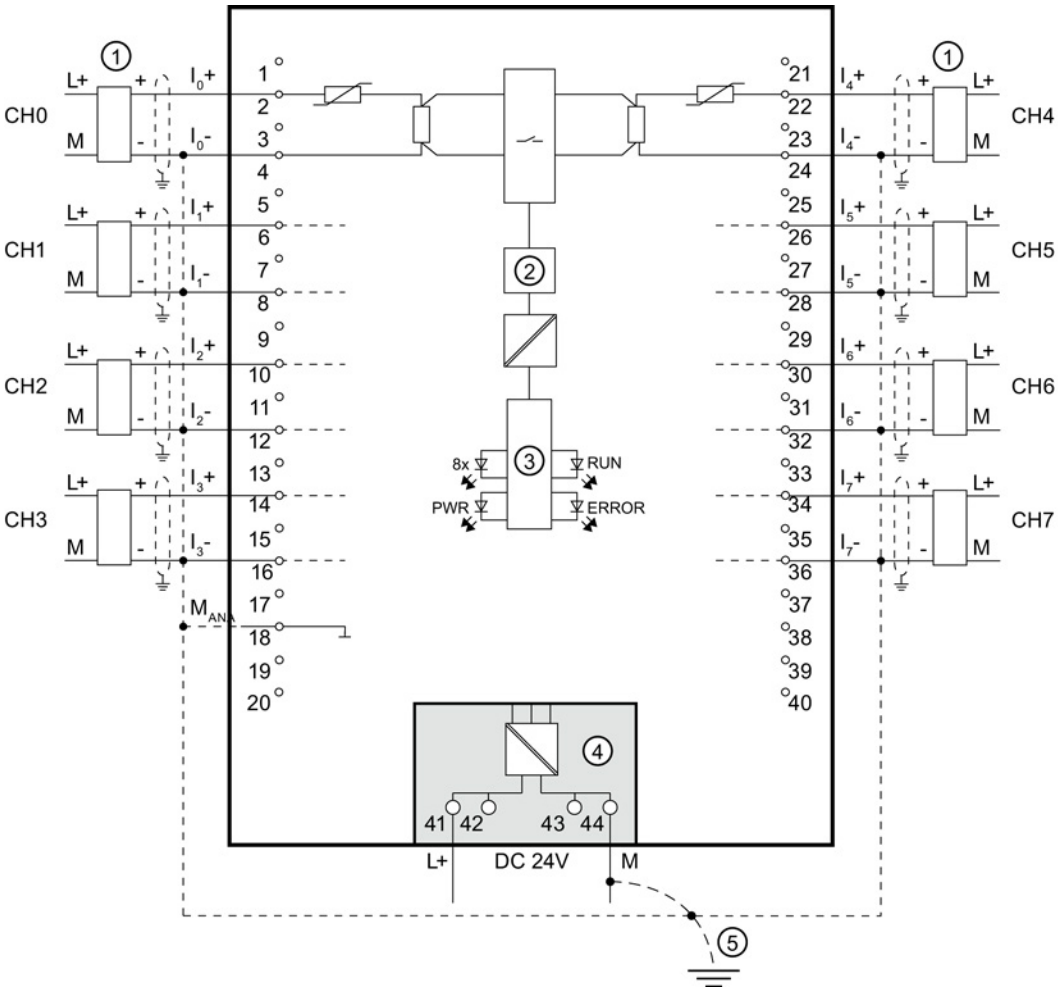


① Analog-to-Digital Converter (ADC)
② Backplane bus interface
③ Supply voltage via power supply element
④ Equipotential bonding cable (optional)

Figure 3-2 Block diagram and pin assignment for voltage measurement

Block diagram and pin assignment for 4-wire transmitter for current measurement

The example in the following figure shows the pin assignment for current measurement with 4-wire transmitters.

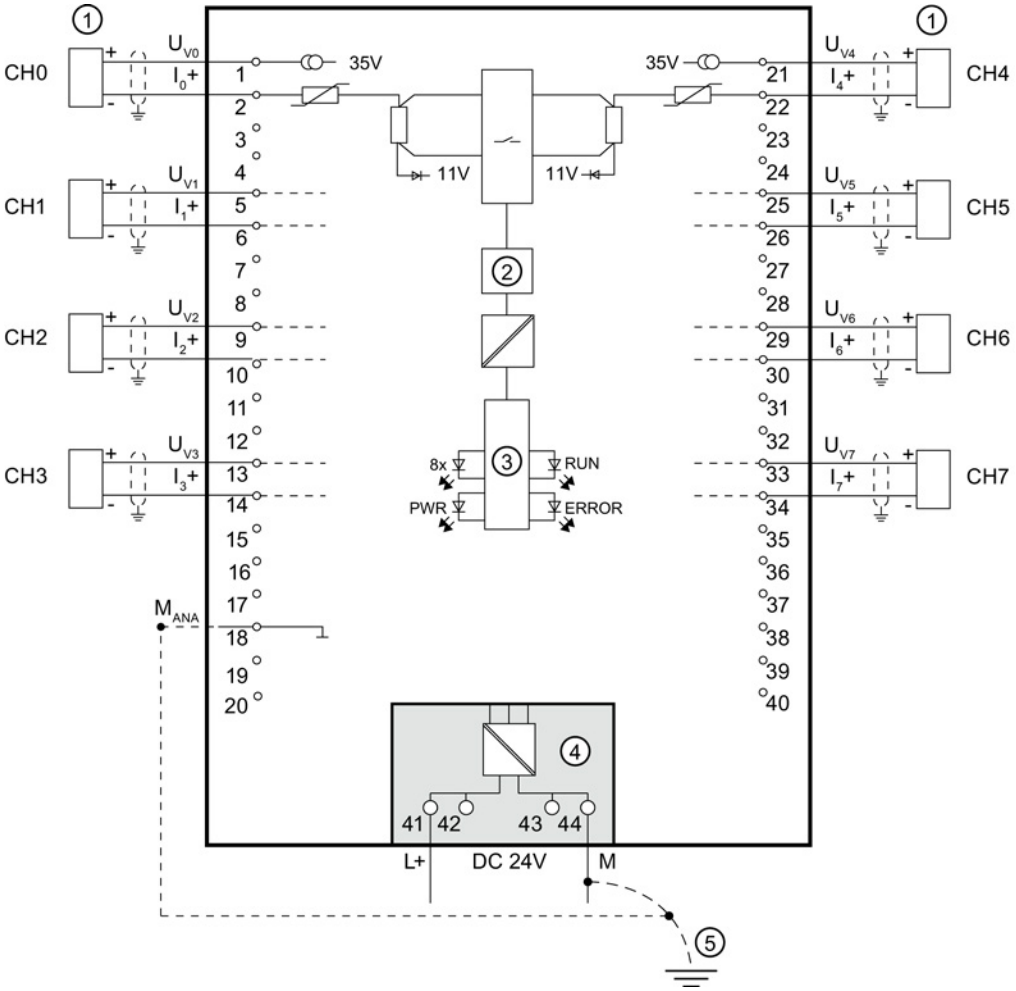


① Wiring 4-wire transmitter
② Analog-to-Digital Converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-3 Block diagram and pin assignment for 4-wire transmitter for current measurement

Block diagram and pin assignment for 2-wire transmitter for current measurement

The example in the following figure shows the pin assignment for current measurement with 2-wire transmitters.



① Wiring 2-wire transmitter
② Analog-to-Digital Converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-4 Block diagram and pin assignment for 2-wire transmitter for current measurement

Parameters/address space 4

4.1 Measuring types and ranges

Introduction

The module is set to voltage measuring type with measuring range ±10 V by default. You need to reassign the module parameters with STEP 7 if you want to use a different measuring type or range.

Measuring types and ranges

The following table shows the measuring types and the respective measuring range.

Measuring type	Measuring range
Voltage	1 to 5 V ±5 V ±10 V
Current 2WMT (2-wire transmitter)	4 to 20 mA
Current 4WMT (4-wire transmitter)	4 to 20 mA 0 to 20 mA ±20 mA
Disabled	-

The tables of the input ranges, overflow, undershoot range, etc. are available in appendix Representation of analog values (Page 47).

4.2 Parameters

Parameters of the AI 8xU/I HS

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of the parameter data records (Page 41).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel [1]	Module [3]
• Overflow	Yes/No	No	Yes	Channel	Module [3]
• Underflow	Yes/No	No	Yes	Channel	Module [3]
• Wire break	Yes/No (Voltage: 1 V to 5 V Current: 4 mA to 20 mA)	No	Yes	Channel	Module [3]
• Current limit for wire break diagnostics [2]	1.185 mA or 3.6 mA	1.185 mA	Yes	Channel	--- [4]
Measuring					
• Measuring type	See chapter Measuring types and ranges (Page 19)	Voltage	Yes	Channel	Channel
• Measuring range		±10 V	Yes	Channel	Channel
• Smoothing	None/low/medium /high	None	Yes	Channel	Channel

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt					
• Hardware interrupt high limit 1	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt low limit 1	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt high limit 2	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt low limit 2	Yes/No	No	Yes	Channel	--- [4]

[1] If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

[2] When "Wire break" diagnostics is disabled, the current limit of 1.185 mA is applied to the value status. For measured values below 1.185 mA, the value status is always: 0 = fault.

[3] You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 7.

[4] You can set the current limit for wire break diagnostics, the "Hardware interrupt" parameter and the hardware interrupt limits in the user program with data records 0 to 7.

4.3 Declaration of parameters

Missing supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Overflow

Enabling of the diagnostics if the measured value violates the high limit.

Underflow

Enabling of the diagnostics if the measured value violates the low limit.

Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak for the measurement at the corresponding configured input or the applied voltage is too low.

Current limit for wire break diagnostics

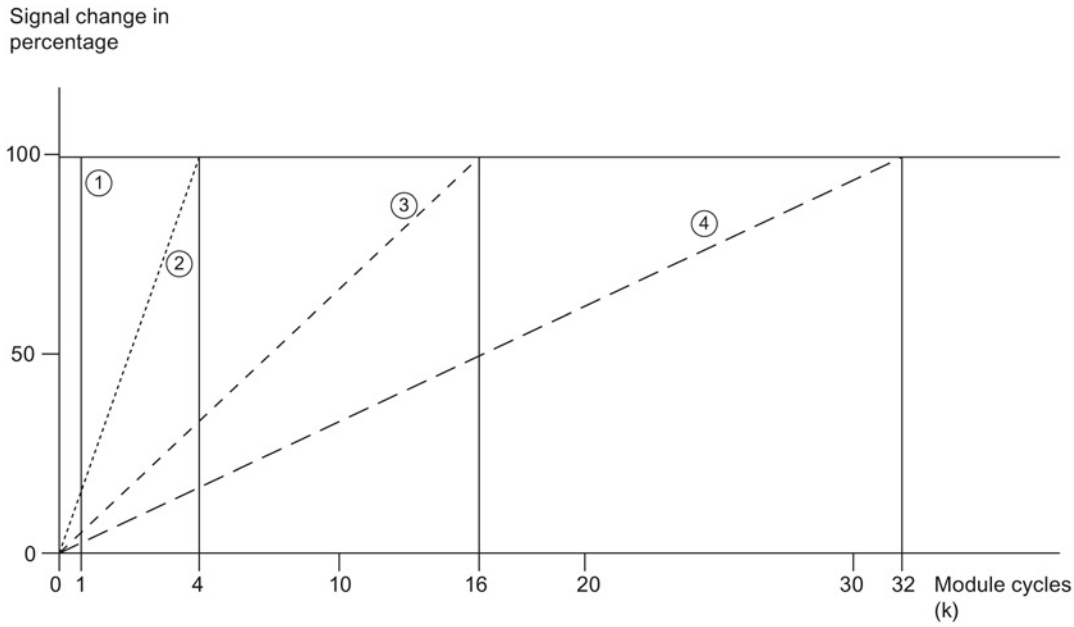
Threshold for reporting wire breaks. The value can be set to 1.185 mA or 3.6 mA, depending on the sensor used.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows after how many module cycles the smoothed analog value is almost 100%, depending on the set smoothing. Is valid for each signal change at the analog input.



① None (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 4-1 Smoothing with AI 8xU/I HS

Hardware interrupt 1 or 2

Enable a hardware interrupt at violation of high limit 1 or 2 or low limit 1 or 2.

Low limit 1 or 2

Specifies the low limit threshold that triggers hardware interrupt 1 or 2.

High limit 1 or 2

Specifies the high limit threshold that triggers hardware interrupt 1 or 2.

4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 8xU/I HS

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	AI 8xU/I HS	X	X
1 x 8-channel with value status	AI 8xU/I HS QI	X	X
8 x 1-channel without value status	AI 8xU/I HS S	X	---
8 x 1-channel with value status	AI 8xU/I HS S QI	X	---
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	AI 8xU/I HS MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 8xU/I HS QI
- AI 8xU/I HS S QI
- AI 8xU/I HS MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space of AI 8xU/I HS

The following figure shows the address space allocation for the configuration as 8-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IB x", for example represents the module start address input byte x.

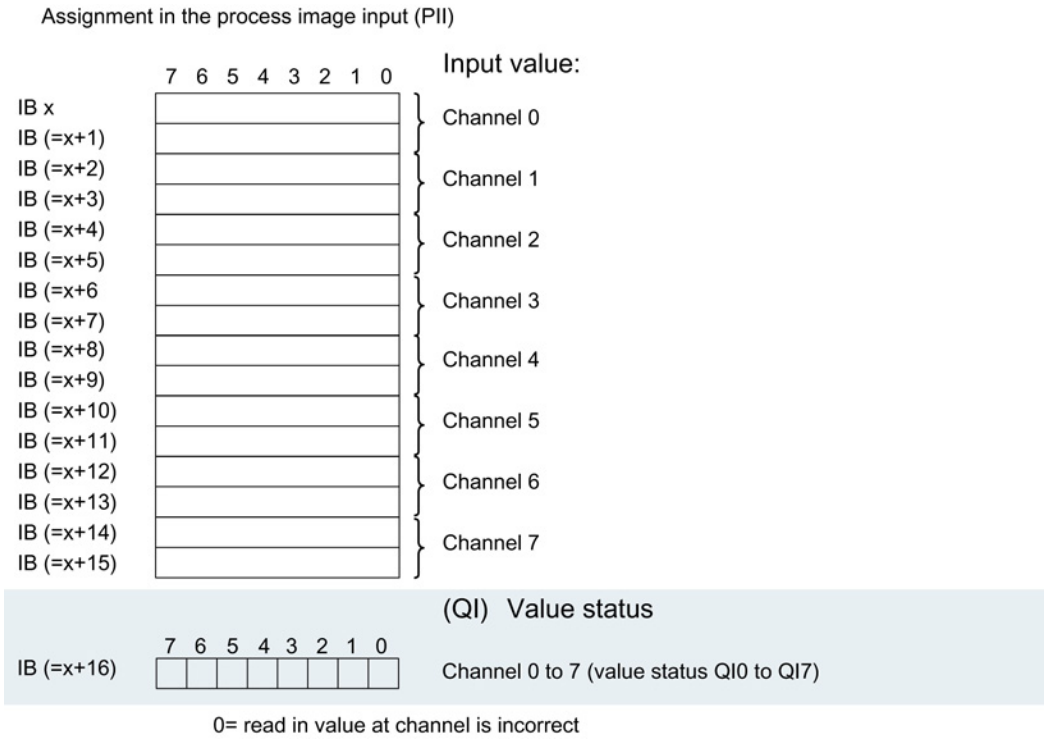


Figure 4-2 Address space for configuration as 1 x 8-channel AI 8xU/I HS with value status

Address space for configuration as 8 x 1-channel AI 8xU/I HS S QI

For the configuration as a 8 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 8-channel module configuration, each of the eight submodules has a freely assignable start address.

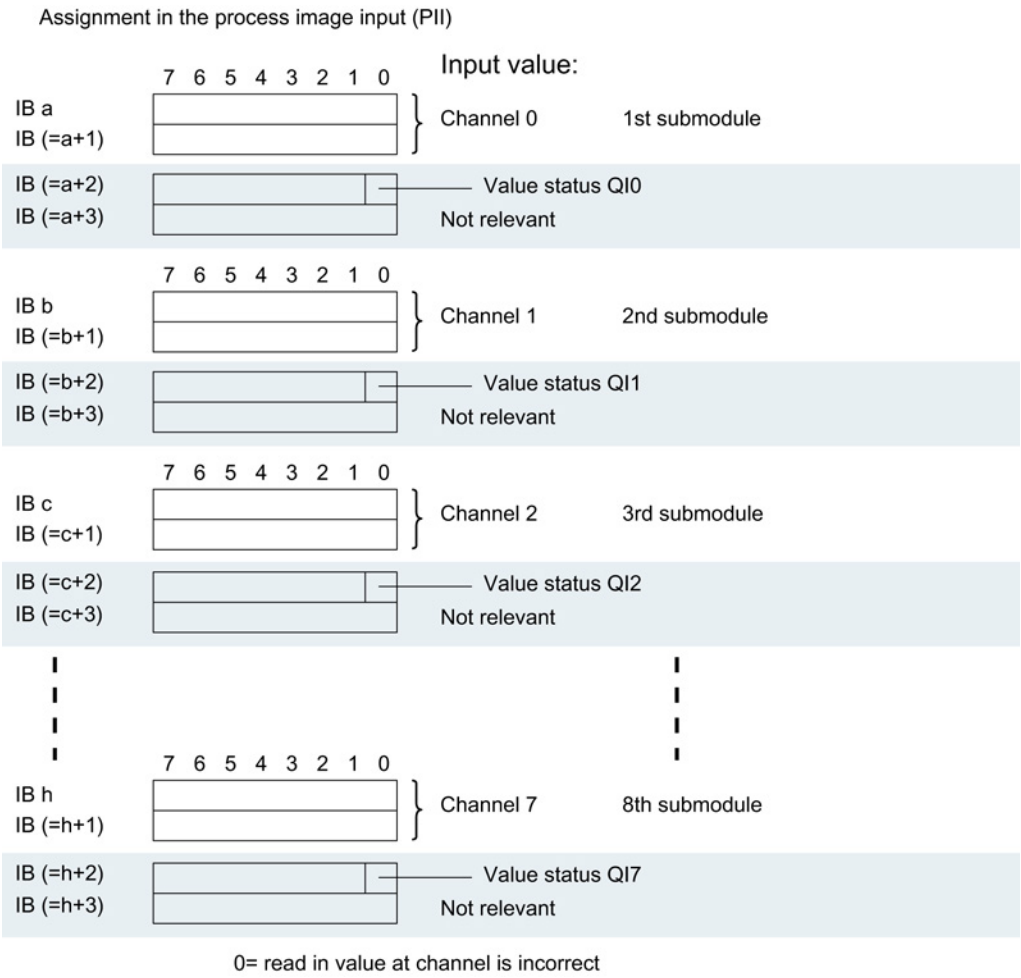


Figure 4-3 Address space for configuration as 8 x 1-channel AI 8xU/I HS S QI with value status

Address space for configuration as 1 x 8-channel AI 8xU/I HS MSI

The channels 0 to 7 of the module are copied in up to four submodules with configuration 1 x 8-channel module (Module-internal shared input, MSI). Channels 0 to 7 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

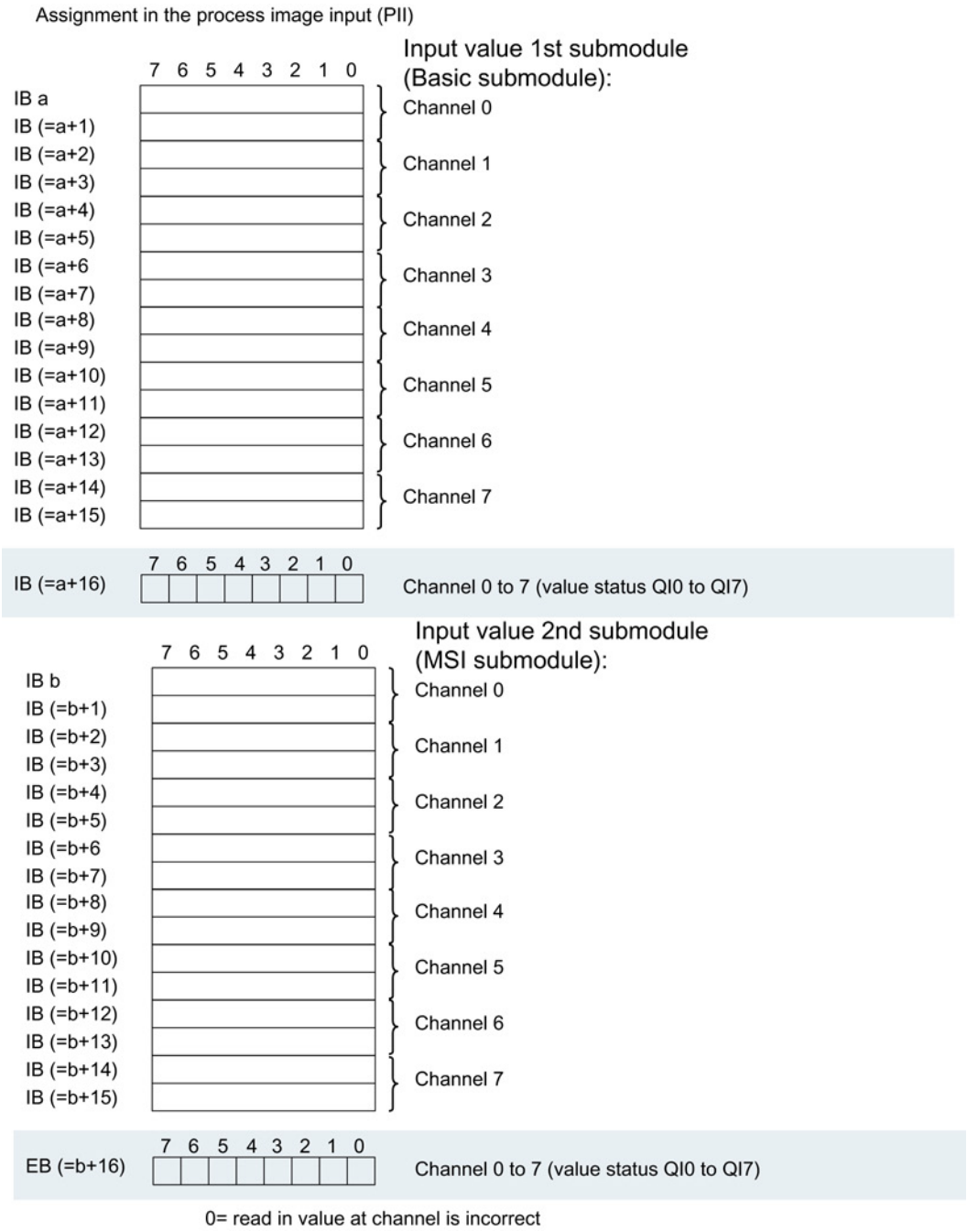


Figure 4-4 Address space for configuration as 1 x 8-channel AI 8xU/I HS MSI with value status

The following figure shows the assignment of the address space with submodules 3 and 4.

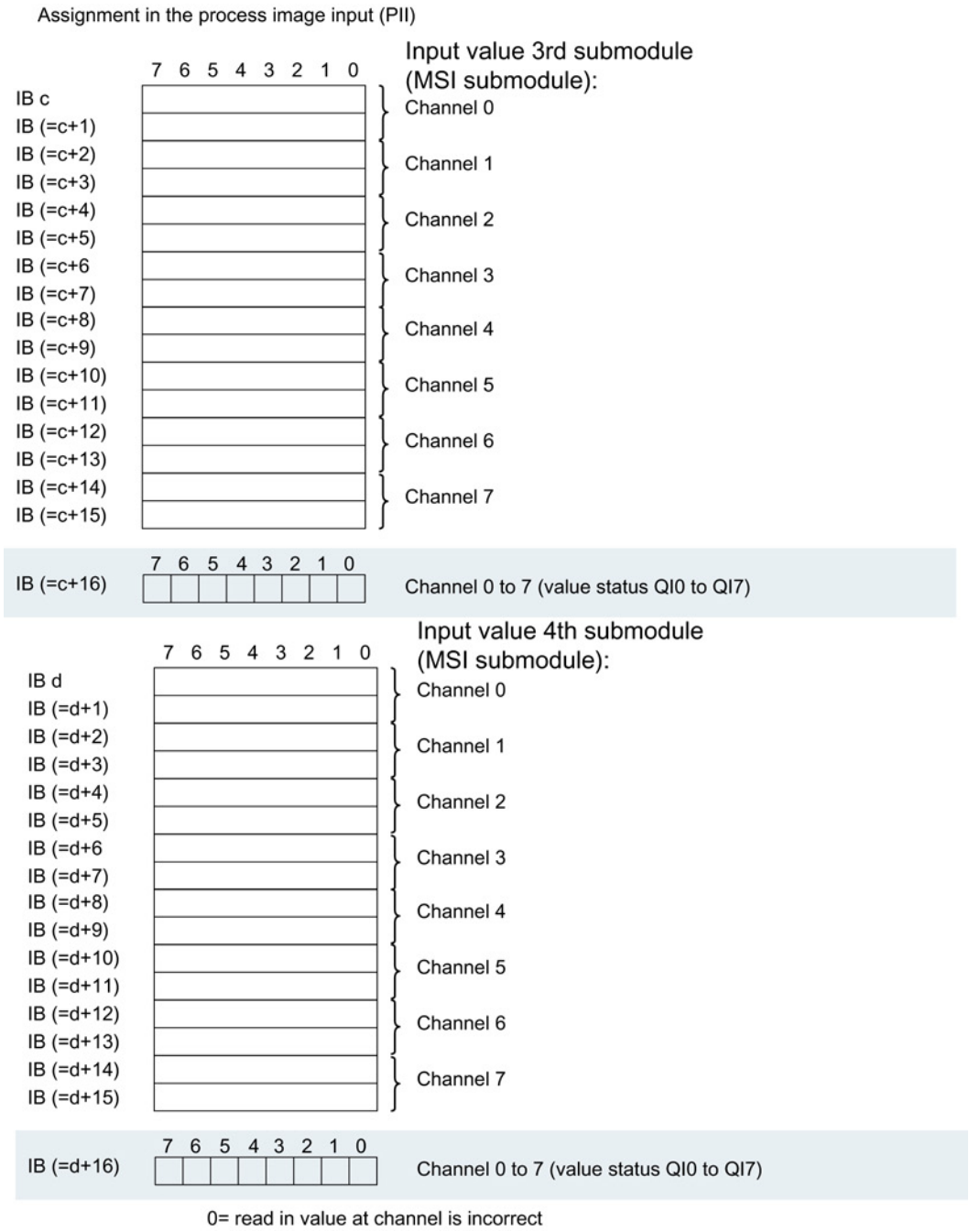


Figure 4-5 Address space for configuration as 1 x 8-channel AI 8xU/I HS MSI with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of AI 8xU/I HS.

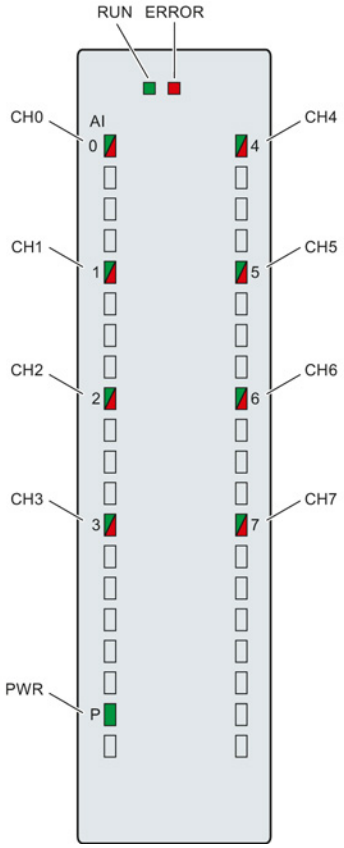


Figure 5-1 LED displays of the module AI 8xU/I HS

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in section Diagnostic alarms (Page 34).

Table 5- 1 Status and error displays RUN/ERROR

LED		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus.	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid configuration is set.	---
On	Off	Module is configured.	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective.	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	To correct or avoid errors
Off	Supply voltage L+ to module too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

Table 5- 3 CHx status display

LED CHx	Meaning	To correct or avoid errors
Off	Channel disabled	---
On	Channel configured and OK.	---
On	Channel is configured (channel error pending). Diagnostic alarm: e.g. wire break	Check the wiring Disable diagnostics.

5.2 Interrupts

Analog input module AI 8xU/I HS supports the following diagnostic and hardware interrupts:

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break
- Overflow
- Underflow

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Low limit violated 1
- High limit violated 1
- Low limit violated 2
- Violation of high limit 2

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The diagram below shows the assignment to the bits of double word 8 in local data.

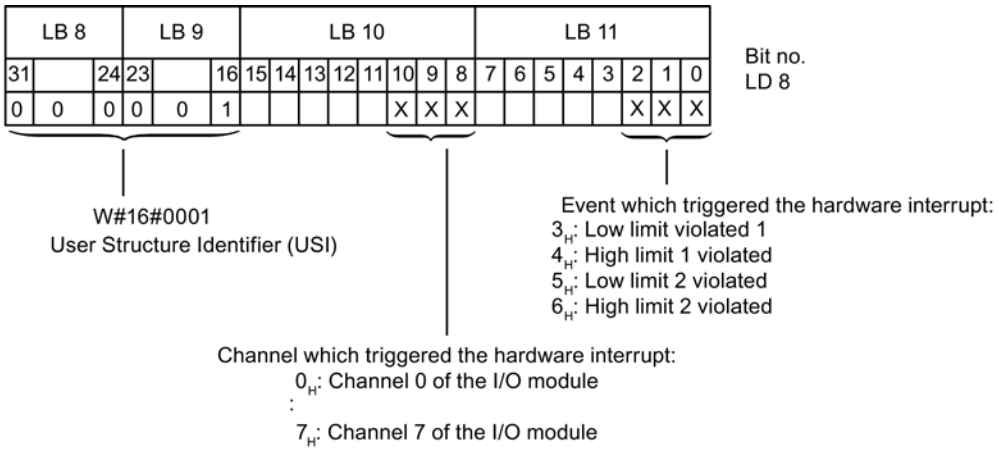


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Contents	Remark	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#n	Number of the event-triggering channel (n = number of module channels)	1
It follows the error event that triggered the hardware interrupt.				
	Event	B#16#03	Low limit violated 1	1
		B#16#04	High limit violated 1	
		B#16#05	Low limit violated 2	
		B#16#06	Violation of high limit 2	

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6_H	Impedance of sensor circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range violated	Check the measuring range
Underflow	8_H	Measuring range violated	Check the measuring range
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel

Technical specifications 6

Technical specifications of the AI 8xU/I HS

	6ES7531-7NF10-0AB0
Product type designation	AI 8xU/I HS
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	240 mA; (with 24 V DC supply)
Encoder supply	
24 V encoder supply	
Short-circuit protection	Yes
Output current, max.	53 mA
Power	
Power consumption from the backplane bus	1.2 W
Power loss	
Power loss, typ.	3.4 W

	6ES7531-7NF10-0AB0
Analog inputs	
Number of analog inputs	8
Number of analog inputs with current measurement	8
Number of analog inputs for voltage measurement	8
Permissible input voltage for voltage input (destruction limit), max.	28.8 V
Permissible input current for current input (destruction limit), max.	40 mA
Input ranges (rated values), voltages	
1 V to 5 V	Yes
Input resistance (1 V to 5 V)	50 kΩ
-10 V to +10 V	Yes
Input resistance (-10 V to +10 V)	100 kΩ
-5 V to +5 V	Yes
Input resistance (-5 V to +5 V)	50 kΩ
Input ranges (rated values), currents	
0 mA to 20 mA	Yes
Input resistance (0 mA to 20 mA)	41 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	41 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)
4 mA to 20 mA	Yes
Input resistance (4 mA to 20 mA)	41 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)
Cable length	
Cable length shielded, max.	800 m
Analog value formation	
Integration and conversion time / resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Basic execution time of the module (all channels enabled)	62.5 µs
Smoothing of the measured values	
Configurable	Yes
Level: None	Yes
Level: Weak	Yes
Level: Medium	Yes
Level: Strong	Yes

	6ES7531-7NF10-0AB0
Encoders	
Connection of the signal encoders	
For voltage measurement	Yes
For current measurement as 2-wire transmitter	Yes
Load of 2-wire transmitter, max.	820 Ω
For current measurement as 4-wire transmitter	Yes
Errors/accuracies	
Linearity error (relative to input range)	± 0.02 %
Temperature error (relative to input range)	± 0.005 %
Crosstalk between inputs, min.	-60 dB
Repeat accuracy in steady state at 25 °C (relative to input range)	± 0.02 %
Operational limit in overall temperature range	
Voltage, relative to input range	± 0.3 %
Current, relative to input range	± 0.3 %
Basic error limit (operational limit at 25 °C)	
Voltage, relative to input range	± 0.2 %
Current, relative to input range	± 0.2 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Common mode voltage, max.	10 V
Common mode interference, min.	60 dB; (at 400Hz: 50dB)
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	80 µs
Bus cycle time (TDP), min.	250 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes, only for 1 V to 5 V, 4 mA to 20 mA
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED

	6ES7531-7NF10-0AB0
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between the inputs (UCM)	20 V DC
Between inputs and MANA (UCM)	10 V DC
Between M internally and the inputs	75 V DC / 60 V AC
Isolation	
Isolation tested with	707 V DC
Ambient conditions	
Operating temperature	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	40 °C
Distributed mode	
Prioritized startup	No
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	200 g

Dimensional drawing

A

This appendix contains the dimensional drawing of the module installed on a mounting rail and with a shield bracket. Always adhere to the specified dimensions for installations in cabinets, control rooms, etc.

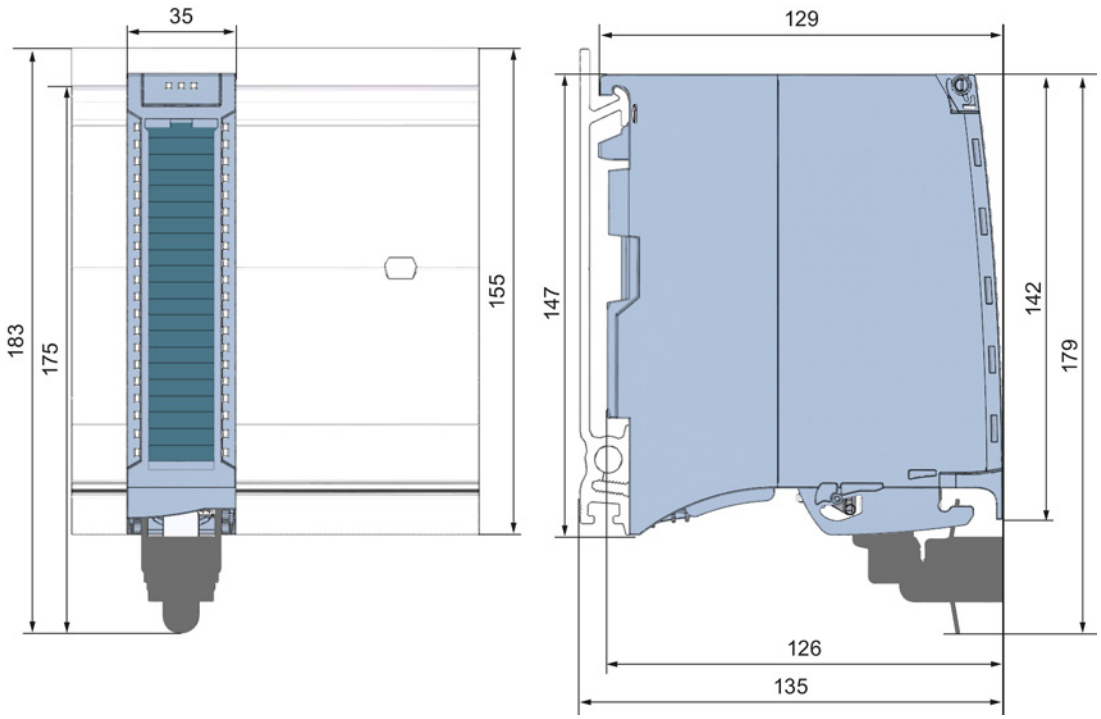


Figure A-1 Dimensional drawing of the AI 8xU/I HS module

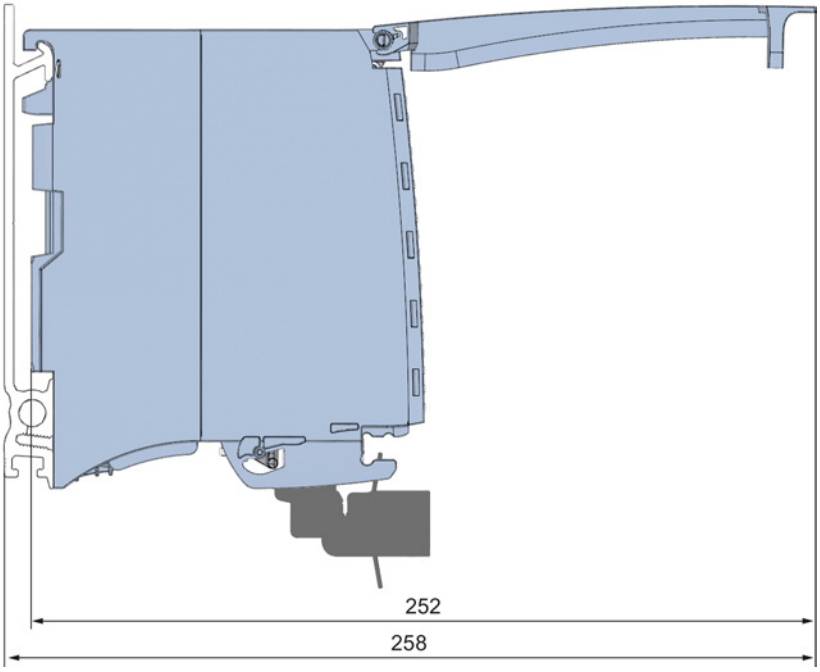


Figure A-2 Dimensional drawing of the AI 8xU/I HS module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

Note for configuration of the module with GSD file that the settings of some parameters are dependent on each other, see the table below.

The parameters are only checked for plausibility by the module after the transfer.

If errors occur during the transfer of parameters with the GSD file, the module continues operation with the previous parameter assignment.

Table B- 1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Current limit for wire break	Only for **measuring type** current with **measuring range** 4 mA to 20 mA.
Wire break	Only for **measuring type** resistance with **measuring range** 1V to 5 V and current with **measuring range** 4 mA to 20 mA.
Hardware interrupt limits	Only if hardware interrupts are enabled.

Parameter assignment in the user program

You have the option to assign module parameters in RUN (e.g., the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 7. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

For the configuration as a 1 x 8-channel module, the parameters are located in data records 0 to 7 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 6 for channel 6
- Data record 7 for channel 7

For configuration 8 x 1-channel, the module has 8 submodules with one channel each. The parameters for the channel are available in data record 0 and are assigned as follows:

- Data record 0 for channel 0 (submodule 1)
- Data record 0 for channel 1 (submodule 2)
- …
- Data record 0 for channel 6 (submodule 7)
- Data record 0 for channel 7 (submodule 8)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 0 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

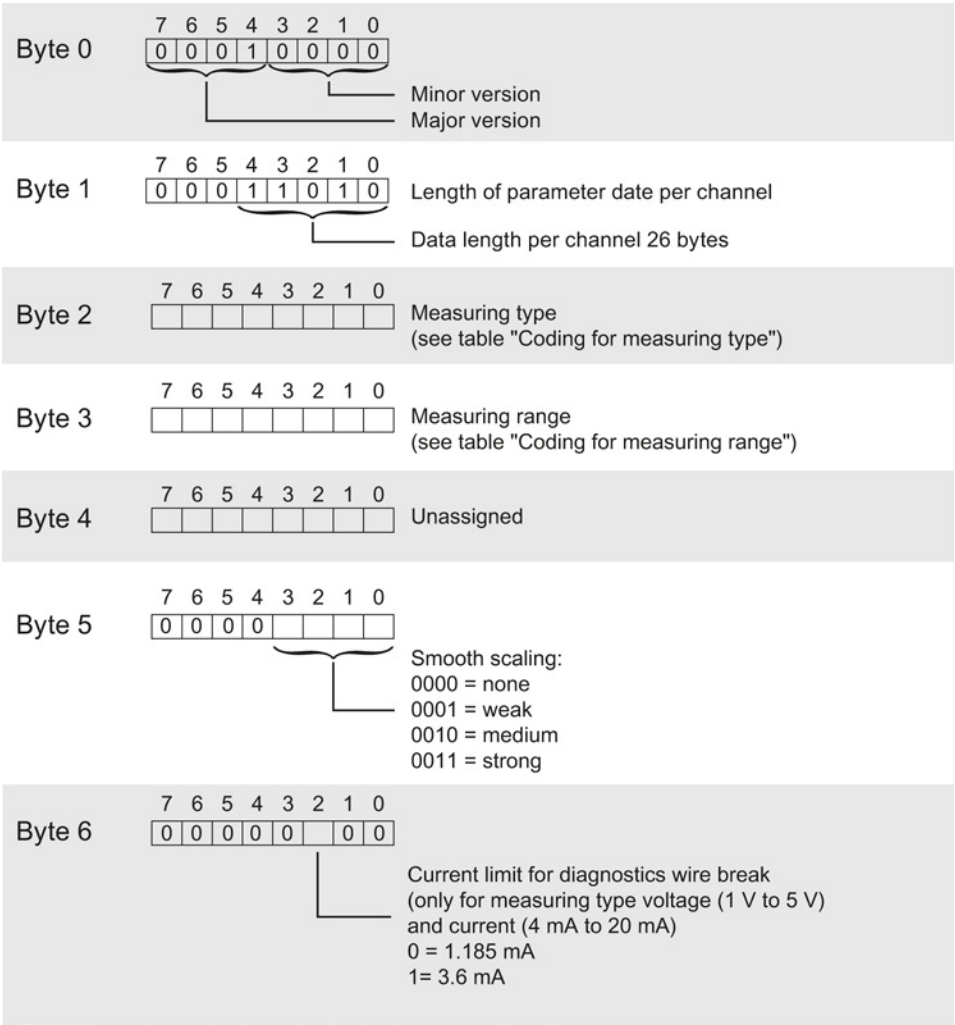


Figure B-1 Structure of data record 0: Bytes 0 to 6

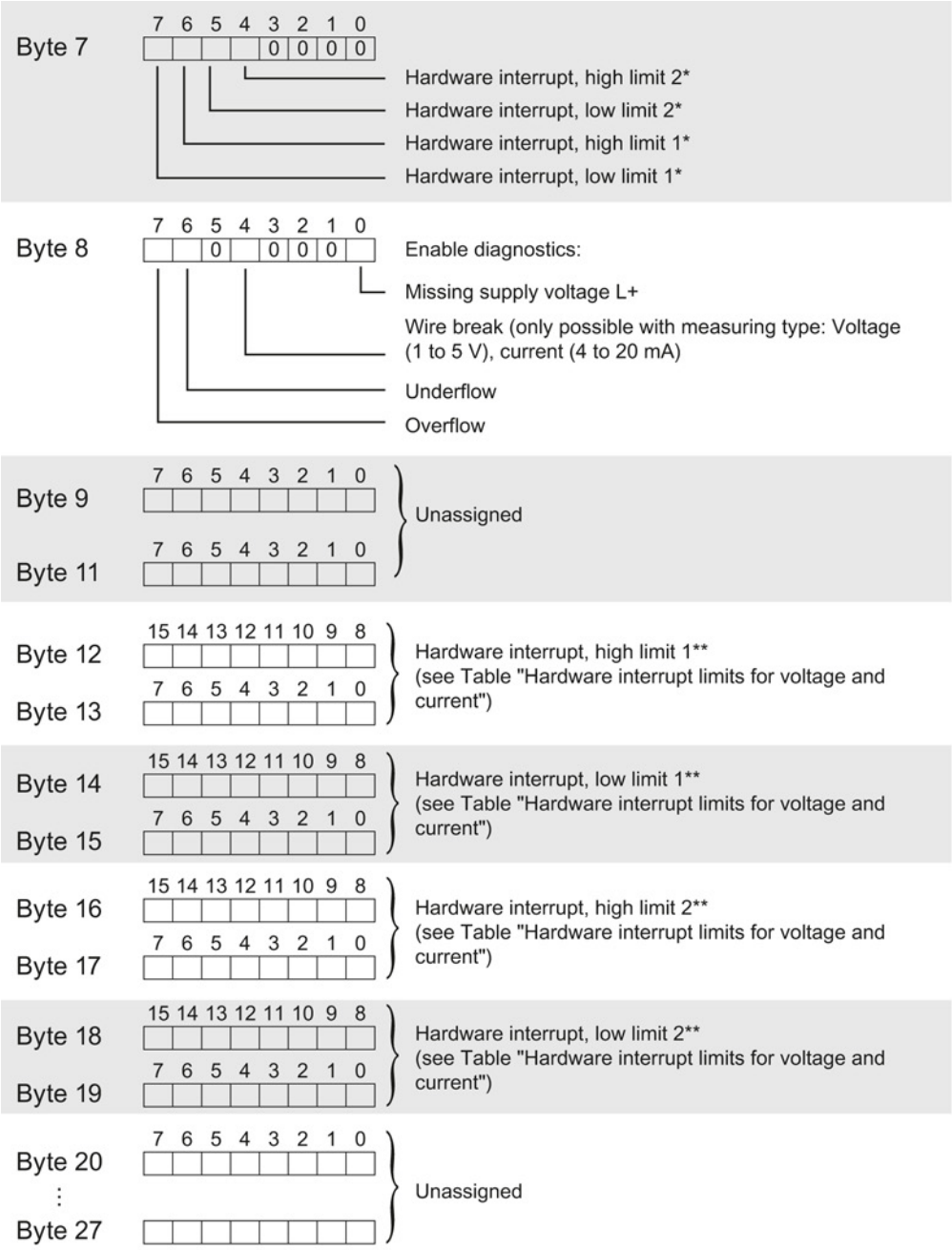


Figure B-2 Structure of data record 0: Bytes 7 to 27

Codes for measuring types

The following table lists all measuring types of the analog input module along with their codes. Enter these codes at byte 2 of the respective data record (see previous figure).

Table B- 2 Code for the measuring type

Measuring type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current 4-wire transmitter	0000 0010
Current 2-wire transmitter	0000 0011

Codes for measuring ranges

The following table lists all measuring ranges of the analog input module along with their codes. Enter these codes at byte 3 of the respective data record (see previous figure).

Table B- 3 Code for the measuring range

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 V to 5 V	0000 1010
Current 4-wire transmitter	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100
Current 2-wire transmitter	
4 mA to 20 mA	0000 0011

Hardware interrupt limits

The values that you can set for hardware interrupts (high/low limit) must not exceed the respective rated measuring range.

The following tables list the valid hardware interrupt limits. The limit values depend on the selected measuring type and range.

Table B- 4 Limits of hardware interrupts for voltage and current

Voltage		Current		
± 5 V, ± 10 V	1 V to 5 V	±20 mA	4 mA to 20 mA, 0 mA to 20 mA	
32510	32510	32510	32510	High limit
-32511	-4863	-32511	-4863	Low limit

Representation of analog values

C

Introduction

This chapter shows the analog values for all measuring ranges supported by the AI 8xU/I HS analog module.

Measured value resolution

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table C- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.1 Representation of input ranges

The following tables set out the digitalized representation of the input ranges by bipolar and unipolar range. The resolution is 16 bits.

Table C- 2 Bipolar input ranges

Units	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table C- 3 Unipolar input ranges

Units	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Rated range
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Undershoot range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

C.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table C- 4 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
dec	hex	±10 V	±5 V	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overshoot range
27649	6C01			
27648	6C00	10 V	5 V	Rated range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Undershoot range
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	< -11.759 V	< -5.879 V	Underflow

Table C- 5 Voltage measuring range 1 to 5 V

Values		Voltage measuring range	Range
dec	hex	1 to 5 V	
32767	7FFF	>5.704 V	Overflow
32511	7EFF	5.704 V	Overshoot range
27649	6C01		
27648	6C00	5 V	Rated range
20736	5100	4 V	
1	1	1 V + 144.7 µV	
0	0	1 V	
-1	FFFF		Undershoot range
-4864	ED00	0.296 V	
-32768	8000	< 0.296 V	Underflow

C.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table C- 6 Current measuring range ±20 mA

Values		Current measuring range	
dec	hex	±20 mA	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overshoot range
27649	6C01		
27648	6C00	20 mA	Rated range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Undershoot range
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table C- 7 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		
dec	hex	0 to 20 mA	4 to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Rated range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Undershoot range
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<- 3.52 mA	< 1.185 mA	Underflow

C.4 Measured values for wire break diagnostic

Measured values on diagnostic event "wire break", dependent on diagnostics enables

Error events initiate a diagnostics entry and trigger a diagnostics interrupt if configured accordingly.

Table C- 8 Measured values for wire break diagnostic

Format	Parameter assignment	Measured values		Explanation
S7	• "Wire break" diagnostics enabled • "Overflow/Underflow" diagnostics enabled or disabled ("Wire break" diagnostics takes priority over "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Open circuit" diagnostic alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the undershoot range • Diagnostic alarm "Low limit violated"
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the undershoot range

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S7-1500/ET 200MP Analog input module AI 8xU/I/RTD/TC ST (6ES7531-7KF00-0AB0)

Manual

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Parameter data records B

Representation of analog values C

08/2013

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP Distributed I/O System

Functions that relate in general to the systems are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Compared to the previous version this manual includes descriptions of the new functions of the module as of firmware version V2.0.0:

- Module-internal shared input (MSI) for shared device
- Configurable submodules, e.g., for shared device
- Configurable after interface module IM 155-5 DP ST

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

Note

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

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Documentation guide

1

Introduction

The documentation of SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manual, function manuals and manuals.

The STEP 7 information system (online help) also helps you configure and program your automation system.

Overview of the documentation provided for analog input module AI 8xU/I/RTD/TC ST

The following table lists further documentation that you will need when using the AI 8xU/I/RTD/TC ST analog input module.

Table 1- 1 Documentation for analog input module AI 8xU/I/RTD/TC ST

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
Designing interference-free controllers	Function manual Designing Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual System Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Most important contents
Analog value processing	Function manual Analog Value Processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology), etc. • Description/explanation of meanings, e.g. conversion and cycle time, basic and operation limits, etc.
Amendments and special features of the S7-1500/ ET 200MP systems	Product information Amendments to documentation S7-1500/ ET 200MP (http://support.automation.siemens.com/WW/view//68052815)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7531-7KF00-0AB0

View of the module

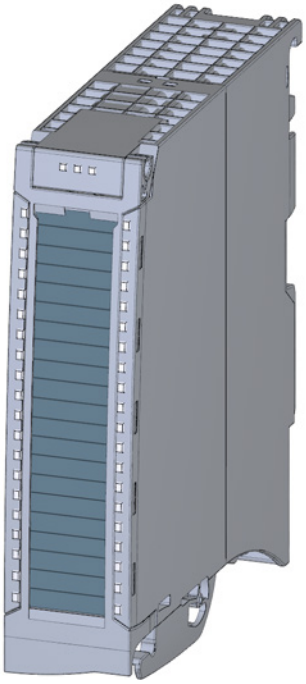


Figure 2-1 View of the AI 8xU/I/RTD/TC ST module

Properties

The module has the following properties:

- Technical properties
  - 8 analog inputs
  - Voltage measuring type can be set per channel
  - Current measuring type can be set per channel
  - Measuring type resistance adjustable for channel 0, 2, 4 and 6
  - Measuring type resistance thermometers (RTD) adjustable for channel 0, 2, 4 and 6
  - Thermocouple (TC) measuring type can be set per channel
  - Resolution 16 bits including sign
  - Configurable diagnostics (per channel)
  - Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

The following functions are supported by the module:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) V12 or higher	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Isochronous mode	V1.0.0 or higher	X	---
Calibration in runtime	V1.0.0 or higher	X	X
Module internal shared input (MSI)	V2.0.0 or higher	---	PROFINET IO only
Configurable submodules for shared device	V2.0.0 or higher	---	PROFINET IO only
Configurable after interface module IM 155-5 DP ST	V2.0.0 or higher	---	X

Accessories

The following components are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strips
- U connector
- Universal front door

Other components

The following component must be ordered separately:

Front connectors, including potential jumpers and cable ties

Wiring

3

The following figures show the block diagram of the module and various wiring options.

For more information on front connector wiring and creating cable shields, etc., refer to the "Wiring" section in the Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792) and Distributed I/O System ET 200MP (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

You can find additional information on compensating the reference junction temperature in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559), the structure of a data record in the section Structure of a data record for dynamic reference temperature (Page 64).

Note

You may use and combine the different wiring options for all channels.

Note

Do not insert the potential jumpers included with the front connector!

Abbreviations used

Meaning of the abbreviations used in the following figures:

U_n+/U_n-	Voltage input channel n (voltage only)
M_n+/M_n-	Measuring input channel n
I_n+/I_n-	Current input channel n (current only)
$I_{c\,n}$+/$I_{c\,n}$-	Current output for RTD, channel n
U_{Vn}	Supply voltage at channel n for 2-wire transmitters (2WT)
Comp+/Comp-	Compensation input
I_{Comp}+/I_{Comp}-	Current output for compensation
L+	Connection for supply voltage
M	Connection for ground
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status
PWR	Display for the supply voltage

Pin assignment for the power supply element

The power supply element is plugged onto the front connector for powering the analog module. Wire the supply voltage to terminals 41 (L+) and 44 (M). You can use terminals 42 (L+) and 43 (M) to loop the potential to the next module.

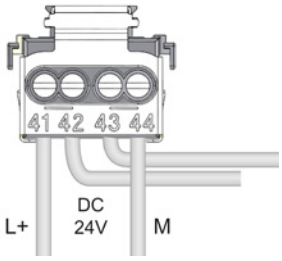
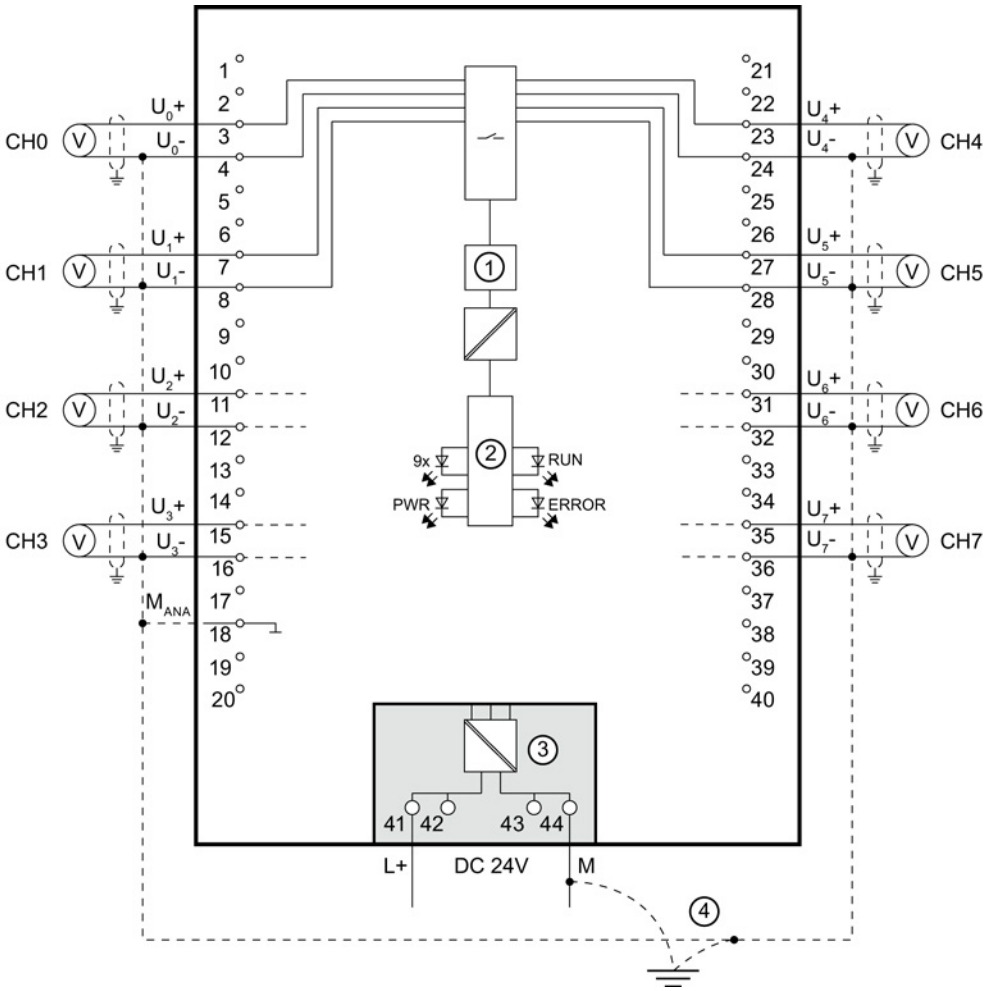


Figure 3-1 Power supply element wiring

Block diagram and pin assignment for voltage measurement

The example in the following figure shows the pin assignment for voltage measurement.

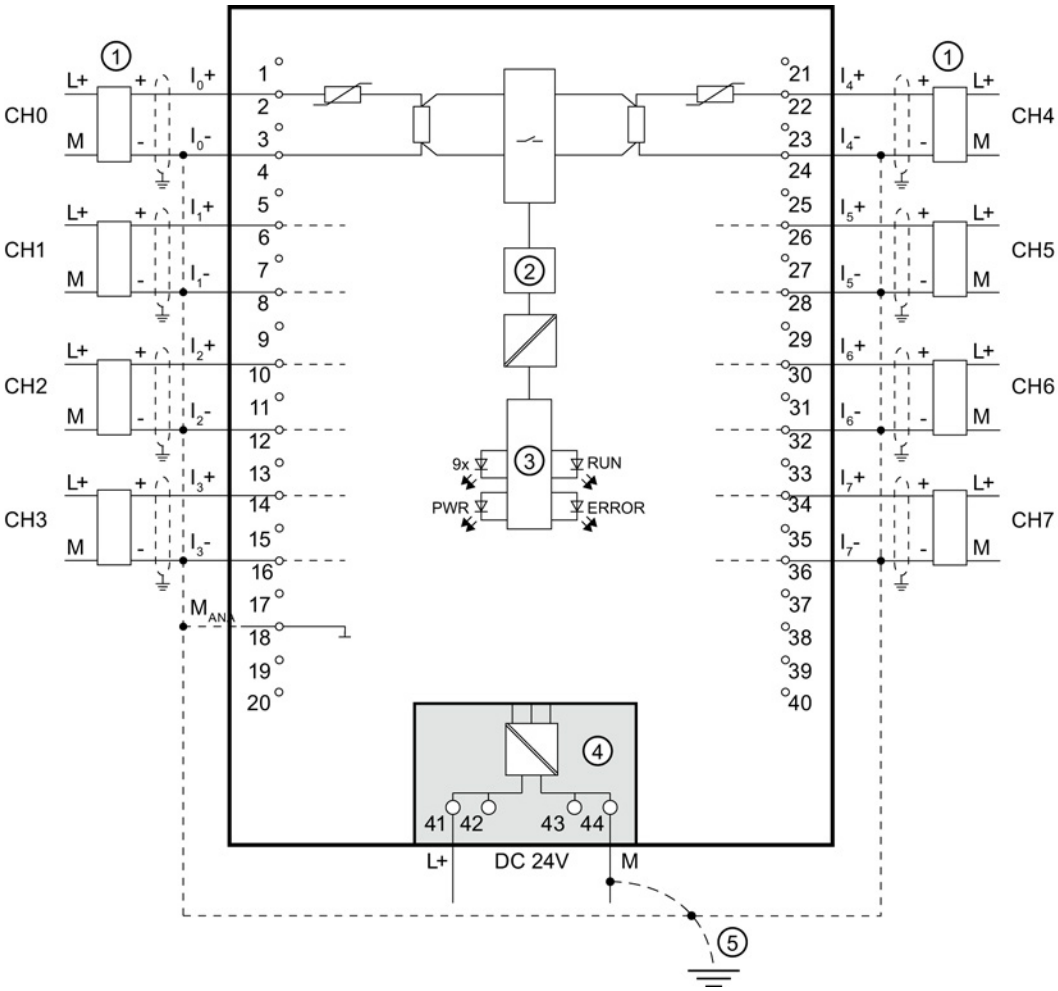


① Analog-to-Digital Converter (ADC)
② Backplane bus interface
③ Supply voltage via power supply element
④ Equipotential bonding cable (optional)

Figure 3-2 Block diagram and pin assignment for voltage measurement

Connection: 4-wire transmitters for current measurement

The example in the following figure shows the pin assignment for current measurement with 4-wire transmitters.

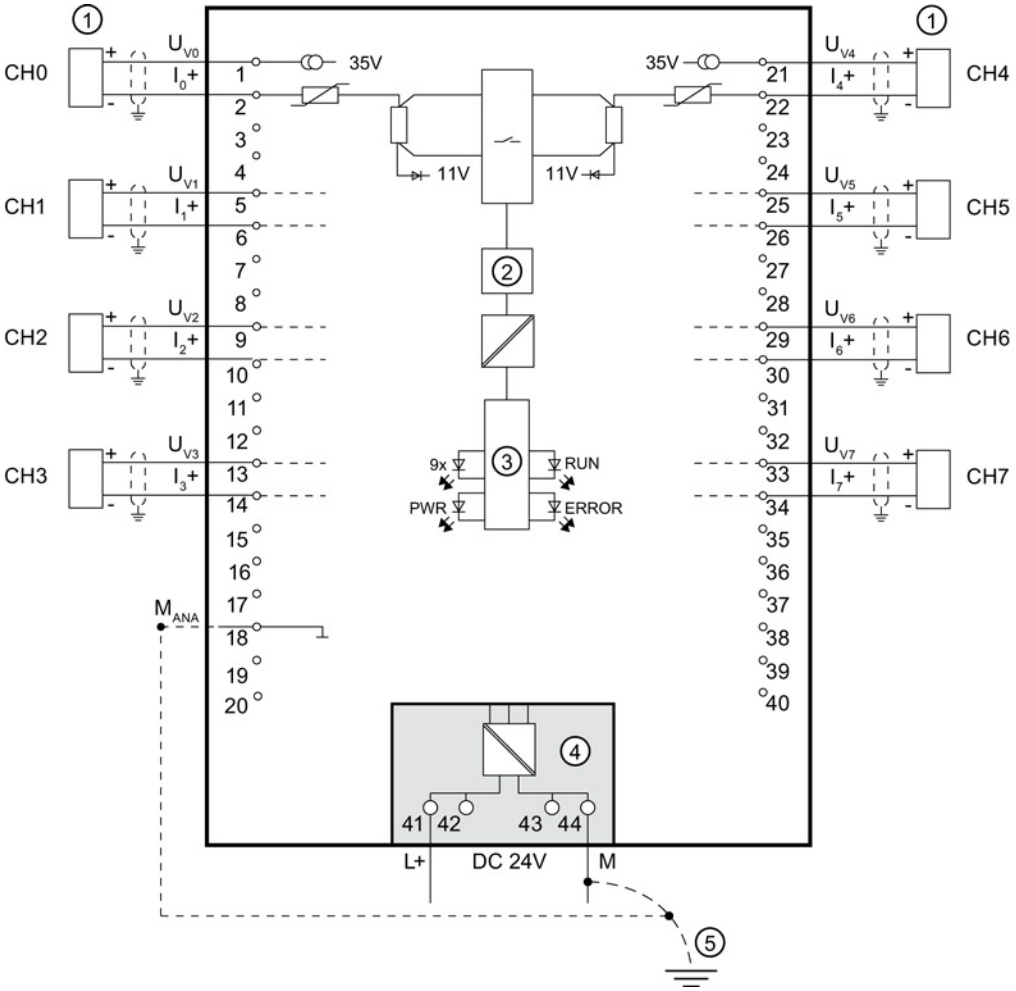


① Wiring 4-wire transmitter
② Analog-to-Digital Converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-3 Block diagram and pin assignment for current measurement

Connection: 2-wire transmitters for current measurement

The example in the following figure shows the pin assignment for current measurement with 2-wire transmitters.

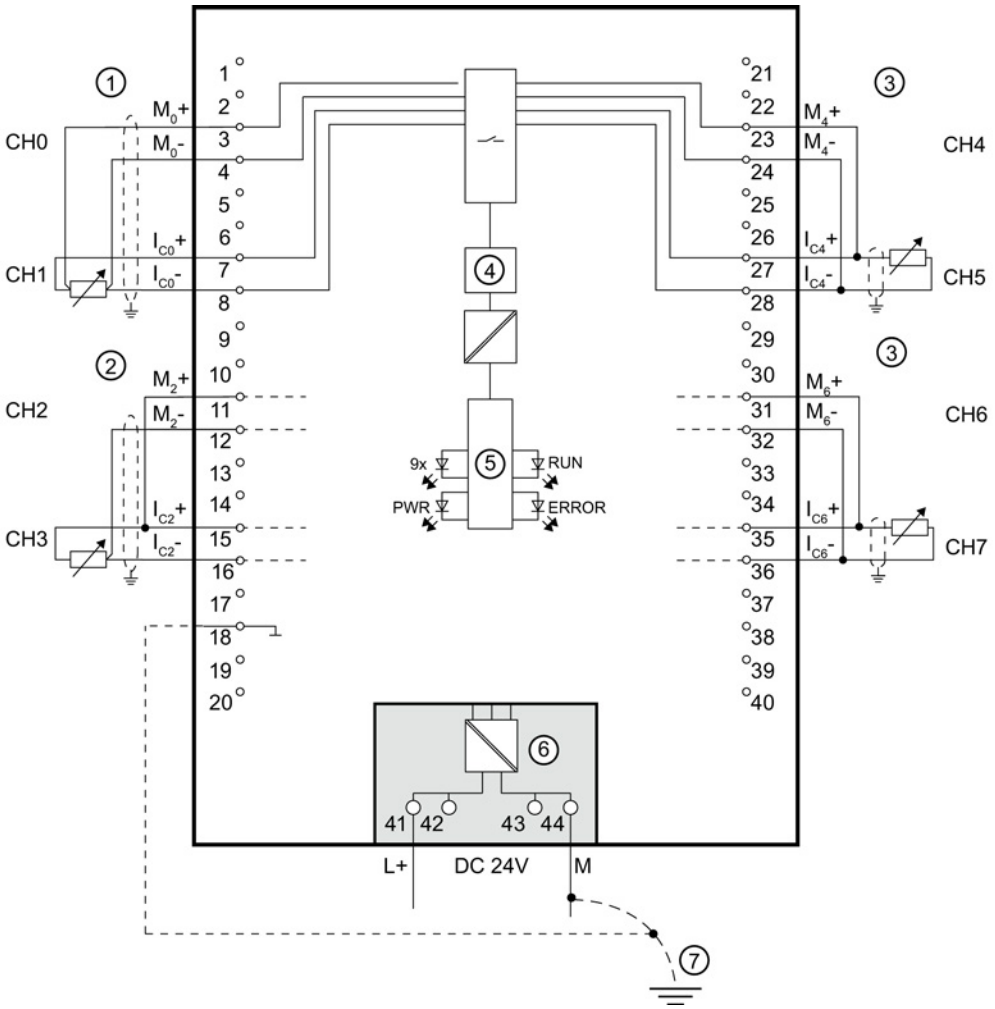


① Wiring 2-wire transmitter
② Analog-to-Digital Converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-4 Block diagram and pin assignment for current measurement

Connection: 2-, 3- and 4-wire connection of resistance-based sensors or resistance thermometers

The example in the following figure shows the pin assignment for 2-, 3- and 4-wire connections of resistance-based sensors or resistance thermometers.

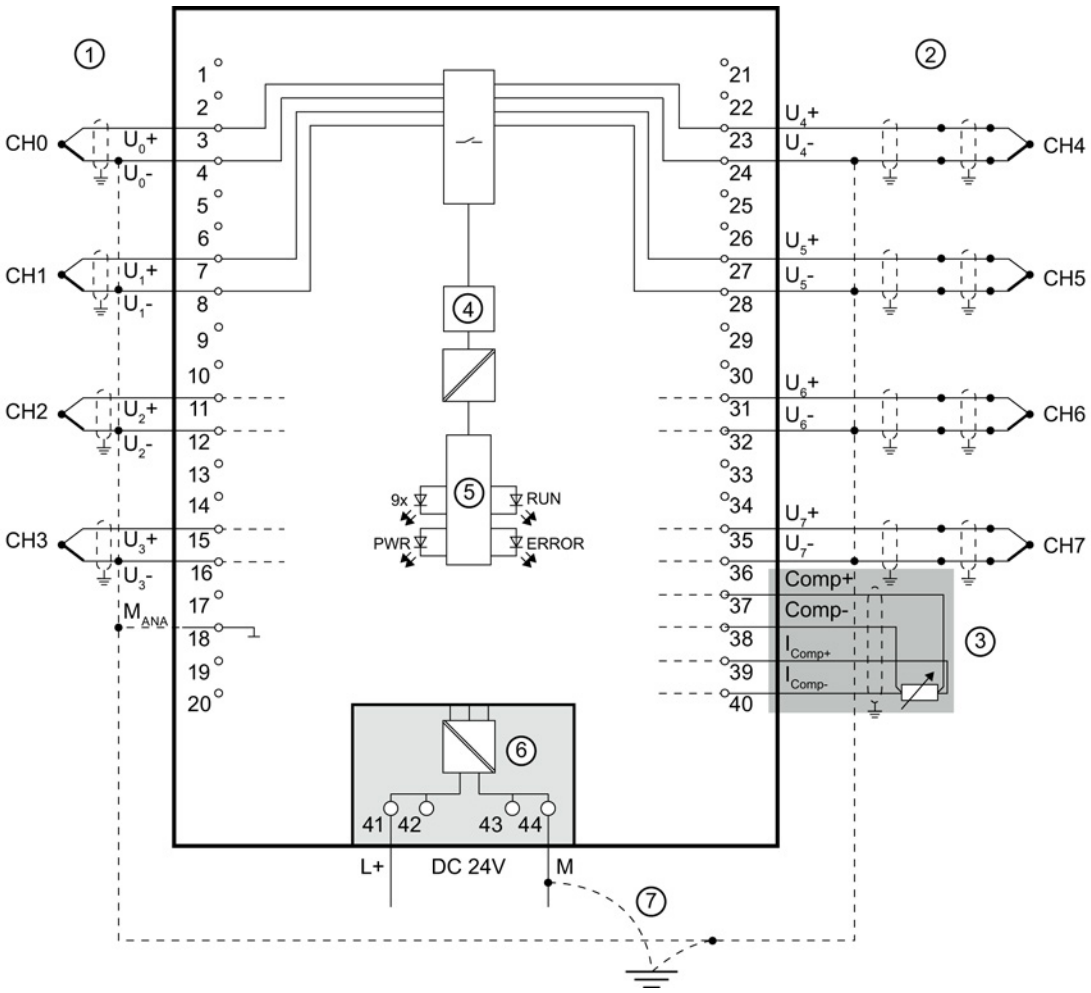


① 4-wire connection
② 3-wire connection
③ 2-wire connection
④ Analog-to-Digital Converter (ADC)
⑤ Backplane bus interface
⑥ Supply voltage via power supply element
⑦ Equipotential bonding cable (optional)

Figure 3-5 Block diagram and pin assignment for 2-, 3- and 4-wire connections

Connection: Thermocouples for external/internal compensation and connection of a resistance thermometer (RTD) at the reference channel

The following figure shows an example of the pin assignment of thermocouples for external/internal compensation and the connection of a resistance thermometer (RTD) at the reference channel.

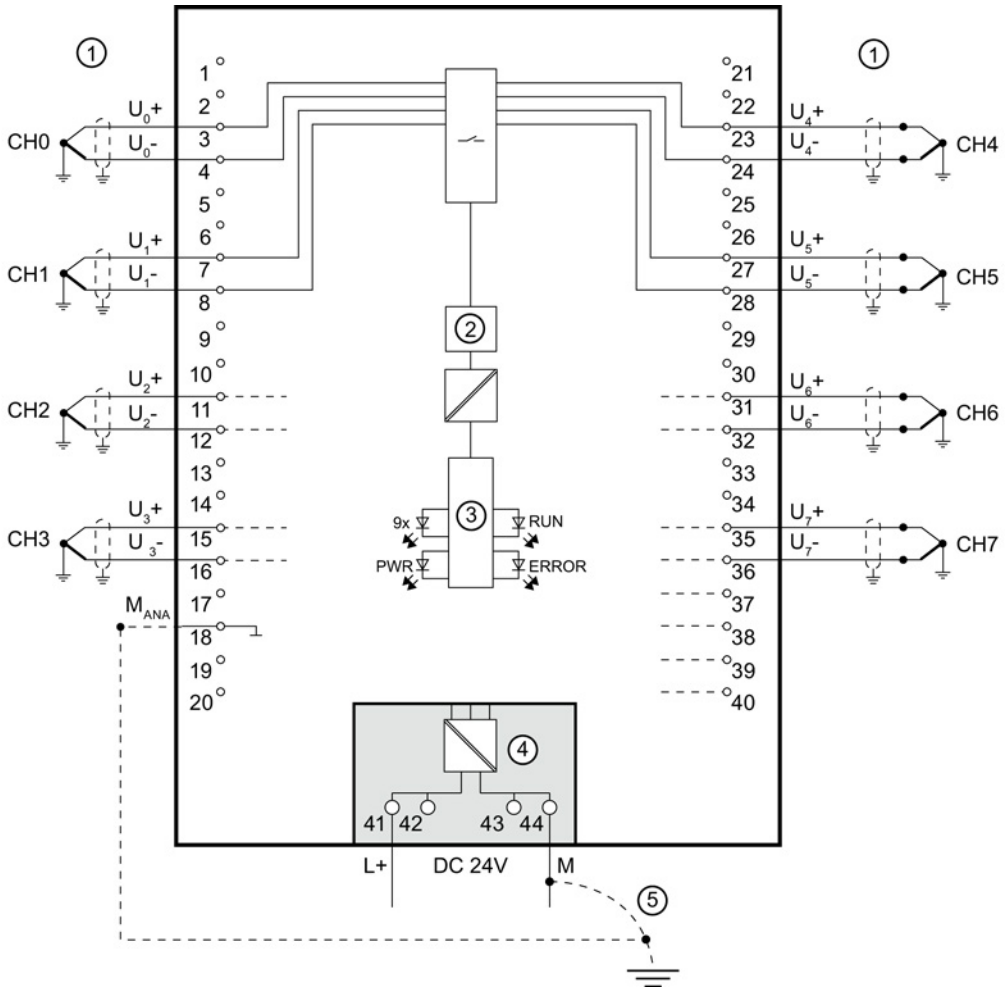


① Wiring of a thermocouple for internal compensation
② Wiring of a thermocouple for external compensation
③ Wiring of a resistance thermometer (RTD) at the reference channel
④ Analog-to-Digital Converter (ADC)
⑤ Backplane bus interface
⑥ Supply voltage via power supply element
⑦ Equipotential bonding cable (optional)

Figure 3-6 Block diagram and pin assignment for thermocouples and resistance thermometers

Connection: Grounded thermocouples for internal compensation

The following figure shows an example of the pin assignment for grounded thermocouples for internal compensation.



① Wiring of a thermocouple (grounded) for internal compensation
② Analog-to-Digital Converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-7 Block diagram and pin assignment for grounded thermocouples

Parameters/address space 4

4.1 Measuring types and ranges

Introduction

The module is set to voltage measuring type with measuring range ±10 V by default. You need to reassign the module parameters with STEP 7 if you want to use a different measuring type or range.

Deactivate the input if it is not going to be used. This reduces the cycle time of the module.

Measuring types and ranges

The following table shows the measuring types and the respective measuring range.

Table 4- 1 Measuring types and ranges

Measuring type	Measuring range
Voltage	±50 mV ±80 mV ±250 mV ±500 mV ±1 V ±2.5 V 1 to 5 V ±5 V ±10 V
Current 2WMT (2-wire transmitter)	4 to 20 mA
Current 4WMT (4-wire transmitter)	0 to 20 mA 4 to 20 mA ±20 mA
Resistor (2-wire connection)	PTC
Resistor (3-wire connection) (4-wire connection)	150 Ω 300 Ω 600 Ω 6000 Ω

Measuring type	Measuring range
Thermal resistor RTD (3-wire connection) (4-wire connection)	PT100 standard/climate PT200 standard/climate PT500 standard/climate PT1000 standard/climate Ni100 standard/climate Ni1000 standard/climate LG-Ni1000 standard/climate
Thermocouple (TC)	Type B Type E Type J Type K Type N Type R Type S Type T
Disabled	-

The tables of the input ranges, overflow, undershoot range, etc. are available in appendix Representation of analog values (Page 67).

Special features for the use of PTC resistors

PTCs are suitable for use as temperature monitoring or thermal protection device for drives, transformer windings, etc.

- Select "2-wire resistor" and "PTC" in the parameter settings:
- Wire the PTC with 2-wire connectivity.
- Use PTC resistors type A (PTC resistance thermometer) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostics is enabled, a "Low limit undershoot" diagnostic alarm indicates a short-circuit is generated for resistance values <18 Ω.

The following image shows the address space assignment for AI 8xU/I/RTD/TC ST with PTC resistors.

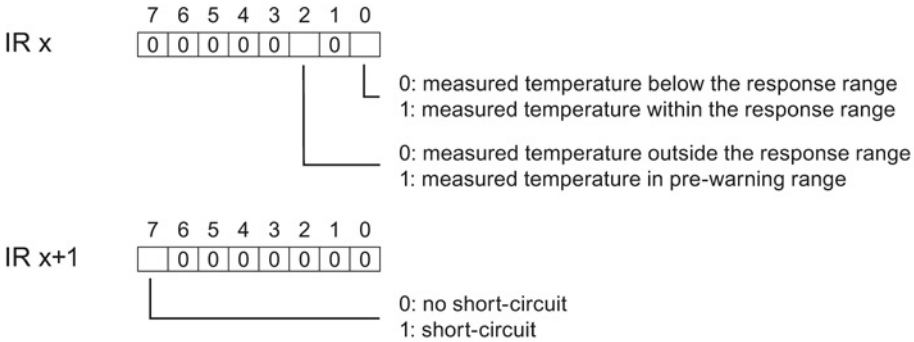


Figure 4-1 Address space for AI 8xU/I/RTD/TC ST with PTC resistors

The diagram below shows the temperature profile and the corresponding switching points.

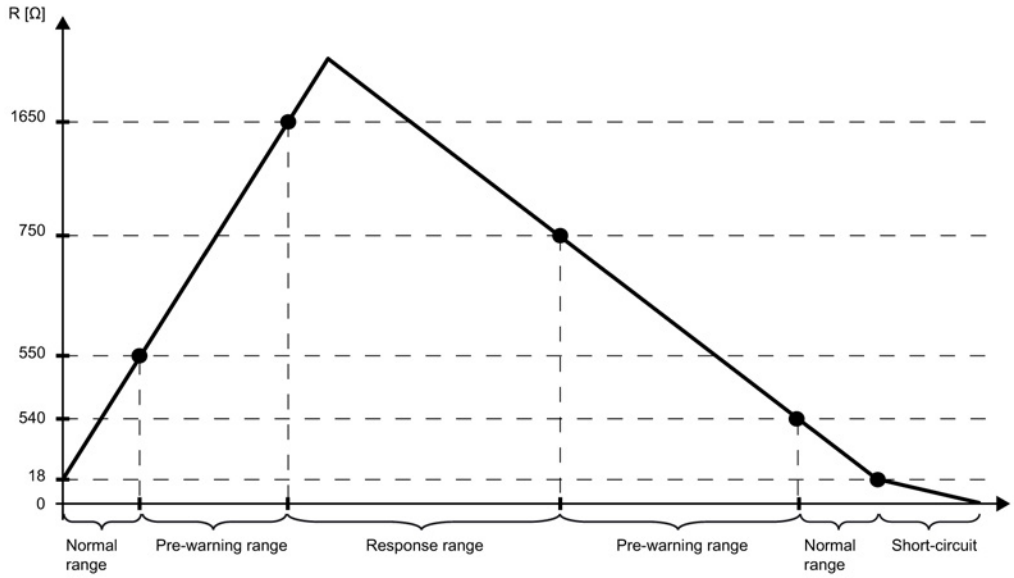


Figure 4-2 Temperature profile and the corresponding switching points

Special features of the measured value acquisition with PTC resistors

If faults occur (for example supply voltage L+ missing) that make it impossible to acquire measured values with PTC resistors, the corresponding channels (IR x/IR x+1) report overflow ($7FFF_H$). If the value status (QI) is enabled, the value 0 = fault is output in the corresponding bit.

4.2 Parameters

AI 8xU/I/RTD/TC ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of the parameter data records (Page 53).

The following parameter settings for the channels are possible:

Table 4- 2 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel [1]	Module [3]
• Overflow	Yes/No	No	Yes	Channel	Module [3]
• Underflow	Yes/No	No	Yes	Channel	Module [3]
• Common mode error	Yes/No	No	Yes	Channel	Module [3]
• Reference channel error	Yes/No	No	Yes	Channel	Module [3]
• Wire break	Yes/No	No	Yes	Channel	Module [3]
• Current limit for wire break diagnostics [2]	1,185 mA or 3.6 mA	1,185 mA	Yes	Channel	--- [4]

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Measuring					
• Measuring type	See chapter Measuring types and ranges (Page 21)	Voltage	Yes	Channel	Channel
• Measuring range		±10 V	Yes	Channel	Channel
• Temperature coefficient	Pt: 0,003851 Pt: 0,003902 Pt: 0,003916 Pt: 0,003920 Ni: 0,00618 Ni: 0,00672 LG-Ni: 0,005000	0,003851	Yes	Channel	Channel
• Temperature unit	• Kelvin (K) • Fahrenheit (°F) • Celsius (°C)	°C	Yes	Channel	Module
• Interference frequency suppression	400 Hz 60 Hz 50 Hz 10 Hz	50 Hz	Yes	Channel	Module
• Smoothing	None/low/medium/high	None	Yes	Channel	Channel
• Reference junction for TC	• Fixed reference temperature • Dynamic reference temperature • Internal reference junction • Reference channel of the module	Internal reference junction	Yes	Channel	Module [4)] • Dynamic reference temperature • Internal reference junction
• Fixed reference temperature	Temperature	25 °C	Yes	Channel	--- [4)]

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupts					
• Hardware interrupt low limit 1	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt high limit 1	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt low limit 2	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt high limit 2	Yes/No	No	Yes	Channel	--- 4)

1) If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

2) When "Wire break" diagnostics is disabled, the current limit of 1.185 mA is applied to the value status. For measured values below 1.185 mA, the value status is always: 0 = fault.

3) You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 7.

4) You can set the current limit for wire break diagnostics, the setting "Fixed reference temperature" and "Reference channel of the module" as well as the limits for hardware interrupts in the user program with data records 0 to 7.

Parameters of the reference channel

You cannot configure the reference channel with GSD file. You have to transfer the reference channel to the module with data record 8.

If you want to change the default settings, you have to transfer the parameters to the module with data record 8, see chapter Parameter assignment and structure of the parameter data records (Page 53).

The diagnostics "Common mode error" and "Reference channel error" cannot be configured for the reference channel.

4.3 Declaration of parameters

Missing supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Overflow

Enabling of the diagnostics if the measured value violates the high limit.

Underflow

Enabling of the diagnostics if the measured value violates the low limit.

Common mode error

Enable diagnostics if the valid common mode voltage is exceeded.

Enable the Common mode error diagnostic when 2WMT is connected, for example, to check for a short circuit to M_{ANA} or a wire break. If you do not need the Common mode error diagnostics, disable the parameter.

Reference channel error

- Enable diagnostics for an error at the temperature compensation channel, e.g. wire break.
- Dynamic reference temperature compensation type is configured and no reference temperature has been transferred to the module yet.

Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak for the measurement at the corresponding configured input or the applied voltage is too low.

Current limit for wire break diagnostics

Threshold for reporting wire breaks. The value can be set to 1.185 mA or 3.6 mA, depending on the sensor used.

Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The correction factor for the temperature coefficient (α value) specifies how much the resistance of a certain material changes when the temperature is raised by 1 °C.

The further values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

Interference frequency suppression

At analog input modules, this suppresses interference caused by the frequency of AC mains.

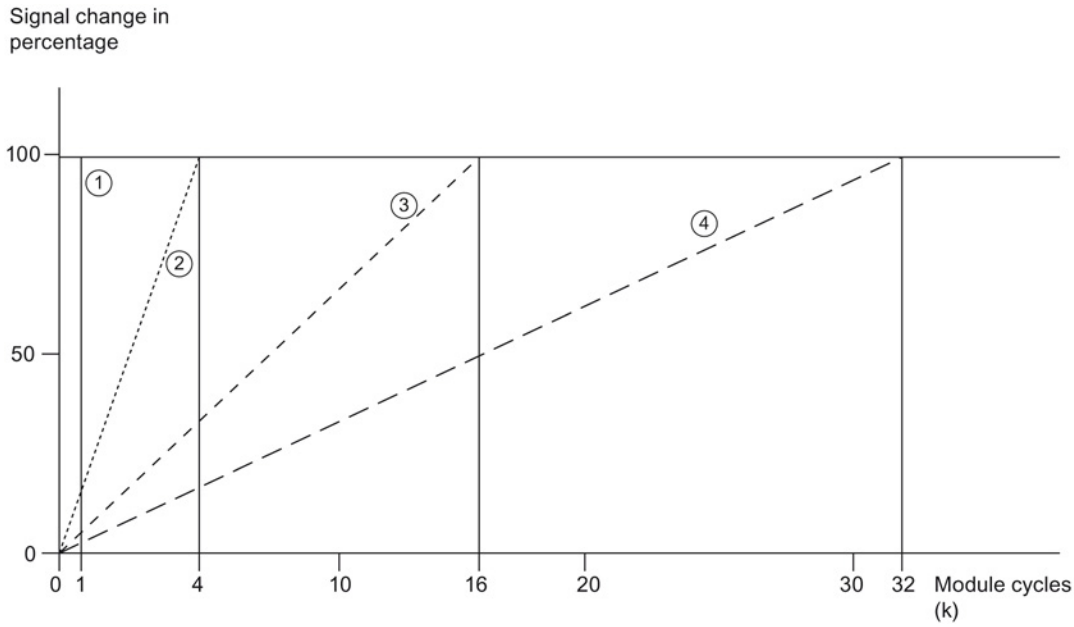
The frequency of AC network may corrupt measurements, particularly in the low voltage ranges, and when thermocouples are being used. For this parameter, the user defines the mains frequency prevailing on his system.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows after how many module cycles the smoothed analog value is almost 100%, depending on the set smoothing. Is valid for each signal change at the analog input.



① None (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 4-3 Smoothing with AI 8xU/I/RTD/TC ST

Reference junction for TC

The following settings can be configured for the reference junction parameter:

Table 4- 3 Possible parameter assignments for the reference junction parameter TC

Setting	Description
Fixed reference temperature	The reference junction temperature is configured and stored in the module as a fixed value.
Dynamic reference temperature	The reference junction temperature is transferred in the user program from the CPU to the module by data records 192 to 199 using the WRREC (SFB 53) instruction.
Internal reference junction	The reference junction temperature is determined using an integrated sensor of the module.
Reference channel of the module	The reference junction temperature is determined using an external resistance thermometer (RTD) at the reference channel (COMP) of the module.

Hardware interrupt 1 or 2

Enable a hardware interrupt at violation of high limit 1 or 2 or low limit 1 or 2.

Low limit 1 or 2

Specifies the low limit threshold that triggers hardware interrupt 1 or 2.

High limit 1 or 2

Specifies the high limit threshold that triggers hardware interrupt 1 or 2.

4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 8xU/I/RTD/TC ST

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 4 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	AI 8xU/I/RTD/TC ST	X	X
1 x 8-channel with value status	AI 8xU/I/RTD/TC ST QI	X	X
8 x 1-channel without value status	AI 8xU/I/RTD/TC ST S	X	---
8 x 1-channel with value status	AI 8xU/I/RTD/TC ST S QI	X	---
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	AI 8xU/I/RTD/TC ST MSI	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 8xU/I/RTD/TC ST QI
- AI 8xU/I/RTD/TC ST S QI
- AI 8xU/I/RTD/TC ST MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space of AI 8xU/I/RTD/TC ST

The following figure shows the address space allocation for the configuration as 8-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IB x", for example represents the module start address input byte x.

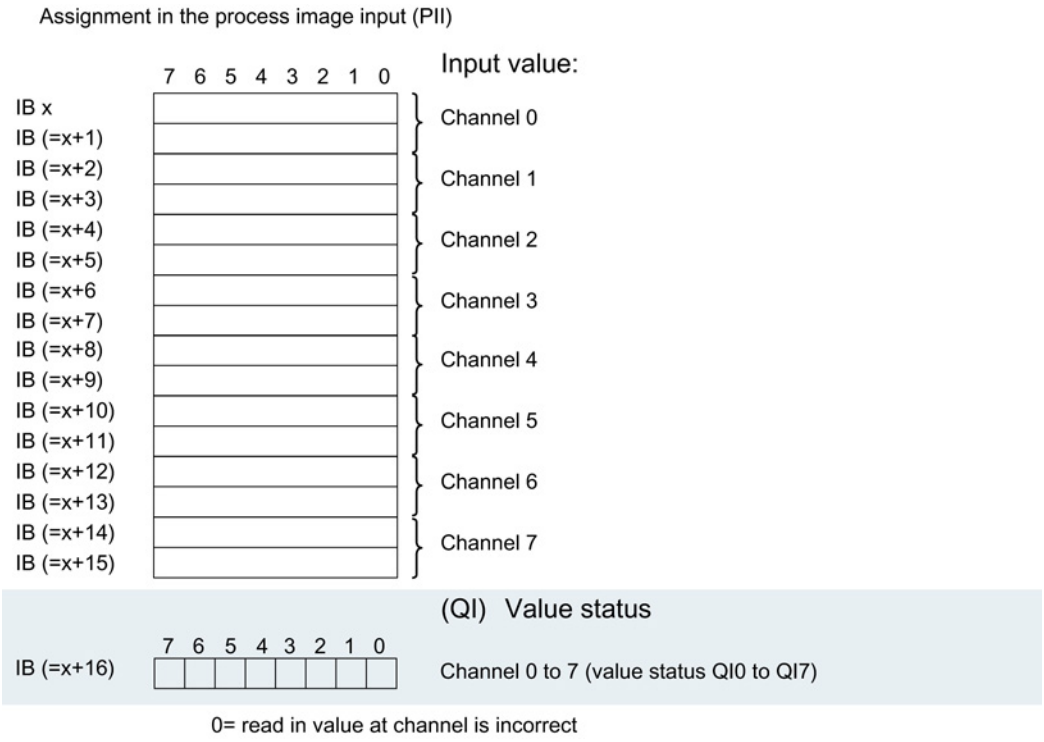


Figure 4-4 Address space for configuration as 1 x 8-channel AI 8xU/I/RTD/TC ST with value status

Address space for configuration as 8 x 1-channel AI 8xU/I/RTD/TC ST QI

For the configuration as a 8 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

Contrary to the 1 x 8-channel module configuration, each of the eight submodules has a freely assignable start address.

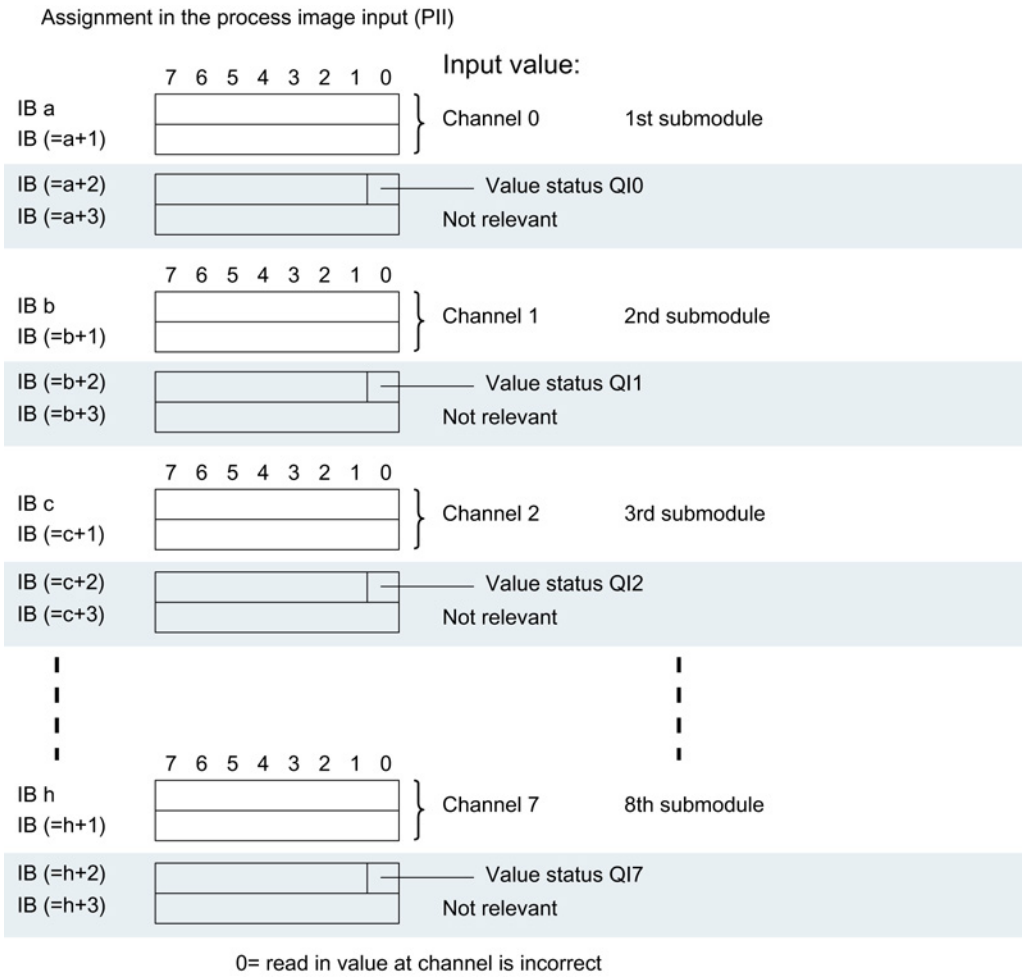


Figure 4-5 Address space for configuration as 8 x 1-channel AI 8xU/I/RTD/TC ST S QI with value status

Address space for configuration as 1 x 8-channel AI 8xU/I/RTD/TC ST MSI

The channels 0 to 7 of the module are copied in up to four submodules with configuration 1 x 8-channel module (Module-internal shared input, MSI). Channels 0 to 7 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

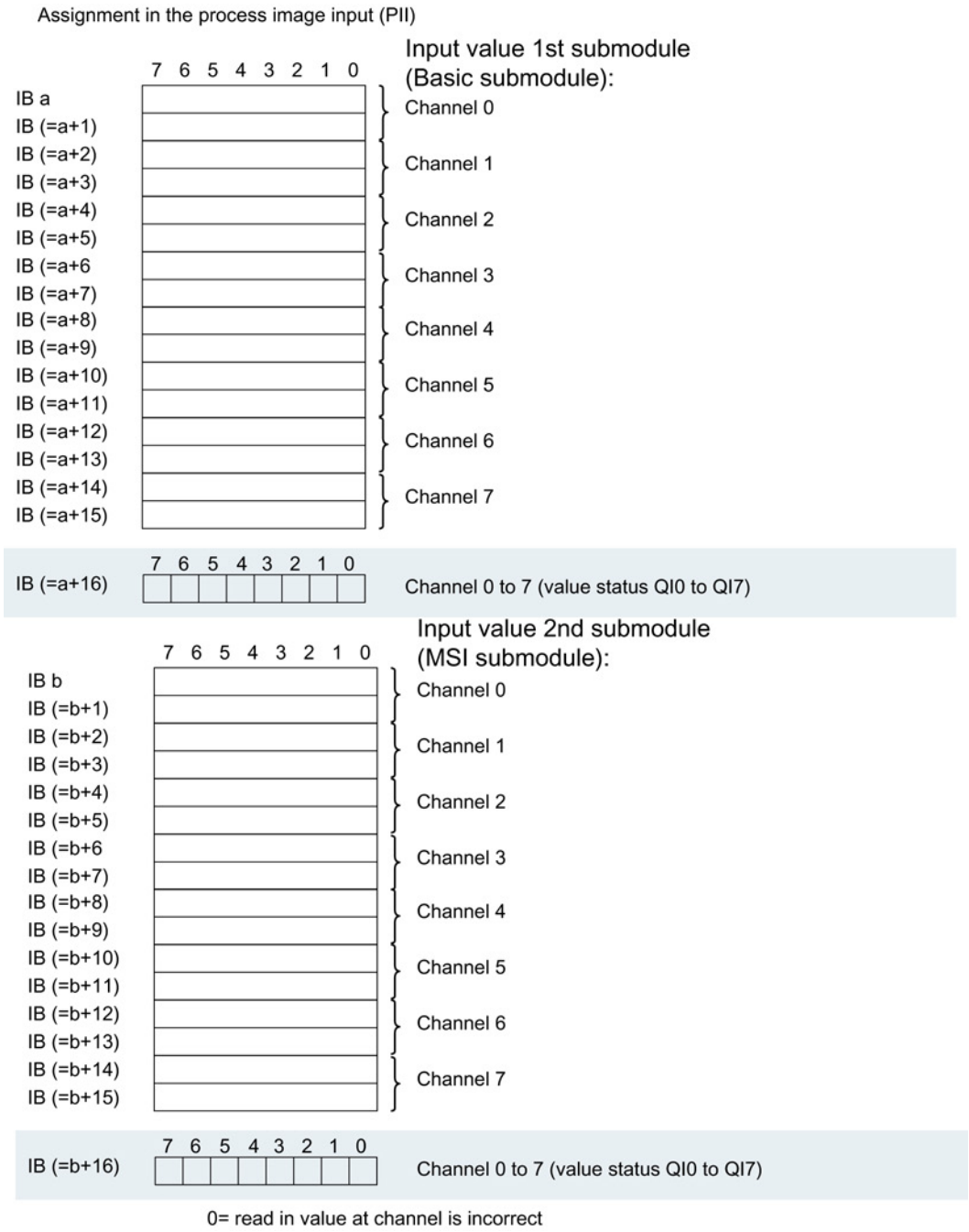


Figure 4-6 Address space for configuration as 1 x 8-channelAI 8xU/I/RTD/TC ST MSI with value status

The following figure shows the assignment of the address space with submodules 3 and 4.

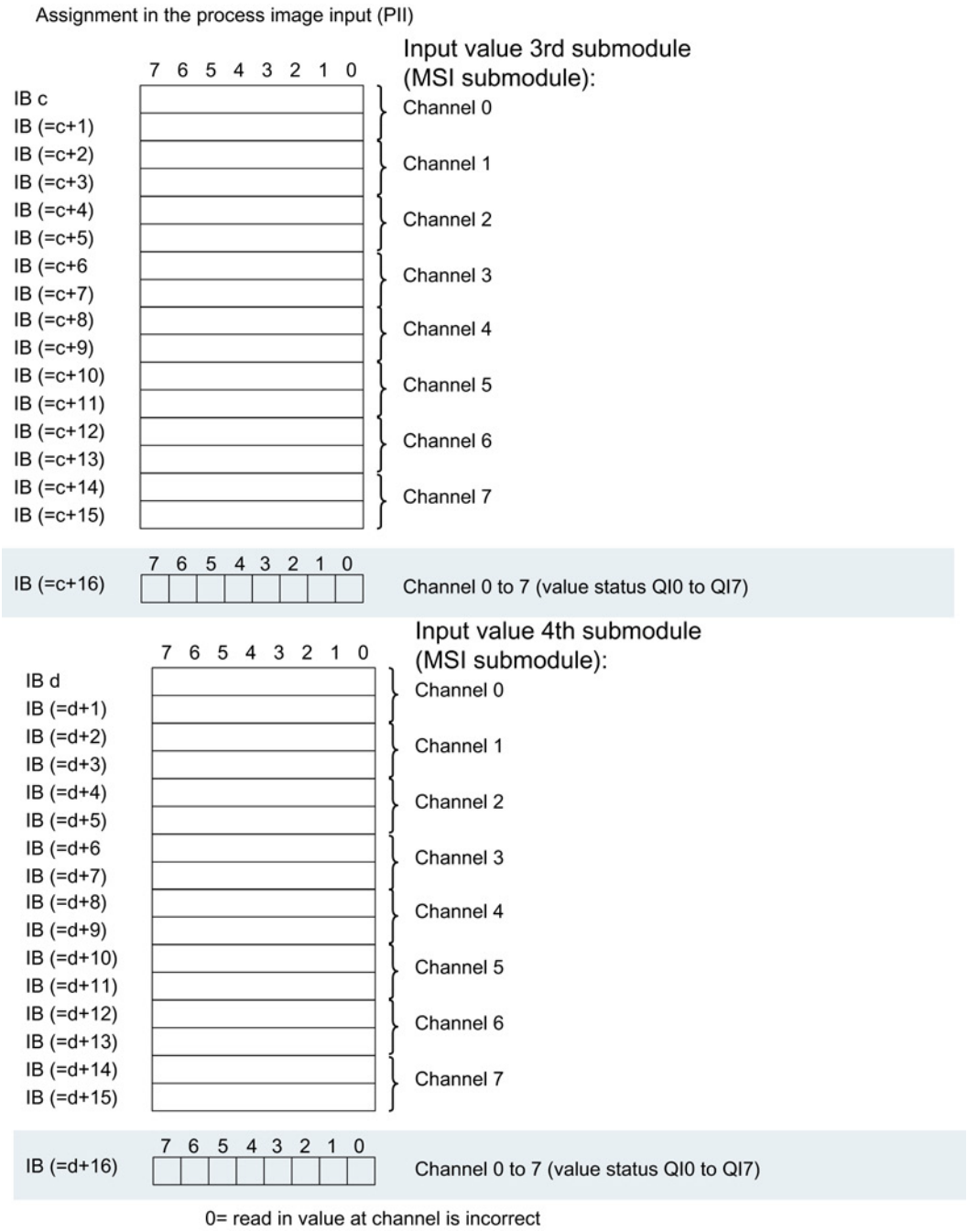


Figure 4-7 Address space for configuration as 1 x 8-channelAI 8xU/I/RTD/TC ST MSI with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays (status and error displays) of AI 8xU/I/RTD/TC ST.

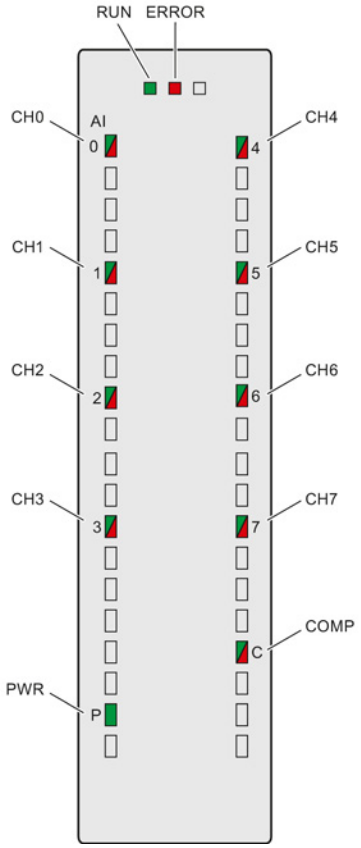


Figure 5-1 LED displays of the module AI 8xU/I/RTD/TC ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 41).

Table 5- 1 Status and error displays RUN/ERROR

LEDs		Meaning	To correct or avoid errors
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus.	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid configuration is set.	---
On	Off	Module is configured.	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective.	Replace the module.

Table 5- 2 PWR status display

LED PWR	Meaning	To correct or avoid errors
Off	Supply voltage L+ to module too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

Table 5- 3 CHx and COMP status indication

LED CHx/COMP	Meaning	To correct or avoid errors
Off	Channel disabled.	---
On	Channel configured and OK.	---
On	Channel is configured (channel error pending). Diagnostic alarm: e.g. wire break	Check the wiring Disable diagnostics.

5.2 Interrupts

Analog input module AI 8xU/I/RTD/TC ST supports the following diagnostic and hardware interrupts:

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break
- Overflow
- Underflow
- Common mode error
- Reference channel error

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Low limit violated 1
- High limit violated 1
- Low limit violated 2
- Violation of high limit 2

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The diagram below shows the assignment to the bits of double word 8 in local data.

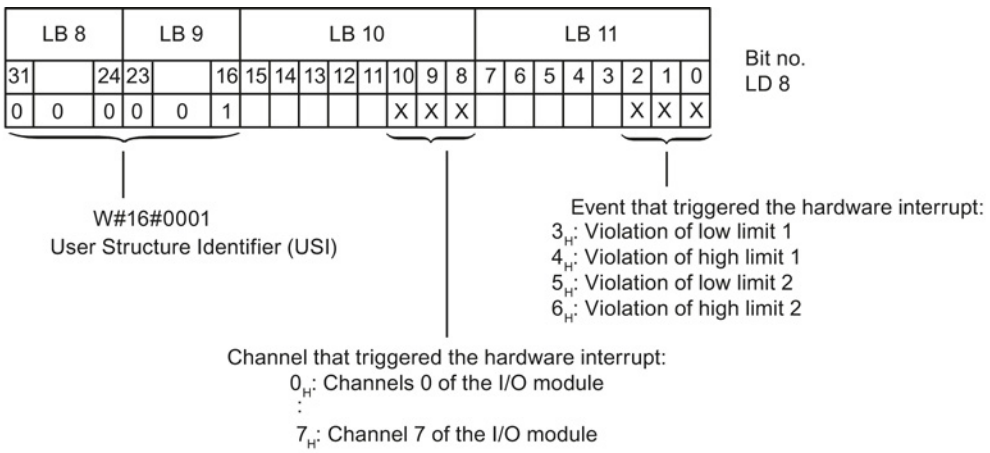


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Contents	Remark	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#n	Number of the event-triggering channel (n = number of module channels)	1
It follows the error event that triggered the hardware interrupt.				
	Event	B#16#03	Low limit violated 1	1
		B#16#04	High limit violated 1	
		B#16#05	Low limit violated 2	
		B#16#06	Violation of high limit 2	

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range violated	Check the measuring range
Underflow	8_H	Measuring range violated	Check the measuring range
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel
Reference channel error	15_H	Invalid reference temperature for the used TC channel with compensation	Check the resistance thermometer. For the compensation with data record, restore communication to the module/station.
Common mode error	118_H	Valid common mode voltage exceeded Causes when a 2WT is connected, e.g.: • Wire break • Galvanic connection to M_{ANA}	Check the wiring, e.g. sensor ground connections, use equipotential cables

Technical specifications 6

Technical specifications of the AI 8xU/I/RTD/TC ST

	6ES7531-7KF00-0AB0
Product type designation	AI 8xU/I/RTD/TC ST
General information	
Hardware version	E01
Firmware version	V2.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
Operating mode	
MSI	Yes
CiR Configuration in RUN	
Parameter assignment in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	240 mA; (with 24 V DC supply)
Encoder supply	
24 V encoder supply	
Short-circuit protection	Yes
Output current, max.	53 mA
Power	
Power consumption from the backplane bus	0.7 W
Power loss	
Power loss, typ.	2.7 W

	6ES7531-7KF00-0AB0
Analog inputs	
Number of analog inputs	8
Number of analog inputs with current measurement	8
Number of analog inputs for voltage measurement	8
Number of analog inputs for resistance/resistance thermometer measurement	4
Number of analog inputs with thermocouple measurement	8
Permissible input voltage for voltage input (destruction limit), max.	28.8 V
Permissible input current for current input (destruction limit), max.	40 mA
Technical unit for temperature measurement adjustable	Yes
Input ranges (rated values), voltages	
1 V to 5 V	Yes
Input resistance (1 V to 5 V)	100 kΩ
-1 to +1 V	Yes
Input resistance (-1 to +1 V)	10 MΩ
-10 V to +10 V	Yes
Input resistance (-10 V to +10 V)	100 kΩ
-2.5 V to +2.5 V	Yes
Input resistance (-2.5 to +2.5 V)	10 MΩ
-250 to +250 mV	Yes
Input resistance (-250 to +250 mV)	10 MΩ
-5 V to +5 V	Yes
Input resistance (-5 V to +5 V)	100 kΩ
-50 mV to +50 mV	Yes
Input resistance (-50 mV to +50 mV)	10 MΩ
-500 mV to +500 mV	Yes
Input resistance (-500 mV to +500 mV)	10 MΩ
-80 mV to +80 mV	Yes
Input resistance (-80 mV to +80 mV)	10 MΩ
Input ranges (rated values), currents	
0 mA to 20 mA	Yes
Input resistance (0 mA to 20 mA)	25 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	25 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)
4 mA to 20 mA	Yes
Input resistance (4 mA to 20 mA)	25 Ω; (plus approx. 42 ohm for overvoltage protection by PTC)

	6ES7531-7KF00-0AB0
Input ranges (rated values), thermocouples	
Type B	Yes
Input resistance (type B)	10 MΩ
Type E	Yes
Input resistance (type E)	10 MΩ
Type J	Yes
Input resistance (type J)	10 MΩ
Type K	Yes
Input resistance (type K)	10 MΩ
Type N	Yes
Input resistance (type N)	10 MΩ
Type R	Yes
Input resistance (type R)	10 MΩ
Type S	Yes
Input resistance (type S)	10 MΩ
Type T	Yes
Input resistance (type T)	10 MΩ
Input ranges (rated values), resistance thermometers	
Ni 100	Yes, standard/climate
Input resistance (Ni 100)	10 MΩ
Ni 1000	Yes, standard/climate
Input resistance (Ni 1000)	10 MΩ
LG-Ni 1000	Yes, standard/climate
Input resistance (LG-Ni 1000)	10 MΩ
Pt 100	Yes, standard/climate
Input resistance (Pt 100)	10 MΩ
Pt 1000	Yes, standard/climate
Input resistance (Pt 1000)	10 MΩ
Pt 200	Yes, standard/climate
Input resistance (Pt 200)	10 MΩ
Pt 500	Yes, standard/climate
Input resistance (Pt 500)	10 MΩ
Input ranges (rated values), resistors	
0 to 150 ohm	Yes
Input resistance (0 to 150 ohm)	10 MΩ
0 to 300 ohm	Yes
Input resistance (0 to 300 ohm)	10 MΩ
0 to 600 ohm	Yes
Input resistance (0 to 600 ohm)	10 MΩ
0 to 6000 ohm	Yes
Input resistance (0 to 6000 ohm)	10 MΩ
PTC	Yes
Input resistance (PTC)	10 MΩ

	6ES7531-7KF00-0AB0
Thermocouple (TC)	
Technical unit for temperature measurement	°C/°F/K
Temperature compensation	
• Configurable	Yes
• Internal temperature compensation	Yes
• External temperature compensation via RTD	Yes
• Compensation for 0 °C reference point temperature	Yes, fixed value can be set
Resistance thermometer (RTD)	
Technical unit for temperature measurement	°C/°F/K
Cable length	
Cable length shielded, max.	800 m; for U/I, 200 m for R/RTD, 50 m for TC
Analog value formation	
Integration and conversion time / resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Configurable integration time	Yes
Integration time, ms	2,5 / 16,67 / 20 / 100
Basic conversion time, including integration time, ms	9 / 23 / 27 / 107 ms
• Additional conversion time for wire break monitoring	9 ms
• Additional conversion time for wire break measurement	150Ohm, 300Ohm, 600Ohm, Pt100, Pt200, Ni100: 2ms 6000Ohm, Pt500, Pt1000, Ni1000, LG-Ni1000, PTC: 4ms
Interference voltage suppression at interference frequency f1 in Hz	400 / 60 / 50 / 10
Smoothing of the measured values	
Configurable	Yes
Level: None	Yes
Level: Weak	Yes
Level: Medium	Yes
Level: Strong	Yes

	6ES7531-7KF00-0AB0
Encoders	
Connection of the signal encoders	
For voltage measurement	Yes
For current measurement as 2-wire transmitter	Yes
Load of 2-wire transmitter, max.	820 Ω
For current measurement as 4-wire transmitter	Yes
For resistance measurement with 2-wire connection	Yes; only for PTC
For resistance measurement with 3-wire connection	Yes; all measuring ranges except PTC; internal compensation of line resistance;
For resistance measurement with 4-wire connection	Yes; all measuring ranges except PTC
Errors/accuracies	
Linearity error (relative to input range)	± 0,02 %
Temperature error (relative to input range)	± 0.005 %/K; for TC typ. T 0.02 +/- %/K
Crosstalk between the inputs, max.	-80 dB
Repeat accuracy in steady state at 25 °C (relative to input range)	± 0,02 %
Temperature errors of internal compensation	+/-6 °C
Operational limit in overall temperature range	
Voltage, relative to input range	± 0,3 %
Current, relative to input range	± 0,3 %
Impedance, relative to input range	± 0,3 %
Resistance thermometer, relative to input range	Pt xxx standard: +/- 1.5 K Pt xxx climate: +/- 0,5 K Ni xxx standard: +/- 0.5 K Ni xxx climate: +/- 0.3 K
Thermocouple, relative to input range	Type B: >600 °C +/- 4.6 K type E: >-200 °C +/- 1.5 K type J: >-210 °C +/- 1.9 K type K: >-200 °C +/- 2.4 K type N: >-200 °C +/- 2.9 K type R: >0 °C +/- 4.7 K type S: >0 °C +/- 4.6 K type T: >-200 °C +/- 2.4 K

	6ES7531-7KF00-0AB0
Basic error limit (operational limit at 25 °C)	
Voltage, relative to input range	± 0,1 %
Current, relative to input range	± 0,1 %
Impedance, relative to input range	± 0,1 %
Resistance thermometer, relative to input range	Pt xxx standard: +/- 0.7 K Pt xxx climate: +/- 0.2K Ni xxx standard: +/- 0.3 K Ni xxx climate: +/- 0.15 K
Thermocouple, relative to input range	Type B: >600 °C +/- 1.7 K type E: >-200 °C +/- 0.7 K type J: >-210 °C +/- 0.8 K type K: >-200 °C +/- 1.2 K type N: >-200 °C +/- 1.2 K type R: >0 °C +/- 1.9 K type S: >0 °C +/- 1.9 K type T: >-200 °C +/- 0.8 K
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series mode interference (peak value of interference < rated value of input range), min.	40 dB
Common mode voltage, max.	10 V
Common mode interference, min.	60 dB
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; only for 1 ... 5V, 4 ... 20mA, TC, R and RTD
Overflow/underflow	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED

	6ES7531-7KF00-0AB0
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels, in groups of	8
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between the inputs (UCM)	20 V DC
Between inputs and MANA (UCM)	10 V DC
Between M internally and the inputs	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	No
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	310 g
Miscellaneous	
Note:	Additional basic error and noise for integration time = 2.5 ms: Voltage: +/- 250mV: +/- 0,02% +/- 80mV: +/- 0,05% +/- 50mV: +/- 0,05% Resistance: 150 ohm: +/- 0.02% resistance thermometer: Pt100 climate: +/- 0.08 K Ni100 climate: +/-0.08K thermocouple: Type B, R, S: +/- 3 K type E, J, K, N, T: +/-1 K

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front panel are provided in the appendix. Always adhere to the specified dimensions for installations in cabinets, control rooms, etc.

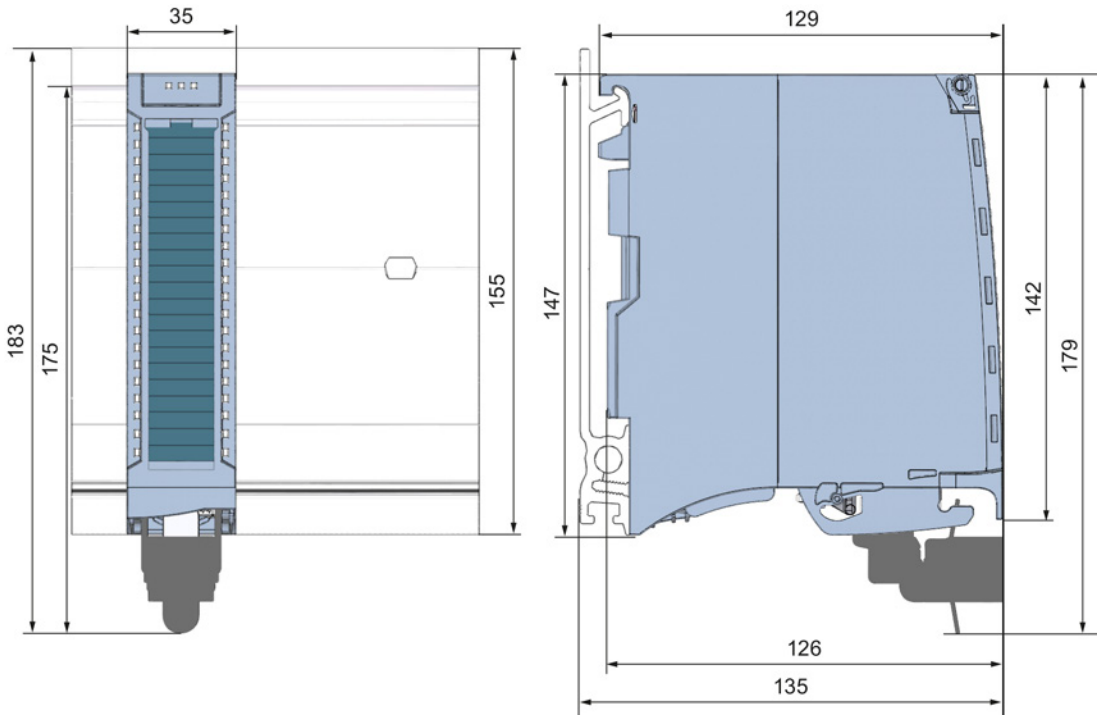


Figure A-1 Dimensional drawing of the AI 8xU/I/RTD/TC ST module

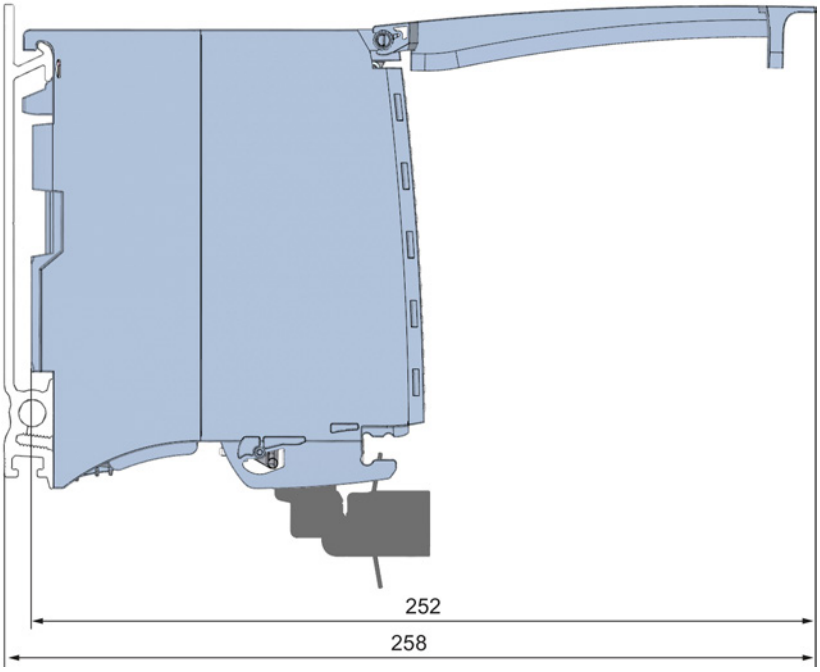


Figure A-2 Dimensional drawing of the AI 8xU/I/RTD/TC ST module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

Note for configuration of the module with GSD file that the settings of some parameters are dependent on each other, see the table below.

The parameters are only checked for plausibility by the module after the transfer.

If errors occur during the transfer of parameters with the GSD file, the module continues operation with the previous parameter assignment.

Table B- 1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Current limit for wire break	Only for **measuring type** current with **measuring range** 4 mA to 20 mA.
Wire break	Only for **measuring type** resistance, thermistor RTD, thermocouple TC, voltage with **measuring range** 1V to 5 V and current with **measuring range** 4 mA to 20 mA.
Common mode error	Only for **measuring type** voltage, current and thermocouple TC.
Reference channel error	Only for **measuring type** thermocouple TC.
Measuring type resistance (4-wire connection, 3-wire connection)	Only for **measuring range** 150 Ω, 300 Ω, 600 Ω and 6000 Ω.
Measuring type resistance (4-wire connection, 3-wire connection, 2-wire connection)	Configurable for even channels (0, 2, 4 and 6) only. The following odd channel (1, 3, 5, 7) must be deactivated.
Measuring type thermistor RTD (4-wire connection, 3-wire connection)	
Hardware interrupt limits	Only if hardware interrupts are enabled.
Fixed reference temperature	Only if the value **Fixed reference temperature** is configured at parameter **Reference junction for TC**.
Temperature unit Kelvin (K)	Only for **measuring type** thermistor RTD and for thermocouple TC.

Parameter assignment in the user program

The module parameters can be assigned in RUN (for example, measuring ranges of selected channels can be edited in RUN without having an effect on the other channels).

Parameter assignment in RUN

Instruction WRREC is used to transfer the parameters by means of data records 0 to 7 and 8. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Assignment of data record and channel

The parameters in data records 0 to 7 and in data record 8 are available for 1x 8-channel configuration and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 6 for channel 6
- Data record 7 for channel 7
- Data record 8 for the reference channel (COMP)

For configuration 8 x 1-channel, the module has 8 submodules with one channel each and one submodule for the reference channel. The parameters for the channel are available in data record 0 and are assigned as follows:

- Data record 0 for channel 0 (submodule 1)
- Data record 0 for channel 1 (submodule 2)
- …
- Data record 0 for channel 6 (submodule 7)
- Data record 0 for channel 7 (submodule 8)
- Data record 0 for the reference channel (COMP) (submodule 9)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 0 for channel 0. The structure of channels 1 to 7 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

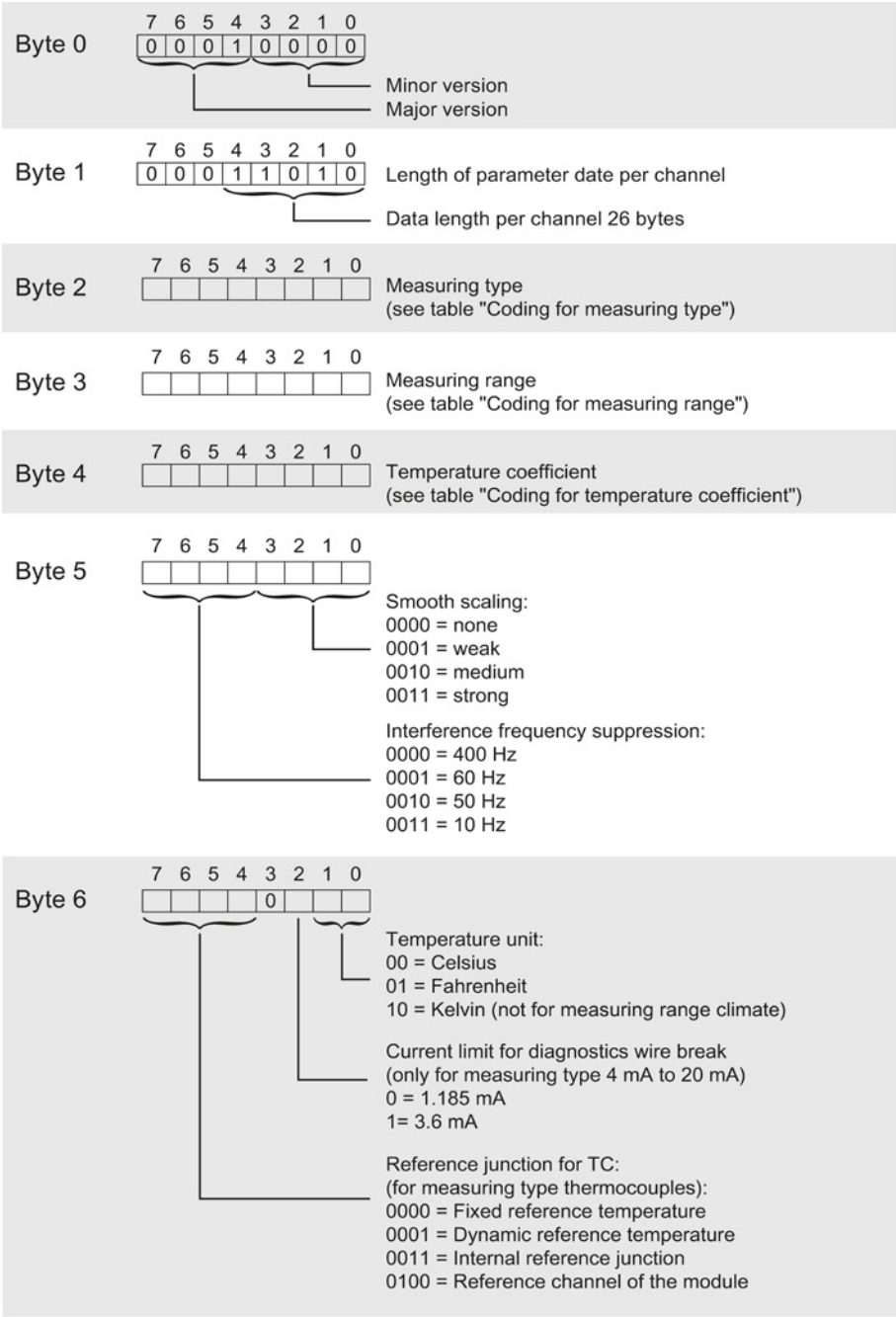
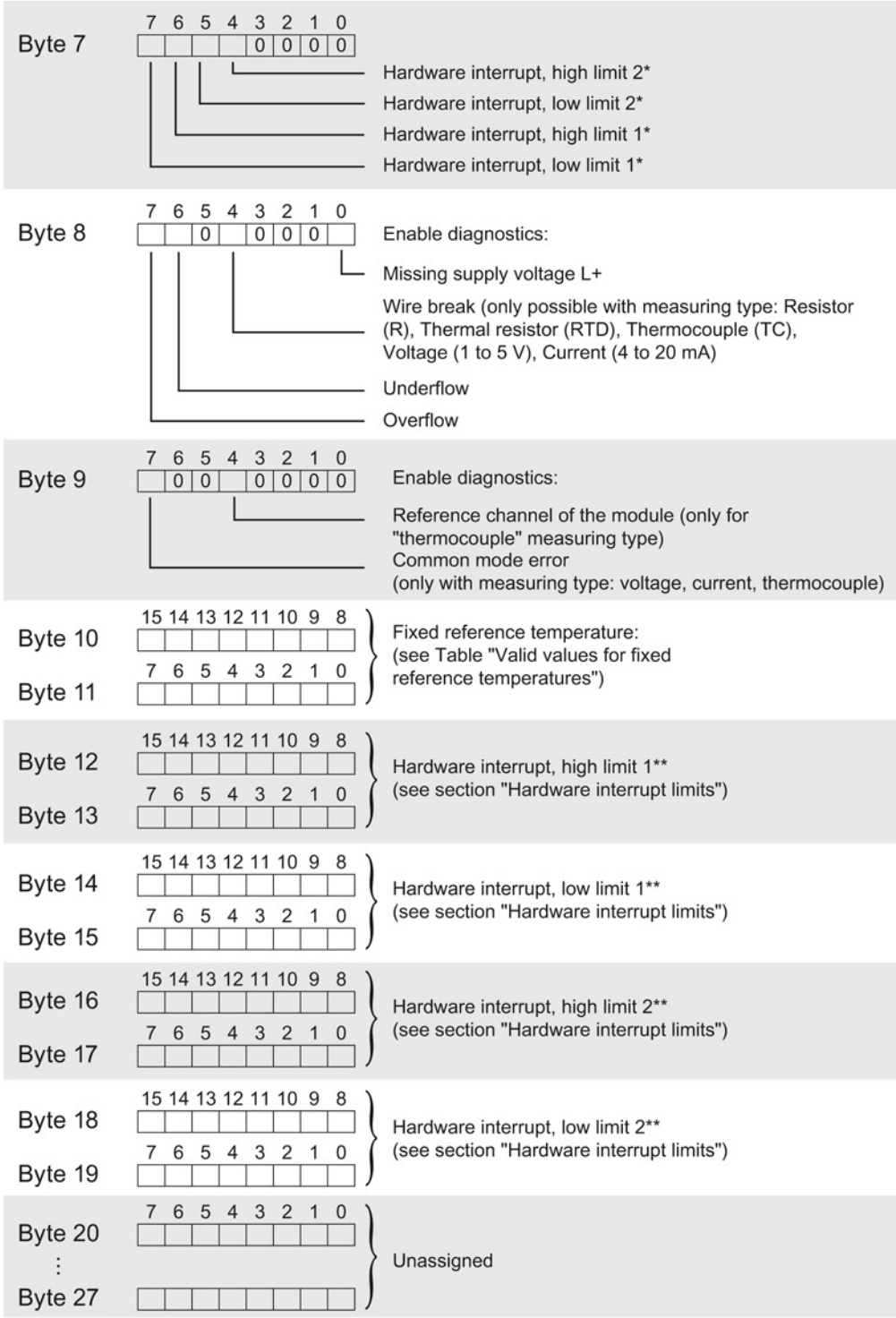


Figure B-1 Structure of data record 0: Bytes 0 to 6



* Enabling the hardware interrupts via data record is only possible when the channel is assigned a hardware interrupt OB in STEP 7

** High limit must be greater than the low limit

Figure B-2 Structure of data record 0: Bytes 7 to 27

Structure of data record 8, reference channel (COMP) of the module

The reference channel compensates for the measured values of channels 0 to 7. The following figure shows the structure of data record 8. Enable a parameter by setting the corresponding bit to "1".

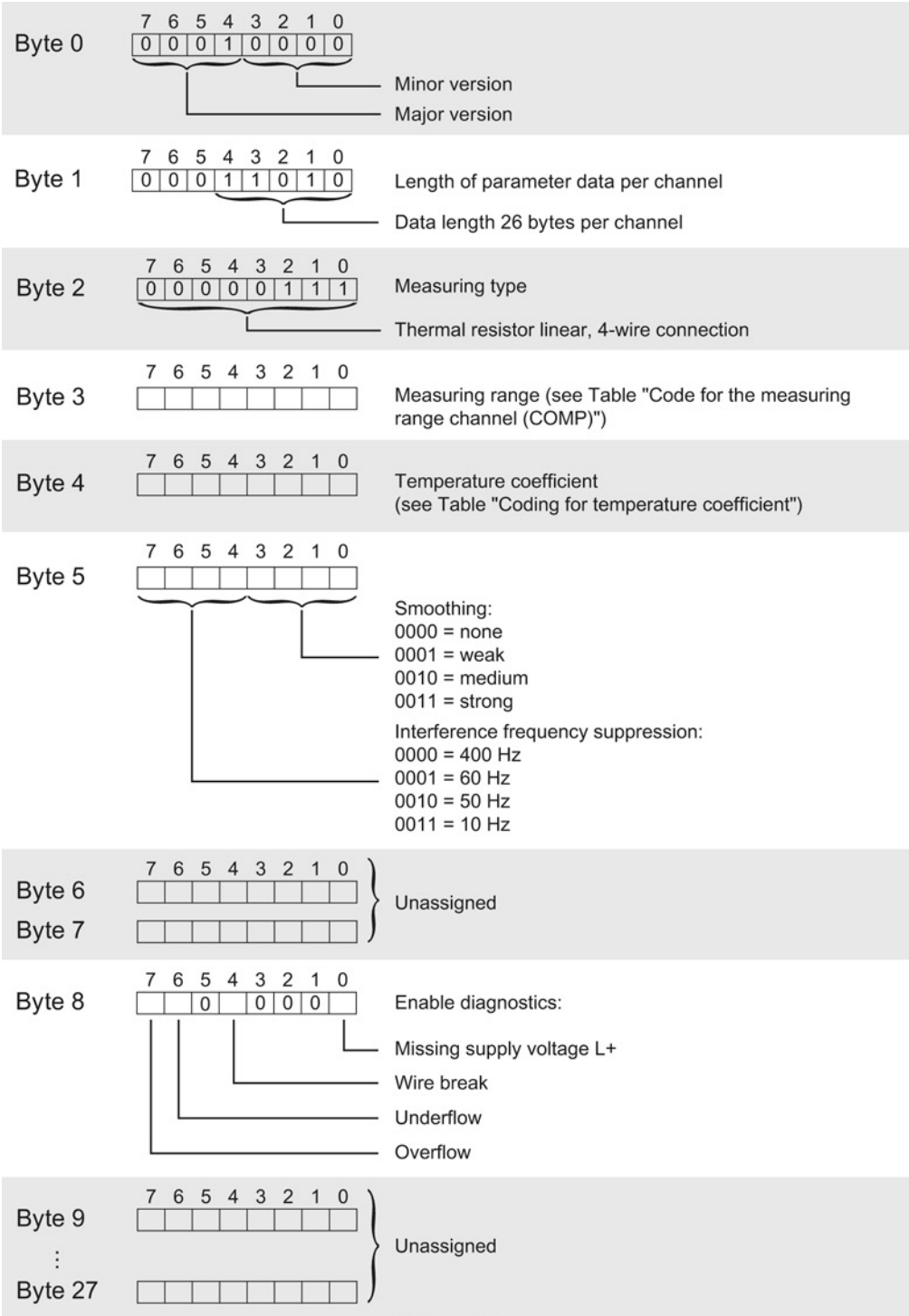


Figure B-3 Structure of data record 8, reference channel of the module: Bytes 0 to 27

Codes for measuring types

The following table lists all measuring types of the analog input module along with their codes. Enter these codes at byte 2 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 27).

Table B- 2 Code for the measuring type

Measuring type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current, 2-wire transmitter	0000 0011
Current, 4-wire transmitter	0000 0010
Resistance, 4-wire connection *) **)	0000 0100
Resistance, 3-wire connection *) **)	0000 0101
Resistance, 2-wire connection *) ***)	0000 0110
Thermal resistor linear, 4-wire connection *)	0000 0111
Thermal resistor linear, 3-wire connection *)	0000 1000
Thermocouple	0000 1010

*) only possible for channels 0, 2, 4 and 6

**) only for the following measuring ranges: 150 Ω, 300 Ω, 600 Ω, 6 kΩ

***) only for measuring range PTC

Special feature for configuration

If you configure one of the following measuring types at one of the channels 0, 2, 4 and 6:

- Resistance, 4-wire connection
- Resistance, 3-wire connection
- Resistance, 2-wire connection
- Thermal resistor linear, 4-wire connection
- Thermal resistor linear, 3-wire connection

then one of the following channels must be disabled.

Example:

You have configured "Resistance, 4-wire connection" at channel 0; channel 1 must be disabled. You have configured "Resistance, 2-wire connection" at channel 2; channel 3 must be disabled.

Codes for measuring ranges

The following table lists all measuring ranges of the analog input module along with their codes. Enter these codes accordingly at byte 3 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 27).

Table B- 3 Code for the measuring range

Measuring range	Code
Voltage	
±50 mV	0000 0001
±80 mV	0000 0010
±250 mV	0000 0011
±500 mV	0000 0100
±1 V	0000 0101
±2.5 V	0000 0111
±5 V	0000 1000
±10 V	0000 1001
1 V to 5 V	0000 1010
Current, 4-wire transmitter	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100
Current, 2-wire transmitter	
4 mA to 20 mA	0000 0011
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
6 kΩ	0000 0101
PTC	0000 1111

Thermal resistor	
Pt100 climate	0000 0000
Ni100 climate	0000 0001
Pt100 standard	0000 0010
Ni100 standard	0000 0011
Pt500 standard	0000 0100
Pt1000 standard	0000 0101
Ni1000 standard	0000 0110
Pt200 climate	0000 0111
Pt500 climate	0000 1000
Pt1000 climate	0000 1001
Ni1000 climate	0000 1010
Pt200 standard	0000 1011
LG-Ni1000 standard	0001 1100
LG-Ni1000 climate	0001 1101
Thermocouple	
B	0000 0000
N	0000 0001
E	0000 0010
R	0000 0011
S	0000 0100
J	0000 0101
T	0000 0111
K	0000 1000

Codes for measuring ranges, reference channel (COMP) of the module

The following table lists all measuring ranges along with their codes for the reference channel (COMP). Enter these codes in byte 3 of data record 8 (see figure Structure of data record 8, reference channel of the module: Bytes 0 to 27).

Table B- 4 Code for the measuring range, reference channel (COMP)

Measuring range	Code
Thermal resistor	
Pt100 climate	0000 0000
Ni100 climate	0000 0001
Pt100 standard	0000 0010
Ni100 standard	0000 0011
Pt500 standard	0000 0100
Pt1000 standard	0000 0101
Ni1000 standard	0000 0110
Pt200 climate	0000 0111
Pt500 climate	0000 1000
Pt1000 climate	0000 1001
Ni1000 climate	0000 1010
Pt200 standard	0000 1011
LG-Ni1000 standard	0001 1100
LG-Ni1000 climate	0001 1101

Codes for temperature coefficients

The following table lists all temperature coefficients along with their codes for temperature measurements with the resistance thermometers. You need to enter these codes in

- byte 4 of data record 8 (see figure, Structure of data record 8, reference channel of the module: bytes 0 to 27) and
- byte 4 of data records 0, 2, 4, 6 and 8 (see figure, Structure of data record 0: Bytes 0 to 6)

Table B- 5 Codes for temperature coefficient

Temperature coefficient	Code
Pt xxx	
0.003851	0000 0000
0.003916	0000 0001
0.003902	0000 0010
0.003920	0000 0011
Ni xxx	
0.006180	0000 1000
0.006720	0000 1001
LG-Ni	
0.005000	0000 1010

Valid values for fixed reference temperatures

The values that you can set for fixed reference temperatures must be in the valid range of values. The resolution is a tenth of a degree.

Table B- 6 Valid values for fixed reference temperatures

Temperature unit	Decimal	Hexadecimal
Celsius (default)	-1450 to 1550	$FA56_H$ to $60E_H$
Fahrenheit (default)	-2290 to 3110	$F70E_H$ to CCC_H
Kelvin (default)	1282 to 3276	502_H to $10BA_H$

Hardware interrupt limits

The values that you can set for hardware interrupts (high/low limit) must not exceed the over/underrange of respective rated measuring range.

The following tables list the valid hardware interrupt limits. The limit values depend on the selected measuring type and range.

Table B- 7 Voltage limits

Voltage		
±50 mV, ±80 mV, ±250 mV, ±500 mV, ±1 V, ±2.5 V, ±5 V, ±10 V	1 V to 5 V	
32510	32510	High limit
-32511	-4863	Low limit

Table B- 8 Current and resistance limits

Current		Resistor	
±20 mA	4 mA to 20 mA / 0 mA to 20 mA	(all configurable measuring ranges)	
32510	32510	32510	High limit
-32511	-4863	1	Low limit

Table B- 9 Limits for thermocouple types B, C, E, and J

Thermocouple									
Type B			Type E			Type J			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	11999	21919	14731	14499	26419	17231	High limit
1	321	2733	-2699	-4539	33	-2099	-3459	633	Low limit

Table B- 10 Limits for thermocouples type K, N, R, and S

Thermocouple									
Type K			Type N			Types R, S			
°C	°F	K	°C	°F	K	°C	°F	K	
16219	29515	18951	15499	28219	18231	20189	32765	22921	High limit
-2699	-4539	33	-2699	-4539	33	-1699	-2739	1033	Low limit

Table B- 11 Limits for thermocouple type T

Thermocouple			
Type T			
°C	°F	K	
5399	10039	8131	High limit
-2699	-4539	33	Low limit

Table B- 12 Limits for resistance thermometer Pt xxx Standard and Pt xxx Climate

Thermal resistor						
Pt xxx standard			Pt xxx climate			
°C	°F	K	°C	°F	K	
9999	18319	12731	15499	31099	---	High limit
-2429	-4539	303	-14499	-22899	---	Low limit

Table B- 13 Limits for resistance thermometer Ni xxx Standard and Ni xxx Climate

Thermal resistor						
Ni xxx Standard			Ni xxx Climate			
°C	°F	K	°C	°F	K	
2949	5629	5681	15499	31099	---	High limit
-1049	-1569	1683	-10499	-15699	---	Low limit

B.2 Structure of a data record for dynamic reference temperature

The **WRREC** instruction is used to transfer the reference junction temperature via data record 192 to data record 199 to the module.

The description of the WRREC instruction can be found in the online help from STEP 7.

Assignment of data record and channel

The following assignment applies if no submodules (1 x 8-channel) are configured for the module:

- Data record 192 for channel 0
- Data record 193 for channel 1
- Data record 194 for channel 2
- Data record 195 for channel 3
- Data record 196 for channel 4
- Data record 197 for channel 5
- Data record 198 for channel 6
- Data record 199 for channel 7

If eight submodules (8 x 1-channel) are configured for the module, each submodule has only one channel. The parameters of the channel are in data record 192.

Background: Each submodule you address for the data record transfer has only one channel.

Structure of data record 192 for dynamic reference temperature

The following figure shows an example of the structure of data record 192 for channel 0. The structure for data records 193 to 199 is identical.

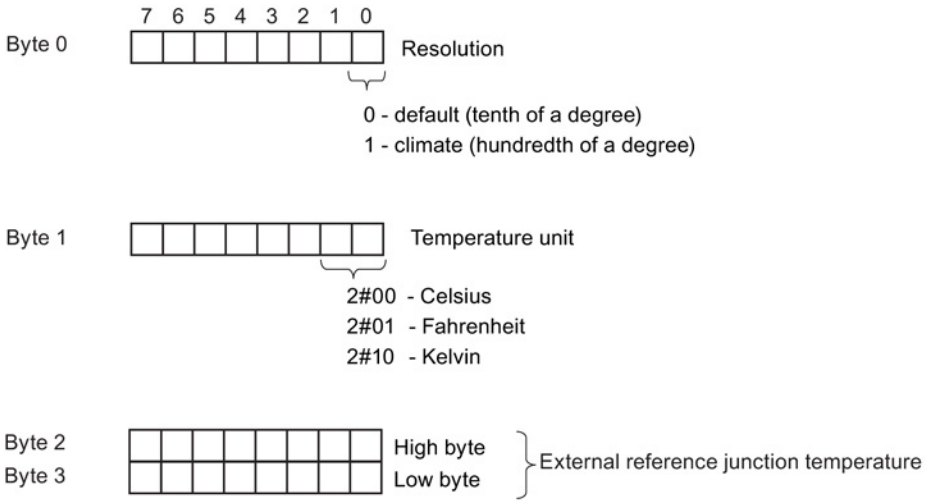


Figure B-4 Structure of data record 192

Valid values for fixed temperature compensation

You can enter the selectable values at byte 1 of the data record for the corresponding channel. The selectable values must lie within the permitted value range, see following table. The resolution is a tenth of a degree.

Table B- 14 Valid values for temperature compensation via data record

Temperature unit	Decimal	Hexadecimal
Celsius (default)	-1450 to 1550	$FA56_H$ to $60E_H$
Fahrenheit (default)	-2290 to 3110	$F70E_H$ to $C26_H$
Kelvin (default)	1282 to 3276	502_H to CCC_H
Celsius (climatic)	-14500 to 15500	$C75C_H$ to $3C8C_H$
Fahrenheit (climatic)	-22900 to 31100	$A68C_H$ to $797C_H$
Kelvin (climatic)	12820 to 32760	3214_H to $7FF8_H$

Additional information

For more information on compensation of the reference junction temperature via data record refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual in the internet.

Representation of analog values

C

Introduction

This chapter shows the analog values for all measuring ranges supported by the AI 8xU/I/RTD/TC ST analog module.

Measured value resolution

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Note

This resolution does not apply to temperature values. The digitalized temperature values are the result of a conversion in the analog module.

Table C- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.1 Representation of input ranges

The following tables set out the digitalized representation of the input ranges by bipolar and unipolar range. The resolution is 16 bits.

Table C- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table C- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Rated range
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Undershoot range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

C.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table C- 4 Voltage measuring ranges ±10 V, ±5 V, ±2.5 V, ±1 V,

Values		Voltage measuring range				Range
dec	hex	±10 V	±5 V	±2.5 V	±1 V	
32767	7FFF	>11.759 V	>5.879 V	>2.940 V	> 1.176 V	Overflow
32511	7EFF	11.759 V	5.879 V	2.940 V	1.176 V	Overshoot range
27649	6C01					
27648	6C00	10 V	5 V	2.5 V	1 V	Rated range
20736	5100	7.5 V	3.75 V	1.875 V	0.75 V	
1	1	361.7 µV	180.8 µV	90.4 µV	36.17 µV	
0	0	0 V	0 V	0 V	0 V	
-1	FFFF					
-20736	AF00	-7.5 V	-3.75 V	-1.875 V	-0.75 V	
-27648	9400	-10 V	-5 V	-2.5 V	-1 V	
-27649	93FF					Undershoot range
-32512	8100	-11.759 V	-5.879 V	-2.940 V	-1.176 V	
-32768	8000	< -11.759 V	< -5.879 V	< -2.940 V	< -1.176 V	Underflow

Table C- 5 Voltage measuring ranges ±500 mV, ±250 mV, ±80 mV, and ±50 mV,

Values		Voltage measuring range				Range
dec	hex	±500 mV	±250 mV	±80 mV	±50 mV	
32767	7FFF	>587.9 mV	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	587.9 mV	294.0 mV	94.1 mV	58.8 mV	Overshoot range
27649	6C01					
27648	6C00	500 mV	250 mV	80 mV	50 mV	Rated range
20736	5100	375 mV	187.5 mV	60 mV	37.5 mA	
1	1	18.08 µV	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	0 mV	
-1	FFFF					
-20736	AF00	-375 mV	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-500 mV	-250 mV	-80 mV	-50 mV	
-27649	93FF					Undershoot range
-32512	8100	-587.9 mV	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-587.9 mV	< -294.0 mV	< -94.1 mV	< -58.8 mV	Underflow

Table C- 6 Voltage measuring range 1 to 5 V

Values		Voltage measuring range	Range
dec	hex	1 to 5 V	
32767	7FFF	>5.704 V	Overflow
32511	7EFF	5.704 V	Overshoot range
27649	6C01		
27648	6C00	5 V	Rated range
20736	5100	4 V	
1	1	1 V + 144.7 µV	
0	0	1 V	
-1	FFFF		Undershoot range
-4864	ED00	0.296 V	
-32768	8000	< 0.296 V	Underflow

C.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table C- 7 Current measuring range ±20 mA

Values		Current measuring range	
dec	hex	±20 mA	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overshoot range
27649	6C01		
27648	6C00	20 mA	Rated range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Undershoot range
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table C- 8 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		
dec	hex	0 to 20 mA	4 to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Rated range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Undershoot range
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<- 3.52 mA	< 1.185 mA	Underflow

C.4 Representation of the analog values of resistance-based sensors/resistance thermometers

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-based sensor ranges.

Table C- 9 Resistance-based sensors of 150 Ω, 300 Ω, 600 Ω, and 6000 Ω

Values		Resistive transmitter range				
dec	hex	150 Ω	300 Ω	600 Ω	6000 Ω	
32767	7FFF	>176.38 Ω	>352.77 Ω	>705.53 Ω	>7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	7055.3 Ω	Overshoot range
27649	6C01					
27648	6C00	150 Ω	300 Ω	600 Ω	6000 Ω	Rated range
20736	5100	112.5 Ω	225 Ω	450 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	

The following tables list the decimal and hexadecimal values (codes) of the supported resistance thermometers.

Table C- 10 Thermal resistors Pt 100, Pt 200, Pt 500 and Pt 1000 Standard

Pt x00 Standard in °C (1 digit = 0.1°C)	Values		Pt x00 Standard in °F (1 digit = 0.1 °F)	Values		Pt x00 Standard in K (1 digit = 0.1 K)	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overshoot range
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Rated range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Undershoot range
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table C- 11 Thermal resistors Pt 100, Pt 200, Pt 500 and Pt 1000 Climate

Pt x00 Climate/ in °C (1 digit = 0.01 °C)	Values		Pt x00 Climate/ in °F (1 digit = 0.01 °F)	Values		Range
	dec	hex		dec	hex	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overshoot range
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Rated range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Undershoot range
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table C- 12 Thermal resistors Ni 100, Ni 1000, LG-Ni 1000 Standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 Standard in °F (1 digit = 0.1 °F)	Values		Ni x00 Standard in K (1 digit = 0.1 K)	Values		Range
	dec	hex		dec	hex		dec	hex	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overshoot range
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Rated range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Undershoot range
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table C- 13 Thermal resistors Ni 100, Ni 1000, LG-Ni 1000 Climate

Ni x00 Climate in °C (1 digit = 0.01 °C)	Values		Ni x00 Climate in °F (1 digit = 0.01 °F)	Values		Range
	dec	hex		dec	hex	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overshoot range
130.00 : -60.00	13000 : -6000	32C8 : E890	266.00 : -76.00	26600 : -7600	67E8 : E250	Rated range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Undershoot range
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

C.5 Representation of analog values for thermocouples

The following tables list the decimal and hexadecimal values (codes) of the supported thermocouples.

Table C- 14 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overshoot range
1820.0 : 250.0	18200 : 2500	4718 : 09C4	2786.5 : 482.0	27865 : 4820	6CD9 : 12D4	2093.2 : 523.2	20932 : 5232	51C4 : 1470	Rated range
249.9 : 0.0	2499 : 0	09C3 : 0	481.9 : 32.0	4819 : 320	12D3 : 0140	523.1 : 273.2	5231 : 2732	1469 : 0AAC	Undershoot range
< 0.0	-32768	8000	< 32.0	-32768	8000	< 273.2	32768	8000	Underflow

Table C- 15 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.2	21920 : 18322	55A0 : 4792	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overshoot range
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 0	12732 : 0	31BC : 0000	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	<0	-32768	8000	Underflow

Table C- 16 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.2	26420 : 21922	6734 : 55A2	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overshoot range
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Rated range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table C- 17 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overshoot range
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 0	16452 : 0	4044 : 0000	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 0	-32768	8000	Underflow

Table C- 18 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.2	28220 : 23722	6E3C : 5CAA	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overshoot range
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 0	15732 : 0	3D74 : 0000	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 0	-32768	8000	Underflow

Table C- 19 Thermocouple type R and S

Type R, S in °C	Values		Type R, S in °F	Values		Types R, S in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.4	32766 : 32164	7FFE : 7DA4	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overshoot range
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Rated range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Undershoot range
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table C- 20 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.2	10040 : 7522	2738 : 1D62	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overshoot range
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

C.6 Measured values for wire break diagnostic

Measured values on diagnostic event "wire break", dependent on diagnostics enables

Error events initiate a diagnostics entry and trigger a diagnostics interrupt if configured accordingly.

Table C- 21 Measured values for wire break diagnostic

Format	Parameter assignment	Measured values		Explanation
S7	• "Wire break" diagnostics enabled • "Overflow/Underflow" diagnostics enabled or disabled ("Wire break" diagnostics takes priority over "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Open circuit" diagnostic alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the undershoot range • Diagnostic alarm "Low limit violated"
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the undershoot range

SIEMENS

SIMATIC

S7-1500 / ET 200MP
CM PtP RS232 BA communication module (6ES7540-1AD00-0AA0)

Manual

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Legal information

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This device manual complements the system manual S7 1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792). General functions of the S7-1500 are described in the S7-1500 Automation System System Manual.

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP automation systems consists of system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation provided for the CM PtP RS232 BA communications module

The following table lists further references that you will need when using the CM PtP RS232 BA communications module.

Table 1- 1 Documentation for the CM PtP RS232 BA communications module

Topic	Documentation	Key content
System description	System manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Addressing • Commissioning • Maintenance
	Power supply manuals (http://support.automation.siemens.com/WW/view/en/59173914)	• Connecting • Interrupt, error and system messages • Technical specifications • Dimensional drawing
	CPU manuals (http://support.automation.siemens.com/WW/view/en/56926947)	
	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Key content
Point-to-point communication	Function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093)	• Basic information • Data transmission functions • Diagnostics functions

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7540-1AD00-0AA0

View of the module

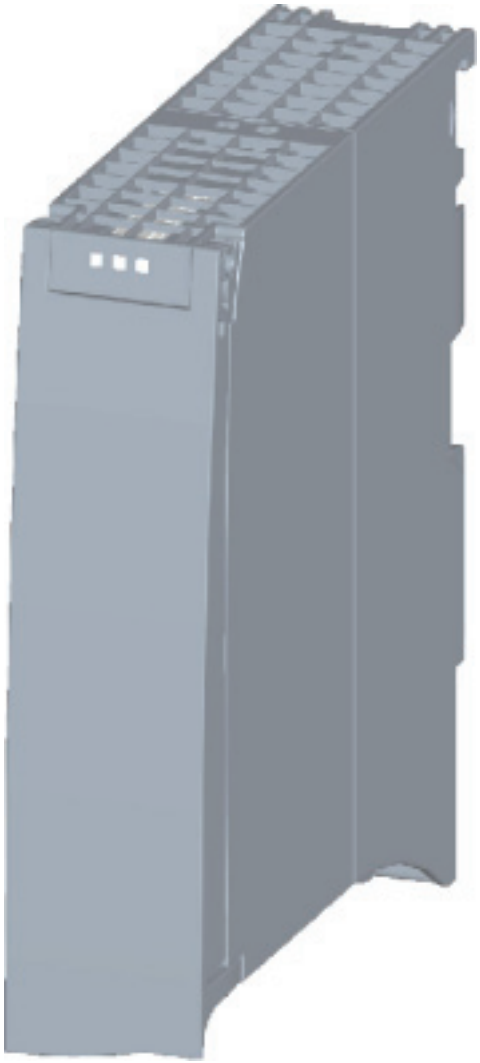


Figure 2-1 CM PtP RS232 BA view

Properties

The communication module has the following properties:

- Technical properties
  - RS232 interface
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Freeport and USS with instructions
- Supported system functions
  - Firmware update
  - Identification data I&M0
  - Parameter re-assignment in CPU RUN mode (using instructions)
  - Diagnostic interrupts

Additional information

Additional information on the properties of the CM PtP RS232 BA can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Information on the properties of the S7-1500 and associated modules can be found in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Accessories

Scope of delivery

The scope of delivery of the communication module includes a U connector for connection to the backplane bus.

Connecting cables

The following connecting cables can be ordered separately in the standard lengths: 5 m, 10 m and 15 m (each with a 9-pin sub D female connector).

Table 2- 1 Order numbers of connecting cables

Connecting cables for CM PtP RS232 BA CM PtP RS232 HF	Type	Order number
RS232 interface	RS232, 5 m	6ES7902–1AB00–0AA0
	RS232, 10 m	6ES7902–1AC00–0AA0
	RS232, 15 m	6ES7902–1AD00–0AA0

Online catalog

Additional order numbers for S7-1500 can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

2.3 Functions

Introduction

The communication module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP RS232 BA

The CM PtP RS232 BA communications module offers the following functionality:

- RS232 interface
- Data transmission rate: 300 to 19200 bps
- Maximum frame length: 1 kbyte
- Transmission protocols: Freeport and 3964(R)

Note

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP RS232 BA.

Components	Function
CPU module Accessories: Memory card	... executes the user program.
CM PtP RS232 BA communications module	... communicates with a communication partner (point-to-point) by means of the interface.
Connecting cable	... connects the CM PtP RS232 BA communications module with the communication partner.
U connector	... provides the mechanical and electrical connection between the modules.
Optional: Power supply module (PS)	... converts the line voltage (120/230V AC or 24V DC) into the operating voltage required to supply the S7-1500.

System environment

The communication module can be used in the following system environments:

Applications	Components required	Configuration
Central operation in an S7-1500 system	• CPU 151x • CM PtP RS232 BA • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-1500 system	• CPU 151x • IM 155-5 • CM PtP RS232 BA • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-300/400 system	• CPU 31x / CPU 41x • IM 155-5 • CM PtP RS232 BA	STEP 7 (TIA Portal) STEP 7 with integration of a GSD file
Distributed operation in a third-party system	• Third-party programmable controller • IM 155-5 • CM PtP RS232 BA	GSD file imported to/installed in the engineering system [1)]

1) Information on using the communication module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

Information on configuration and programming of the CM PtP RS232 BA communications module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the information system of the TIA Portal.

2.4 Properties of the RS232 interface

Definition

The RS232 interface is a voltage interface used for serial data transmission.

Properties

Table 2- 2 The RS232 interface has the following properties and meets the following requirements:

Type	Voltage interface
Front connector	9-pin sub-D male connector with screw lock
RS232 signals	TXD, RXD, RTS, CTS, DTR, DSR, RI, DCD, GND; all signals isolated against the backplane bus and load voltage
Max. data transmission rate	19.2 kbps
max. cable length	15 m, cable type LIYCY 9 x 0.14
Standard	DIN 66020, DIN 66259, EIA-RS 232C, CCITT V.24/V.28

RS232 signals

Table 2- 3 The table below shows the meaning of the individual RS232 accompanying signals.

Signal	Designation	Meaning
TXD	Transmit Data	Transmit data; transmit cable logically held to "1" by communication module in idle state.
RXD	Receive Data	Receive data; receive cable logically held to "1" by communication partner in idle state.
RTS	Request To Send	Request to send RTS set to "ON": Communication module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communication module not ready to send
CTS	Clear To Send	Clear to send CTS set to "ON": Signals "clear to send" to the communication partner CTS set to "OFF": Signals "Not clear to send" to the communication partner
DTR	Data Terminal Ready	DTR set to "ON": Communications module switched on, ready for operation DTR set to "OFF": Communications module not switched on, not ready for operation
DSR	Data Set Ready	DSR set to "ON": Communication partner signals "ready for operation" DSR set to "OFF": Communication partner not switched on, not ready for operation
RI	Ring Indicator	Incoming call when connecting a modem
DCD	Data Carrier Detect	Carrier signal when connecting a modem. The communication partner signals with a high level that it detects incoming data on the cable.

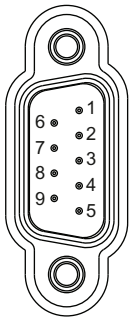
Connecting 3

3.1 RS232 interface of the communications module

Terminal assignment

The table below shows the terminal assignment for the 9-pin sub D male connector in the front panel of the communications module.

Table 3- 1 Terminal assignment for the sub D male connector of the integrated interface of the communications module

Male connector of the communications module	Pin	Designation	Input/output	Meaning
	1	DCD Data Carrier Detect	Input	Received signal level
	2	RXD Receive Data	Input	Receive data
	3	TXD Transmit Data	Output	Transmit data
	4	DTR Data Terminal Ready	Output	Data terminal ready
	5	GND Ground	-	Functional ground (isolated)
	6	DSR Data Set Ready	Input	Data set ready
	7	RTS Request To Send	Output	Request to send
	8	CTS Clear To Send	Input	Clear to send
	9	RI Ring Indicator	Input	Incoming call
* View from the front				

Connecting cables

Standard connecting cables of various lengths (see chapter Accessories (Page 11)) are available for connection with a communication partner which also has a 9-pin sub-D male connector.

Please note that you must only use shielded connector casings and cables. A large surface area of the cable shield must be in contact with the connector casing on both sides.

NOTICE
Never connect the cable shield with the GND, as this could destroy the interfaces. GND must always be connected on both sides (pin 5), otherwise the modules could be destroyed.

3.2 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)).

The cable shield must be installed on a grounding rail to maintain the EMC values (electromagnetic compatibility).

Parameters/Address space 4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 (TIA Portal V12 or later) or with STEP 7 with integration of a GSD file.

Additional information

The device manual of the communication module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the TIA Portal information system.

There you will find information on the following topics:

- Operating modes
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames in the receive buffer are retained. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

4.3 Address space

Address space of the communication module

The input addresses of the communications module total 8 bytes. The input addresses are automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal). Output addresses are not required.

Hardware identification (not freely configurable)

The hardware identification (HW ID) is automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal).

The hardware ID is issued along with the diagnostic messages to localize the module. In addition, the HW identification is required for S7-1500 at the communication instructions in order to identify the communication module. For S7-300/400, the communication module is identified by the start address of the input data.

Programming 5

Overview of the instructions

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules. The instructions process the exchange of data between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place asynchronously across several cycles.

The transmission protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Instruction	Meaning
Port_Config	You use the Port_Config instruction to dynamically assign basic interface parameters.
Send_Config	You use the Send_Config (send configuration) instruction to dynamically assign serial send parameters of a port.
Receive_Config	You use the Receive_Config (receive configuration) instruction to dynamically assign serial receive parameters of a port.
P3964_Config	You use the P3964_Config (protocol configuration) instruction to dynamically assign the parameters of the 3964(R) procedure.
Send_P2P	You use the Send_P2P instruction to send data to a communication partner.
Receive_P2P	You use the Receive_P2P instruction to receive data from a communication partner.
Receive_Reset	You use the Receive_Reset instruction to delete the receive buffer of the communication module.
Signal_Get	You use the Signal_Get instruction to read the RS232 accompanying signals.
Signal_Set	You use the Signal_Set instruction to set the RS232 accompanying signals.
Get_Features	You use the Get_Features instruction to read expanded functions supported by the communication module.
Set_Features	You use the Set_Features instruction to set expanded functions supported by the communication module.
USS_Port_Scan	You use the USS_Port_Scan instruction to communicate via the USS network.
USS_Drive_Control	You use the USS_Drive_Control instruction to exchange data with a drive.
USS_Read_Param	You use the USS_Read_Param instruction to read parameters from the drive.
USS_Write_Param	You use the USS_Write_Param instruction to change parameters in the drive.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

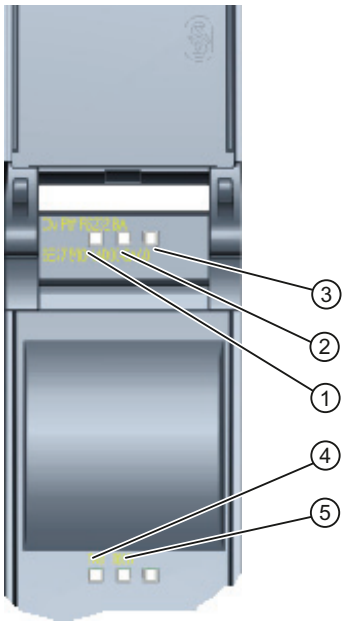
Additional Information on programming the communication modules is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the TIA Portal information system.

Error and system messages

6

LED displays of the communication module

The figure below shows the LED displays of the CM PtP RS232 BA communication module with open front panel.



① LED display RUN
② LED display ERROR
③ LED display MAINT
④ LED display TXD
⑤ LED display RXD

Figure 6-1 CM PtP RS232 BA view

Meaning of the LED displays for RUN/ERROR/(MAINT)

LED			Meaning	Solution
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage not present or too low at communication module	Check the power supply of the station.
Flashes	Off	Off	CM in startup, parameters not assigned yet	---
On	Off	Off	CM configured and ready for operation	---
Off	Flashes	Off	Group error (at least one error pending)	Evaluate the diagnostics data and eliminate the error. [1]

1) Information on startup and diagnostics of the communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Meaning of LED displays for TXD/RXD (under the front panel)

LED		Meaning	Solution
TXD	RXD		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

Technical specifications 7

	6ES7540-1AD00-0AA0
Product type designation	CM PtP RS232 BA
General information	
• I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP2 or higher with a GSD file
PROFIBUS as of GSD version/GSD revision	- / -
PROFINET as of GSD version/GSD revision	V2.3
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Voltage type of supply voltage	System power supply
Input current	
• Current consumption (rated value)	35 mA; from backplane bus
Power	
• Power from the backplane bus	0.65 W
Power loss	
• Power loss, typ.	0.6 W
Address area	
Occupied address area	
• Inputs	8 bytes
Interfaces	
1. Interface	
Interface hardware	
• RS 232	Yes
Interface hardware	
RS 232	
• Transmission rate, max.	19.2 kbps
• Max. cable length	15 m
RS-232 accompanying signals	RTS, CTS, DTR, DSR, RI, DCD

	6ES7540-1AD00-0AA0
Protocols	
Integrated protocols	
Freeport	
• Frame length, max.	1 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
3964 (R)	
• Frame length, max.	1 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
Frame buffer	
• Buffer memory for frames	2 kbyte
• Number of frames which can be buffered	255
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes
• Wire break	Yes
Diagnostics display LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Receive RxD	Yes; yellow LED
• Send TxD	Yes; yellow LED
Electrical isolation	
• between backplane bus and interface	Yes
Insulation	
Insulation tested with	707 V DC (Type Test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C

	6ES7540-1AD00-0AA0
Distributed operation	
• At SIMATIC S7-300	Yes
• At SIMATIC S7-400	Yes
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes
• Supports Fast Startup	Yes
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	127 mm
Weights	
• Weight, approx.	0.22 kg

Additional general technical specifications for SIMATIC S7-1500 are available in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Dimensional drawing

A

The dimensional drawing of the communications module installed on a mounting rail and a dimensional drawing with open front panel are provided in the appendix. Always observe the specified dimensions for installations in cabinets, control rooms, etc.

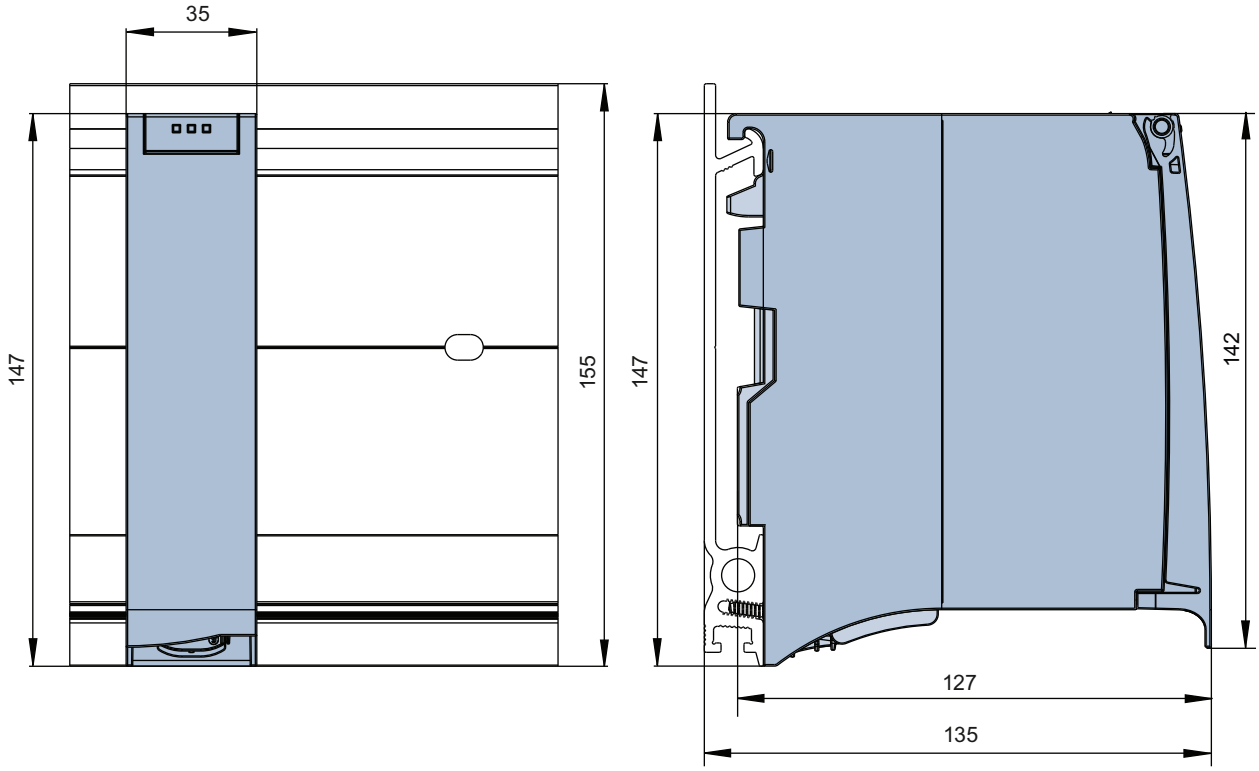


Figure A-1 Dimensional drawing of the CM PtP RS232 BA communications module

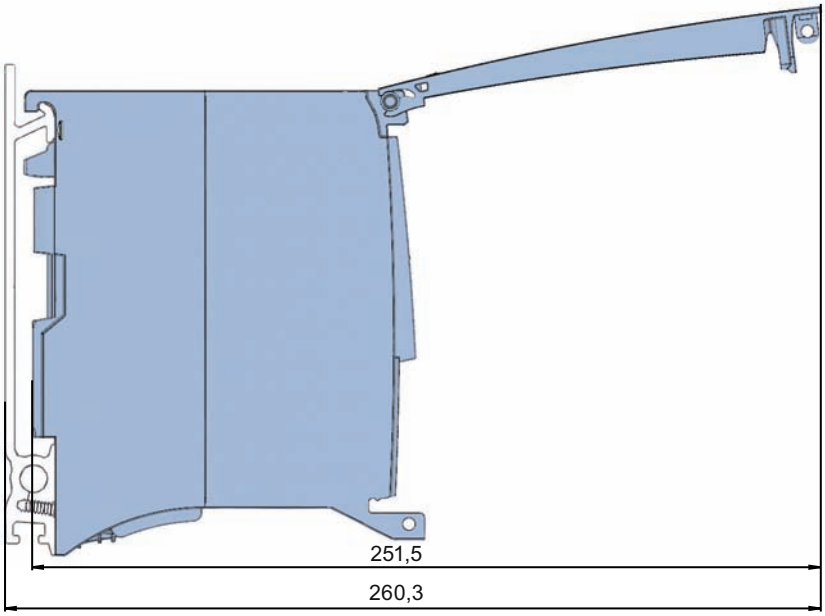


Figure A-2 Dimensional drawing of the CM PtP RS232 BA communications module with open front panel

SIEMENS

SIMATIC

S7-1500/ET 200MP CM PtP RS232 HF (6ES7541-1AD00-0AB0) communication module

Manual

Preface

Documentation guide 1

Product overview 2

Connecting 3

Parameters/address space 4

Programming 5

Error and system messages 6

Technical specifications 7

Dimensional drawing A

01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This device manual complements the system manual S7 1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792). General functions of the S7-1500 are described in the S7-1500 Automation System System Manual.

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP automation systems consists of system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation provided for the CM PtP RS232 HF communication module

The following table lists additional references that you will need when using the CM PtP RS232 HF communication module.

Table 1- 1 Documentation for the CM PtP RS232 HF communication module

Topic	Documentation	Key content
System description	System manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Addressing • Commissioning • Maintenance
	Power supply manuals (http://support.automation.siemens.com/WW/view/en/59173914)	• Connecting • Interrupt, error and system messages • Technical specifications • Dimensional drawing
	CPU manuals (http://support.automation.siemens.com/WW/view/en/56926947)	
	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Key content
Point-to-point communication	Function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093)	• Basic information • Data transmission functions • Diagnostics functions

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7541-1AD00-0AB0

View of the module

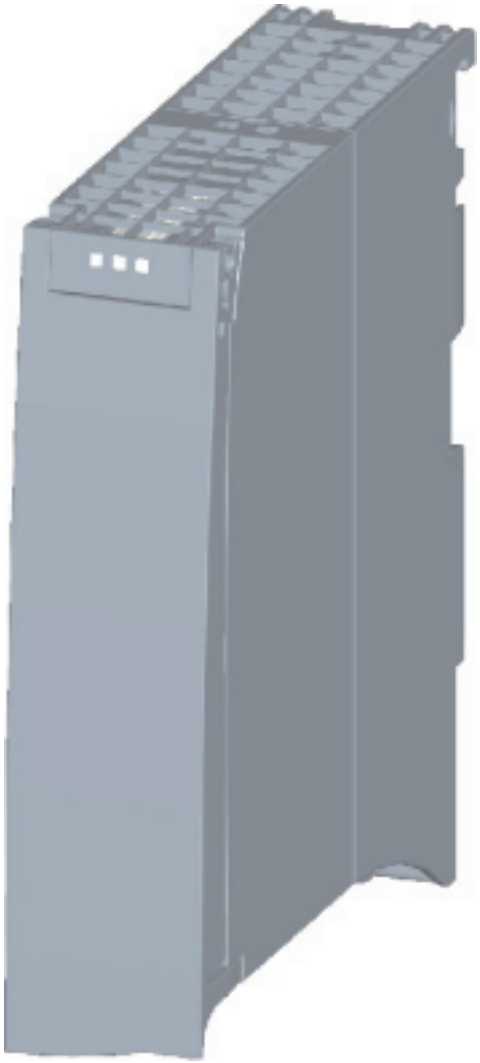


Figure 2-1 CM PtP RS232 HF view

Properties

The communication module has the following properties:

- Technical properties
  - RS232 interface
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Modbus master (RTU), Modbus slave (RTU), Freeport and USS with instructions
- Supported system functions
  - Firmware update
  - Identification data I&M0
  - Parameter re-assignment in CPU RUN mode (using instructions)
  - Diagnostic interrupts

Additional information

Additional information on the properties of the CM PtP RS232 HF can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Information on the properties of the S7-1500 and associated modules can be found in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Accessories

Scope of delivery

The scope of delivery of the communication module includes a U connector for connection to the backplane bus.

Connecting cables

The following connecting cables can be ordered separately in the standard lengths: 5 m, 10 m and 15 m (each with a 9-pin sub D female connector).

Table 2- 1 Order numbers of connecting cables

Connecting cables for CM PtP RS232 BA CM PtP RS232 HF	Type	Order number
RS232 interface	RS232, 5 m	6ES7902–1AB00–0AA0
	RS232, 10 m	6ES7902–1AC00–0AA0
	RS232, 15 m	6ES7902–1AD00–0AA0

Online catalog

Additional order numbers for S7-1500 can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

2.3 Functions

Introduction

The communication module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP RS232 HF

The CM PtP RS232 HF communication module offers the following functionality:

- RS232 interface
- Data transmission rate: 300 to 115200 bps
- Maximum frame length: 4 kbyte
- Transmission protocols: Freeport, 3964(R) and Modbus

Note

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP RS232 HF.

Components	Function
CPU module Accessories: Memory card	... executes the user program.
CM PtP RS232 HF communication module	... communicates with a communication partner (point-to-point) by means of the interface.
Connecting cable	... connects the CM PtP RS232 HF communication module with the communication partner.
U connector	... provides the mechanical and electrical connection between the modules.
Optional: Power supply module (PS)	... converts the line voltage (120/230V AC or 24V DC) into the operating voltage required to supply the S7-1500.

System environment

The communication module can be used in the following system environments:

Applications	Components required	Configuration
Central operation in an S7-1500 system	• CPU 151x • CM PtP RS232 HF • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-1500 system	• CPU 151x • IM 155-5 • CM PtP RS232 HF • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-300/400 system	• CPU 31x / CPU 41x • IM 155-5 • CM PtP RS232 HF	STEP 7 (TIA Portal) STEP 7 with integration of a GSD file
Distributed operation in a third-party system	• Third-party programmable controller • IM 155-5 • CM PtP RS232 HF	GSD file imported to/installed in the engineering system [1)]

1) Information on using the communication module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

Information on configuring and programming the CM PtP RS232 HF communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

2.4 Properties of the RS232 interface

Definition

The RS232 interface is a voltage interface used for serial data transmission.

Properties

The RS232 interface has the following properties and meets the following requirements:

Type	Voltage interface
Front connector	9-pin sub-D male connector with screw lock
RS232 signals	TXD, RXD, RTS, CTS, DTR, DSR, RI, DCD, GND; all signals isolated against the backplane bus and load voltage
Max. data transmission rate	115.2 kbps
max. cable length	15 m, cable type LIYCY 9 x 0.14
Standard	DIN 66020, DIN 66259, EIA-RS 232C, CCITT V.24/V.28

RS232 signals

The table below shows the meaning of the individual RS232 accompanying signals.

Table 2- 2 Signals of the RS232 interface

Signal	Designation	Meaning
TXD	Transmit Data	Transmit data; transmit cable logically held to "1" by communication module in idle state.
RXD	Receive Data	Receive data; receive cable logically held to "1" by communication partner in idle state.
RTS	Request To Send	Request to send RTS set to "ON": Communication module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communication module not ready to send
CTS	Clear To Send	Clear to send CTS set to "ON": Signals "clear to send" to the communication partner CTS set to "OFF": Signals "Not clear to send" to the communication partner
DTR	Data Terminal Ready	DTR set to "ON": Communications module switched on, ready for operation DTR set to "OFF": Communications module not switched on, not ready for operation
DSR	Data Set Ready	DSR set to "ON": Communication partner signals "ready for operation" DSR set to "OFF": Communication partner not switched on, not ready for operation
RI	Ring Indicator	Incoming call when connecting a modem
DCD	Data Carrier Detect	Carrier signal when connecting a modem. The communication partner signals with a high level that it detects incoming data on the cable.

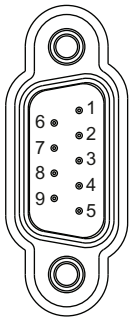
Connecting 3

3.1 RS232 interface of the communications module

Terminal assignment

The table below shows the terminal assignment for the 9-pin sub D male connector in the front panel of the communications module.

Table 3- 1 Terminal assignment for the sub D male connector of the integrated interface of the communications module

Male connector of the communications module	Pin	Designation	Input/output	Meaning
	1	DCD Data Carrier Detect	Input	Received signal level
	2	RXD Receive Data	Input	Receive data
	3	TXD Transmit Data	Output	Transmit data
	4	DTR Data Terminal Ready	Output	Data terminal ready
	5	GND Ground	-	Functional ground (isolated)
	6	DSR Data Set Ready	Input	Data set ready
	7	RTS Request To Send	Output	Request to send
	8	CTS Clear To Send	Input	Clear to send
	9	RI Ring Indicator	Input	Incoming call
* View from the front				

Connecting cables

Standard connecting cables of various lengths (see chapter Accessories (Page 11)) are available for connection with a communication partner which also has a 9-pin sub-D male connector.

Please note that you must only use shielded connector casings and cables. A large surface area of the cable shield must be in contact with the connector casing on both sides.

NOTICE
Never connect the cable shield with the GND, as this could destroy the interfaces. GND must always be connected on both sides (pin 5), otherwise the modules could be destroyed.

3.2 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)).

The cable shield must be installed on a grounding rail to maintain the EMC values (electromagnetic compatibility).

Parameters/address space 4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 (TIA Portal V12 or later) or with STEP 7 with integration of a GSD file.

Additional information

The device manual of the communication module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the TIA Portal information system.

There you will find information on the following topics:

- Operating modes
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames in the receive buffer are retained. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

4.3 Address space

Address space of the communication module

The input addresses of the communications module total 8 bytes. The input addresses are automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal). Output addresses are not required.

Hardware identification (not freely configurable)

The hardware identification (HW ID) is automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal).

The hardware ID is issued along with the diagnostic messages to localize the module. In addition, the HW identification is required for S7-1500 at the communication instructions in order to identify the communication module. For S7-300/400, the communication module is identified by the start address of the input data.

Programming 5

Overview of the instructions

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules. The instructions process the exchange of data between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place asynchronously across several cycles.

The transmission protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Instruction	Meaning
Port_Config	You use the Port_Config instruction to dynamically assign basic interface parameters.
Send_Config	You use the Send_Config (send configuration) instruction to dynamically assign serial send parameters of a port.
Receive_Config	You use the Receive_Config (receive configuration) instruction to dynamically assign serial receive parameters of a port.
P3964_Config	You use the P3964_Config (protocol configuration) instruction to dynamically assign the parameters of the 3964(R) procedure.
Send_P2P	You use the Send_P2P instruction to send data to a communication partner.
Receive_P2P	You use the Receive_P2P instruction to receive data from a communication partner.
Receive_Reset	You use the Receive_Reset instruction to delete the receive buffer of the communication module.
Signal_Get	You use the Signal_Get instruction to read the RS232 accompanying signals.
Signal_Set	You use the Signal_Set instruction to set the RS232 accompanying signals.
Get_Features	You use the Get_Features instruction to read expanded functions supported by the communication module.
Set_Features	You use the Set_Features instruction to set expanded functions supported by the communication module.
USS_Port_Scan	You use the USS_Port_Scan instruction to communicate via the USS network.
USS_Drive_Control	You use the USS_Drive_Control instruction to exchange data with a drive.
USS_Read_Param	You use the USS_Read_Param instruction to read parameters from the drive.
USS_Write_Param	You use the USS_Write_Param instruction to change parameters in the drive.
Modbus_Comm_Load	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU.

Instruction	Meaning
Modbus_Master	The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

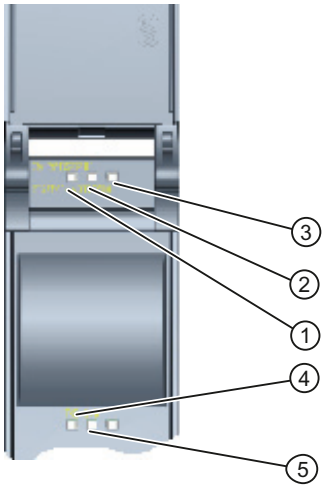
Additional information on programming the communication modules is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the TIA Portal information system.

Error and system messages

6

LED displays of the communication module

The figure below shows the LED displays of the CM PtP RS232 HF communication module with open front panel.



① LED display RUN
② LED display ERROR
③ LED display MAINT
④ LED display TXD
⑤ LED display RXD

Figure 6-1 CM PtP RS232 HF view

Meaning of the LED displays for RUN/ERROR/(MAINT)

LED			Meaning	Solution
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage not present or too low at communication module	Check the power supply of the station.
Flashes	Off	Off	CM in startup, parameters not assigned yet	---
On	Off	Off	CM configured and ready for operation	---
Off	Flashes	Off	Group error (at least one error pending)	Evaluate the diagnostics data and eliminate the error. [1)]

1) Information on startup and diagnostics of the communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Meaning of LED displays for TXD/RXD (under the front panel)

LED		Meaning	Solution
TXD	RXD		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

Technical specifications 7

	6ES7541-1AD00-0AB0
Product type designation	CM PtP RS232 HF
General information	
• I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP2 or higher with a GSD file
PROFIBUS as of GSD version/GSD revision	- / -
PROFINET as of GSD version/GSD revision	V2.3
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Voltage type of supply voltage	System power supply
Input current	
• Current consumption (rated value)	35 mA; from backplane bus
Power	
• Power from the backplane bus	0.65 W
Power loss	
• Power loss, typ.	0.6 W
Address area	
Occupied address area	
• Inputs	8 bytes
Interfaces	
1. Interface	
Interface hardware	
• RS 232	Yes
Interface hardware	
RS 232	
• Transmission rate, max.	115.2 kbps
• Max. cable length	15 m
RS-232 accompanying signals	RTS, CTS, DTR, DSR, RI, DCD
Protocols	
Integrated protocols	
Freeport	

	6ES7541-1AD00-0AB0
• Frame length, max.	4 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
3964 (R)	
• Frame length, max.	4 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
Modbus RTU master	
Address area	1 to 247, extended 1 to 65,535
• Max. number of slaves	1
Modbus RTU slave	
Address area	1 to 247, extended 1 to 65,535
Frame buffer	
• Buffer memory for frames	8 kbyte
• Number of frames which can be buffered	255
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes
• Wire break	Yes
Diagnostics display LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Receive RxD	Yes; yellow LED
• Send TxD	Yes; yellow LED
Electrical isolation	
• between backplane bus and interface	Yes
Insulation	
Insulation tested with	707 V DC (Type Test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C

	6ES7541-1AD00-0AB0
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C
Distributed operation	
• At SIMATIC S7-300	Yes
• At SIMATIC S7-400	Yes
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes
• Supports Fast Startup	Yes
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	127 mm
Weights	
• Weight, approx.	0.22 kg

Additional general technical specifications for SIMATIC S7-1500 are available in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Dimensional drawing

A

This appendix contains the dimensional drawing of the communication module installed on a mounting rail and with a shield bracket. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

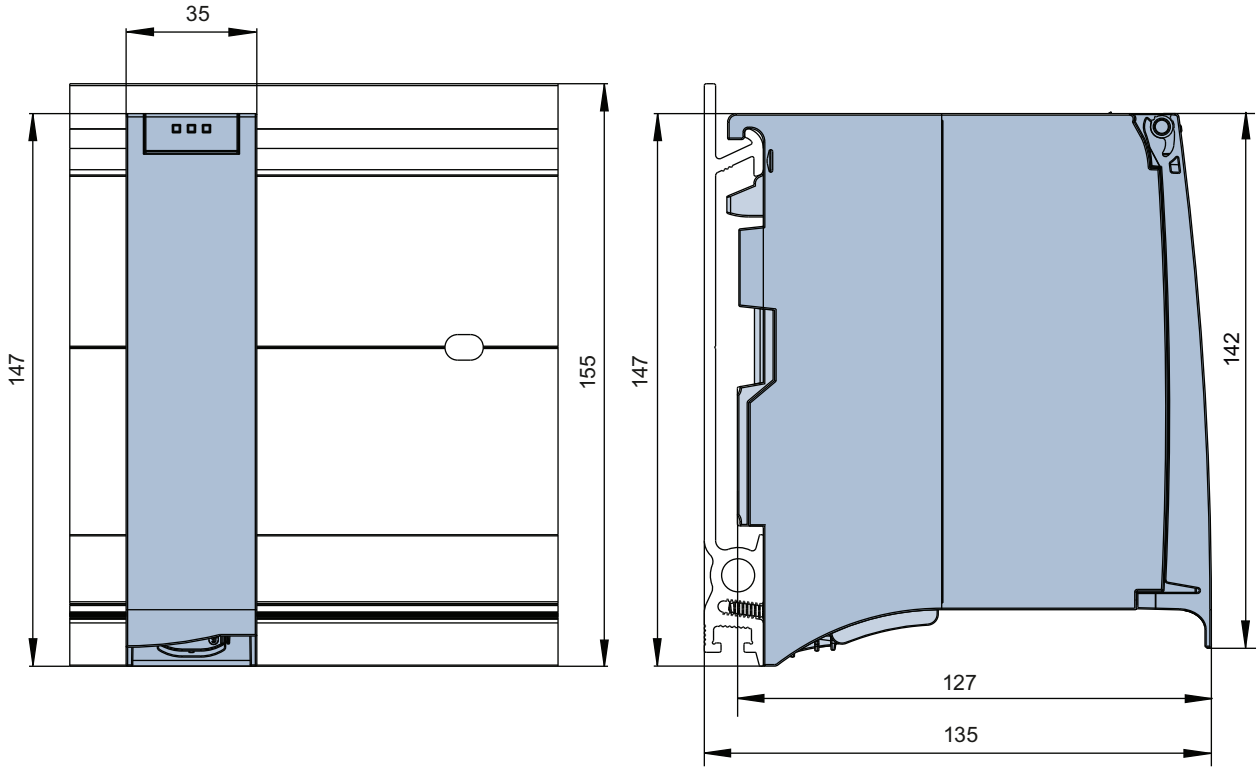


Figure A-1 Dimensional drawing of the CM PtP RS232 HF communication module

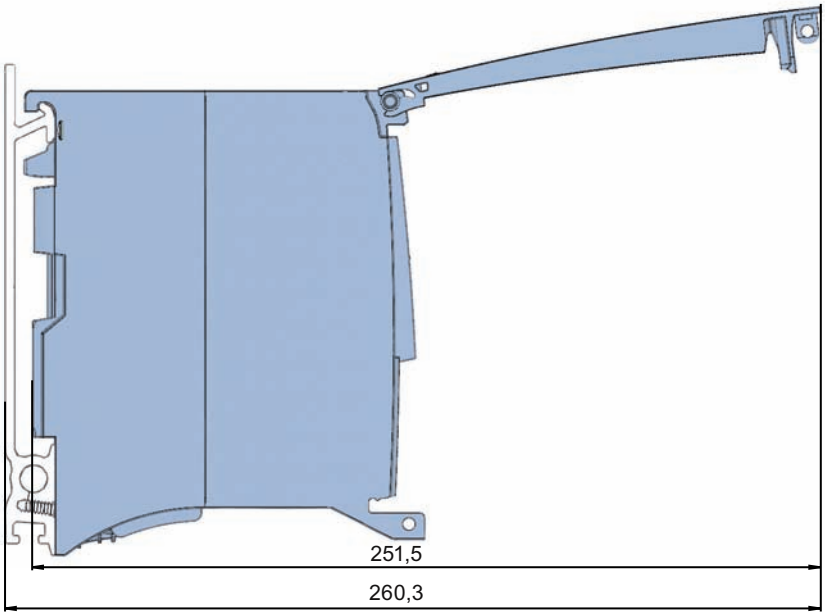


Figure A-2 Dimensional drawing of the CM PtP RS232 HF communication module with open front panel

SIEMENS

SIMATIC

S7-1500/ET 200MP CM PtP RS422/485 BA communication module (6ES7540-1AB00-0AA0)

Manual

Preface

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Product overview 2

Connecting 3

Parameters/address space 4

Programming 5

Error and system messages 6

Technical specifications 7

Dimensional drawing A

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This device manual complements the system manual S7 1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792). General functions of the S7-1500 are described in the S7-1500 Automation System System Manual.

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP automation systems consists of system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation provided for the CM PtP RS422/485 BA communication module

The following table lists additional references that you will need when using the CM PtP RS422/485 BA communication module.

Table 1- 1 Documentation for the CM PtP RS422/485 BA communication module

Topic	Documentation	Key content
System description	System manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Addressing • Commissioning • Maintenance
	Power supply manuals (http://support.automation.siemens.com/WW/view/en/59173914)	• Connecting • Interrupt, error and system messages • Technical specifications • Dimensional drawing
	CPU manuals (http://support.automation.siemens.com/WW/view/en/56926947)	
	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Key content
Point-to-point communication	Function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093)	• Basic information • Data transmission functions • Diagnostics functions

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7540-1AB00-0AA0

View of the module

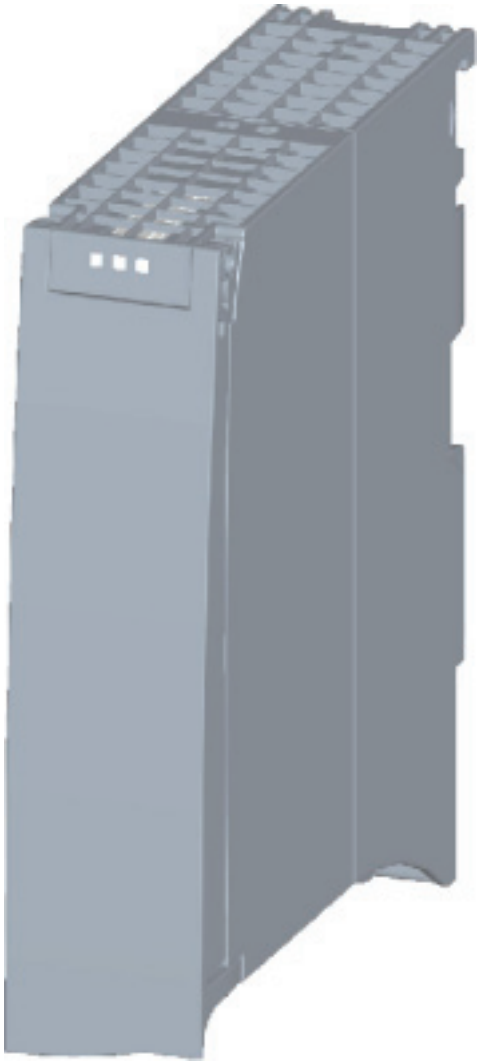


Figure 2-1 CM PtP RS422/485 BA view

Properties

The communication module has the following properties:

- Technical properties
  - RS422/485 interface
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Freeport and USS with instructions
- Supported system functions
  - Firmware update
  - Identification data I&M0
  - Parameter re-assignment in CPU RUN mode (using instructions)
  - Diagnostic interrupts

Additional information

Additional information on the properties of the CM PtP RS422/485 BA can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Additional information on the properties of the S7-1500 and associated modules can be found in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Accessories

Scope of delivery

The scope of delivery of the communication module includes a U connector for connection to the backplane bus.

Connecting cables

Connecting cables are available in the standard lengths: 5 m, 10 m and 50 m (each with a 15-pin sub D connector).

Table 2- 1 Order numbers of connecting cables

Connecting cables for CM PtP RS422/485 BA CM PtP RS422/485 HF	Type	Order number
X27 interface (RS422/485)	X27 (RS 422), 5 m	6ES7902–3AB00–0AA0
	X27 (RS 422), 10 m	6ES7902–3AC00–0AA0
	X27 (RS 422), 50 m	6ES7902–3AG00–0AA0

Online catalog

Additional order numbers for S7-1500 can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

2.3 Functions

Introduction

The communication module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP RS422/485 BA

The CM PtP RS422/485 BA communication module offers the following functionality:

- RS422/485 interface
- Data transmission rate: 300 to 19200 bps
- Maximum frame length: 1 kbyte
- Transmission protocols: Freeport and 3964(R)

Note

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP RS422/485 BA.

Components	Function
Central processor unit (CPU) Accessories: Memory card	... executes the user program.
CM PtP RS422/485 BA communication module	... communicates with a communication partner (point-to-point) by means of the interface.
Connecting cable	... connects the CM PtP RS422/485 BA communication module with the communication partner.
U connector	... provides the mechanical and electrical connection between the modules.
Optional: Power supply module (PS)	... converts the line voltage (120/230 VAC or 24 VDC) into the operating voltage of 15 VDC required for supply of the S7-1500.

System environment

The communication module can be used in the following system environments:

Applications	Components required	Configuration
Central operation in an S7-1500 system	• CPU 151x • CM PtP RS422/485 BA • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-1500 system	• CPU 151x • IM 155-5 • CM PtP RS422/485 BA • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-300/400 system	• CPU 31x / CPU 41x • IM 155-5 • CM PtP RS422/485 BA	STEP 7 (TIA Portal) STEP 7 with integration of a GSD file
Distributed operation in a third-party system	• Third-party programmable controller • IM 155-5 • CM PtP RS422/485 BA	GSD file imported to/installed in the engineering system [1)]

1) Information on using the communication module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

Information on configuring and programming the CM PtP RS422/485 BA communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

2.4 Properties of the RS422/485 interface

Definition

The RS422/485 (X27) interface is a differential voltage interface for serial data transmission.

Properties

The RS422/485 (X27) interface has the following properties and meets the following requirements:

Type	Differential voltage interface
Front connector:	15-pin sub-D female connector, with screw lock
RS422 signals:	T (A), R (A), T (B), R (B), GND; isolated
RS485 signals:	R/T (A), R/T (B), GND; all signals isolated against backplane bus and load voltage
Max. data transmission rate:	19.2 kbps
Max. cable length:	1200 m; cable type LIYCY 3 x 2 x 0.14. T(A)/T(B) and R(A)/R(B) twisted in pairs
Standard:	DIN 66259 Parts 1 and 3, EIA-RS422/485, CCITT V.11

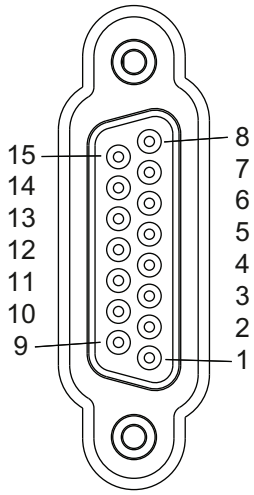
Connecting 3

3.1 RS422/485 (X27) interface of the communication module

Terminal assignment

The table below shows the terminal assignment for the 15-pin sub D female connector in the front panel of the communication module.

Table 3- 1 Terminal assignment for the 15-pin sub D female connector of the integrated interface of the communication module

RS422/485* female connector	Pin	Designation	Input/output	Meaning
	1	-	-	-
	2	T (A) -	Output	Send data (four-wire mode)
	3	-	-	-
	4	R (A)/T (A) -	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	5	-	-	-
	6	-	-	-
	7	-	-	-
	8	GND	-	Functional ground (isolated)
	9	T (B) +	Output	Send data (four-wire mode)
	10	-	-	-
	11	R (B)/T (B) +	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	12	-	-	-
	13	-	-	-
	14	-	-	-
	15	-	-	-
* View from the front				

Connecting cables

Standard connecting cables of various lengths (see chapter Accessories (Page 11)) are available for connection with a communication partner which also has a 15-pin sub-D female connector.

Please note that you must only use shielded connector casings and cables. A large surface area of the cable shield must be in contact with the connector casing on both sides.

⚠ CAUTION
Cable shield - GND Never connect the cable shield to the GND, as this could destroy the modules. GND (pin 8) must always be connected on both sides, as this could otherwise also destroy the modules.

3.2 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)).

The cable shield must be installed on a grounding rail to maintain the EMC values (electromagnetic compatibility).

Parameters/address space 4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 (TIA Portal V12 or later) or with STEP 7 with integration of a GSD file.

Additional information

The device manual of the communication module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the TIA Portal information system.

There you will find information on the following topics:

- Operating modes
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames in the receive buffer are retained. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

4.3 Address space

Address space of the communication module

The input addresses of the communications module total 8 bytes. The input addresses are automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal). Output addresses are not required.

Hardware identification (not freely configurable)

The hardware identification (HW ID) is automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal).

The hardware ID is issued along with the diagnostic messages to localize the module. In addition, the HW identification is required for S7-1500 at the communication instructions in order to identify the communication module. For S7-300/400, the communication module is identified by the start address of the input data.

Programming 5

Overview of the instructions

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules. The instructions process the exchange of data between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place asynchronously across several cycles.

The transmission protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Instruction	Meaning
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Send_Config	You use the Send_Config (send configuration) instruction to dynamically assign serial send parameters of a protocol.
Receive_Config	You use the Receive_Config (receive configuration) instruction to dynamically assign serial receive parameters of a protocol.
P3964_Config	You use the P3964_Config (protocol configuration) instruction to dynamically assign the parameters of the 3964(R) procedure.
Send_P2P	You use the Send_P2P instruction to send data to a communication partner.
Receive_P2P	You use the Receive_P2P instruction to receive data from a communication partner.
Receive_Reset	You use the Receive_Reset instruction to delete the receive buffer of the communication module.
Get_Features	You use the Get_Features instruction to read expanded functions supported by the communication module.
Set_Features	You use the Set_Features instruction to set expanded functions supported by the communication module.
USS_Port_Scan	You use the USS_Port_Scan instruction to communicate using the USS.
USS_Drive_Control	You use the USS_Drive_Control instruction to exchange data with a drive.
USS_Read_Param	You use the USS_Read_Param instruction to read parameters from the drive.
USS_Write_Param	You use the USS_Write_Param instruction to change parameters in the drive.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

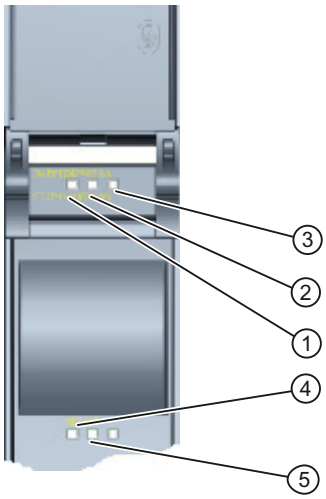
Additional information on programming the communication modules can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Error and system messages

6

LED displays of the communication module

The figure below shows the LED displays of the CM PtP RS422/485 BA communication module with open front panel.



① LED display RUN
② LED display ERROR
③ LED display MAINT
④ LED display TXD
⑤ LED display RXD

Figure 6-1 CM PtP RS422/485 BA view

Meaning of the LED displays for RUN/ERROR/(MAINT)

LED			Meaning	Solution
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage not present or too low at communication module	Check the power supply of the station.
Flashes	Off	Off	CM in startup, parameters not assigned yet	---
On	Off	Off	CM configured and ready for operation	---
On	Flashes	Off	Group error (at least one error pending)	Evaluate the diagnostics data and eliminate the error. [1]

1) Information on startup and diagnostics of the communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Meaning of LED displays for TXD/RXD (under the front panel)

LED		Meaning	Solution
TXD	RXD		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

Technical specifications 7

	6ES7540-1AB00-0AA0
Product type designation	CM PtP RS422/485 BA
General information	
• I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP2 or higher with a GSD file
PROFIBUS as of GSD version/GSD revision	- / -
PROFINET as of GSD version/GSD revision	V2.3
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Voltage type of supply voltage	System power supply
Input current	
• Current consumption (rated value)	33 mA; from backplane bus
Power	
• Power from the backplane bus	0.65 W
Power loss	
• Power loss, typ.	0.6 W
Address area	
Occupied address area	
• Inputs	8 bytes
Interfaces	
1. Interface	
Interface hardware	
• RS 422	Yes
• RS 485	Yes

	6ES7540-1AB00-0AA0
Interface hardware	
RS 485	
• Transmission rate, max.	19.2 kbps
• Max. cable length	1200 m
RS 422	
• Transmission rate, max.	19.2 kbps
• Max. cable length	1200 m
• 4-wire full duplex connection	Yes
• 4-wire multipoint connection	No
Protocols	
Integrated protocols	
Freeport	
• Frame length, max.	1 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
3964 (R)	
• Frame length, max.	1 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
Frame buffer	
• Buffer memory for frames	2 kbyte
• Number of frames which can be buffered	255
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes
• Wire break	Yes
Diagnostics display LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Receive RxD	Yes; yellow LED
• Send TxD	Yes; yellow LED

	6ES7540-1AB00-0AA0
Electrical isolation	
• between backplane bus and interface	Yes
Insulation	
Insulation tested with	707 V DC
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C
Distributed operation	
• At SIMATIC S7-300	Yes
• At SIMATIC S7-400	Yes
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes
• Supports Fast Startup	Yes
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	127 mm
Weights	
• Weight, approx.	0.22 kg

Additional general technical specifications for SIMATIC S7-1500 are available in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Dimensional drawing

A

This appendix contains the dimensional drawing of the communication module installed on a mounting rail and with a shield bracket. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

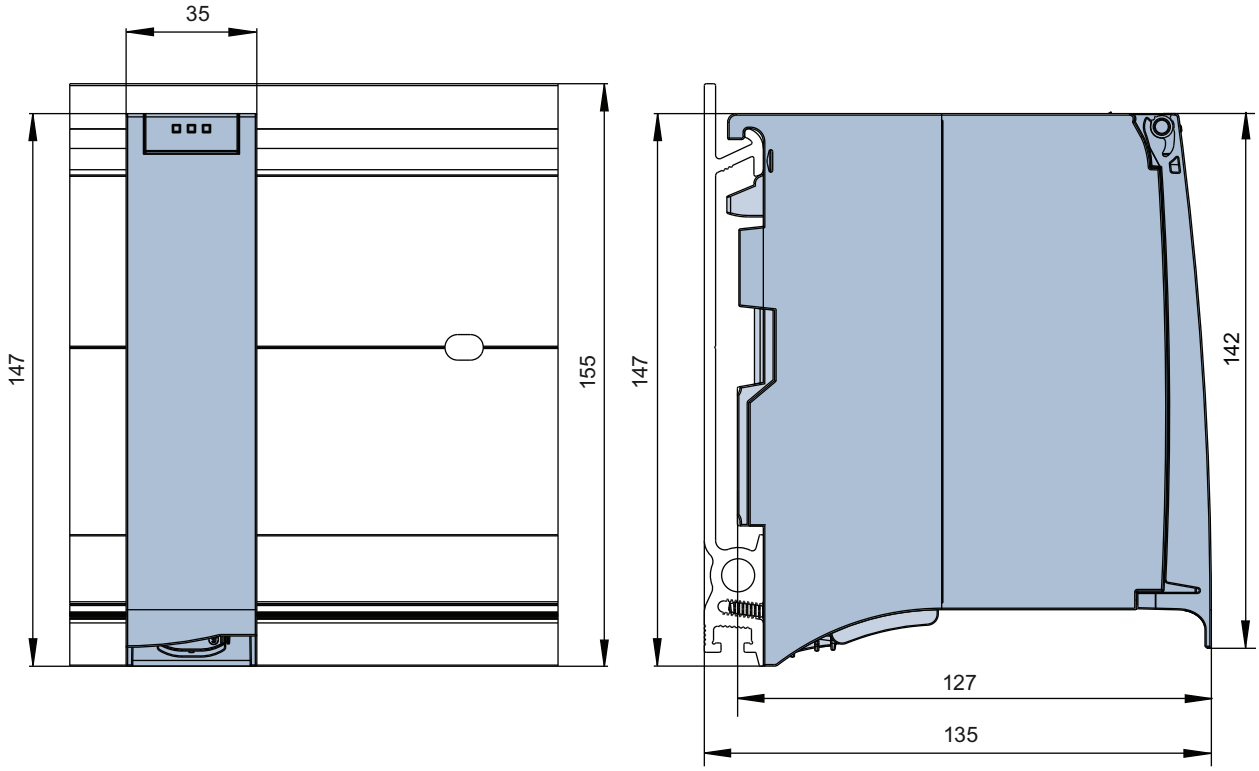


Figure A-1 Dimensional drawing of the CM PtP RS422/485 BA communication module

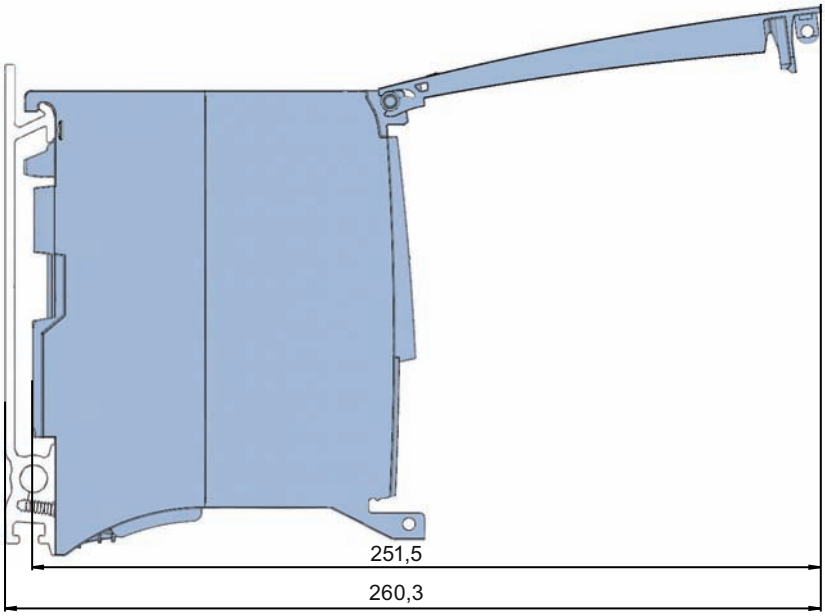


Figure A-2 Dimensional drawing of the CM PtP RS422/485 BA communication module with open front panel

SIEMENS

SIMATIC

S7-1500/ET 200MP CM PtP RS422/485 HF communication module (6ES7541-1AB00-0AB0)

Manual

Preface

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Programming 5

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Dimensional drawing A

01/2013

A5E03790709-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This device manual complements the system manual S7 1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792). General functions of the S7-1500 are described in the S7-1500 Automation System System Manual.

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

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Documentation guide 1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP automation systems consists of system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation provided for the CM PtP RS422/485 HF communication module

The following table lists additional references that you will need when using the CM PtP RS422/485 HF communication module.

Table 1- 1 Documentation for the CM PtP RS422/485 HF communication module

Topic	Documentation	Key content
System description	System manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Addressing • Commissioning • Maintenance
	Power supply manuals (http://support.automation.siemens.com/WW/view/en/59173914)	• Connecting • Interrupt, error and system messages • Technical specifications • Dimensional drawing
	CPU manuals (http://support.automation.siemens.com/WW/view/en/56926947)	
	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Key content
Point-to-point communication	Function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093)	• Basic information • Data transmission functions • Diagnostics functions

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7541-1AB00-0AB0

View of the module

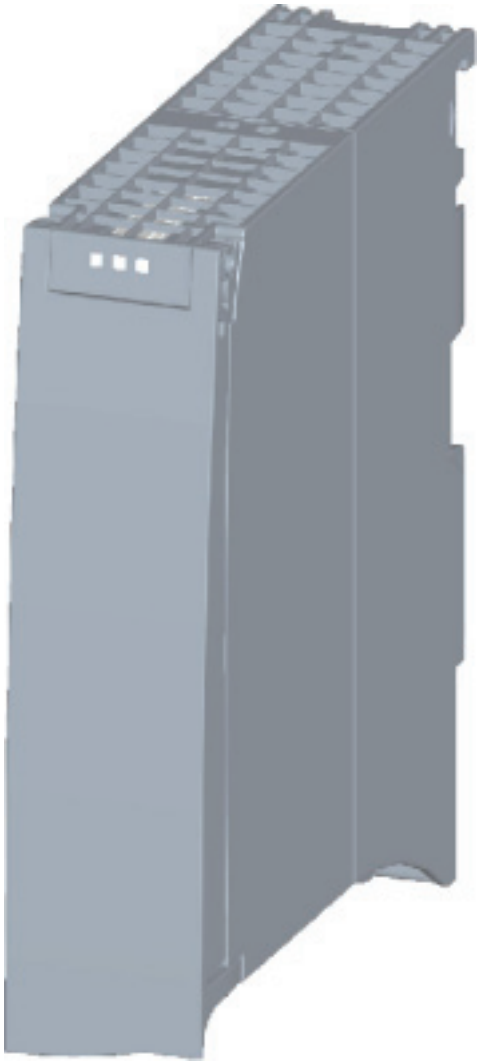


Figure 2-1 CM PtP RS422/485 HF view

Properties

The communication module has the following properties:

- Technical properties
  - RS422/485 interface
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Modbus master (RTU), Modbus slave (RTU), Freeport and USS with instructions
- Supported system functions
  - Firmware update
  - Identification data I&M0
  - Diagnostic interrupts
  - Parameter re-assignment in CPU RUN mode (using instructions)

Additional information

Additional information on the properties of the CM PtP RS422/485 HF can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

You can find additional information on the design of the S7-1500 and the associated modules in the system manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

2.2 Accessories

Scope of delivery

The scope of delivery of the communication module includes a U connector for connection to the backplane bus.

Connecting cables

Connecting cables are available in the standard lengths: 5 m, 10 m and 50 m (each with a 15-pin sub D connector).

Table 2- 1 Order numbers of connecting cables

Connecting cables for CM PtP RS422/485 BA CM PtP RS422/485 HF	Type	Order number
X27 interface (RS422/485)	X27 (RS 422), 5 m	6ES7902–3AB00–0AA0
	X27 (RS 422), 10 m	6ES7902–3AC00–0AA0
	X27 (RS 422), 50 m	6ES7902–3AG00–0AA0

Online catalog

Additional order numbers for S7-1500 can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

2.3 Functions

Introduction

The communication module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP RS422/485 HF

The CM PtP RS422/485 HF communication module offers the following functionality:

- RS422/485 interface
- Data transmission rate: 300 to 115.2 kbps
- Maximum frame length: 4 kbyte
- Transmission protocols: Freeport, 3964(R) and Modbus

Note

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP RS422/485 HF.

Components	Function
Central processor unit (CPU) Accessories: Memory card	... executes the user program.
CM PtP RS422/485 HF communication module	... communicates with a communication partner (point-to-point) by means of the interface.
Connecting cable	... connects the CM PtP RS422/485 HF communication module with the communication partner.
U connector	... provides the mechanical and electrical connection between the modules.
Optional: Power supply module (PS)	... converts the line voltage (120/230 VAC or 24 VDC) into the operating voltage of 15 VDC required for supply of the S7-1500.

System environment

The communication module can be used in the following system environments:

Applications	Components required	Configuration
Central operation in an S7-1500 system	• CPU 151x • CM PtP RS422/485 HF • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-1500 system	• CPU 151x • IM 155-5 • CM PtP RS422/485 HF • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-300/400 system	• CPU 31x / CPU 41x • IM 155-5 • CM PtP RS422/485 HF	STEP 7 (TIA Portal) STEP 7 with integration of a GSD file
Distributed operation in a third-party system	• Third-party programmable controller • IM 155-5 • CM PtP RS422/485 HF	GSD file imported to/installed in the engineering system [1)]

1) Information on using the communication module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

Information on configuring and programming the CM PtP RS422/485 HF communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

2.4 Properties of the RS422/485 interface

Definition

The RS422/485 (X27) interface is a differential voltage interface for serial data transmission.

Properties

The RS422/485 (X27) interface has the following properties and meets the following requirements:

Type	Differential voltage interface
Front connector:	15-pin sub-D female connector, with screw lock
RS422 signals:	T (A), R (A), T (B), R (B), GND; isolated
RS485 signals:	R/T (A), R/T (B), GND; all signals isolated against backplane bus and load voltage
Max. data transmission rate:	115.2 kbps
Max. cable length:	• 250 m for 115.2 kbps • 500 m for 38.4 kbps • 1200 m for up to19.2 kbps Cable type LIYCY 3 x 2 x 0.14. T(A)/T(B) and R(A)/R(B) twisted in pairs
Standard:	DIN 66259 Parts 1 and 3, EIA-RS422/485, CCITT V.11

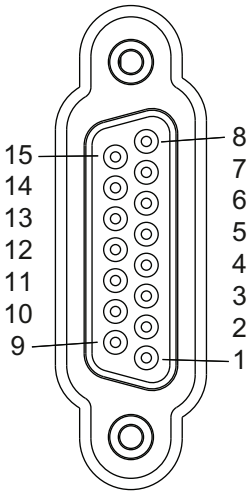
Connecting 3

3.1 RS422/485 (X27) interface of the communication module

Terminal assignment

The table below shows the terminal assignment for the 15-pin sub D female connector in the front panel of the communication module.

Table 3- 1 Terminal assignment for the 15-pin sub D female connector of the integrated interface of the communication module

RS422/485* female connector	Pin	Designation	Input/output	Meaning
	1	-	-	-
	2	T (A) -	Output	Send data (four-wire mode)
	3	-	-	-
	4	R (A)/T (A) -	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	5	-	-	-
	6	-	-	-
	7	-	-	-
	8	GND	-	Functional ground (isolated)
	9	T (B) +	Output	Send data (four-wire mode)
	10	-	-	-
	11	R (B)/T (B) +	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	12	-	-	-
	13	-	-	-
	14	-	-	-
	15	-	-	-
* View from the front				

Connecting cables

Standard connecting cables of various lengths (see chapter Accessories (Page 11)) are available for connection with a communication partner which also has a 15-pin sub-D female connector.

Please note that you must only use shielded connector casings and cables. A large surface area of the cable shield must be in contact with the connector casing on both sides.

⚠ CAUTION
Cable shield - GND Never connect the cable shield to the GND, as this could destroy the modules. GND (pin 8) must always be connected on both sides, as this could otherwise also destroy the modules.

3.2 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)).

The cable shield must be installed on a grounding rail to maintain the EMC values (electromagnetic compatibility).

Parameters/address space 4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 (TIA Portal V12 or later) or with STEP 7 with integration of a GSD file.

Additional information

The device manual of the communication module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the TIA Portal information system.

There you will find information on the following topics:

- Operating modes
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames in the receive buffer are retained. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

4.3 Address space

Address space of the communication module

The input addresses of the communications module total 8 bytes. The input addresses are automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal). Output addresses are not required.

Hardware identification (not freely configurable)

The hardware identification (HW ID) is automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal).

The hardware ID is issued along with the diagnostic messages to localize the module. In addition, the HW identification is required for S7-1500 at the communication instructions in order to identify the communication module. For S7-300/400, the communication module is identified by the start address of the input data.

Programming 5

Overview of the instructions

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules. The instructions process the exchange of data between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place asynchronously across several cycles.

The transmission protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Instruction	Meaning
Port_Config	You use the Port_Config instruction to dynamically assign basic interface parameters.
Send_Config	You use the Send_Config (send configuration) instruction to dynamically assign serial send parameters of a protocol.
Receive_Config	You use the Receive_Config (receive configuration) instruction to dynamically assign serial receive parameters of a protocol.
P3964_Config	You use the P3964_Config (protocol configuration) instruction to dynamically assign the parameters of the 3964(R) procedure.
Send_P2P	You use the Send_P2P instruction to send data to a communication partner.
Receive_P2P	You use the Receive_P2P instruction to receive data from a communication partner.
Receive_Reset	You use the Receive_Reset instruction to delete the receive buffer of the communication module.
Signal_Get	You use the Signal_Get instruction to read the RS232 accompanying signals.
Signal_Set	You use the Signal_Set instruction to set the RS232 accompanying signals.
Get_Features	You use the Get_Features instruction to read expanded functions supported by the communication module.
Set_Features	You use the Set_Features instruction to set expanded functions supported by the communication module.
USS_Port_Scan	You use the USS_Port_Scan instruction to communicate using the USS.
USS_Drive_Control	You use the USS_Drive_Control instruction to exchange data with a drive.
USS_Read_Param	You use the USS_Read_Param instruction to read parameters from the drive.
USS_Write_Param	You use the USS_Write_Param instruction to change parameters in the drive.
Modbus_Comm_Load	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU.

Instruction	Meaning
Modbus_Master	The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

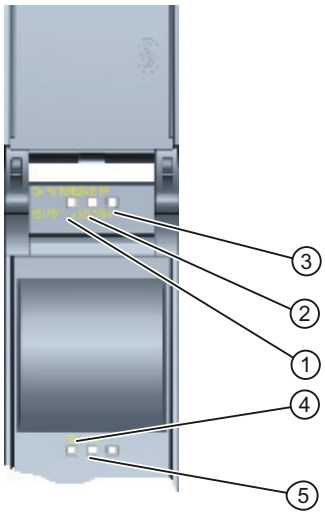
Additional information on programming the communication modules can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Error and system messages

6

LED displays of the communication module

The figure below shows the LED displays of the CM PtP RS422/485 HF communication module with open front panel.



① LED display RUN
② LED display ERROR
③ LED display MAINT
④ LED display TXD
⑤ LED display RXD

Figure 6-1 CM PtP RS422/485 HF view

Meaning of the LED displays for RUN/ERROR/(MAINT)

LED			Meaning	Solution
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage not present or too low at communication module	Check the power supply of the station.
Flashes	Off	Off	CM in startup, parameters not assigned yet	---
On	Off	Off	CM configured and ready for operation	---
On	Flashes	Off	Group error (at least one error pending)	Evaluate the diagnostics data and eliminate the error. [1]

1) Information on startup and diagnostics of the communication module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Meaning of LED displays for TXD/RXD (under the front panel)

LED		Meaning	Solution
TXD	RXD		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

Technical specifications 7

7.1 Technical specifications

	6ES7541-1AB00-0AB0
Product type designation	CM PtP RS422/485 HF
General information	
• I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP2 or higher with a GSD file
PROFIBUS as of GSD version/GSD revision	- / -
PROFINET as of GSD version/GSD revision	V2.3
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Voltage type of supply voltage	System power supply
Input current	
• Current consumption (rated value)	33 mA; from backplane bus
Power	
• Power from the backplane bus	0.65 W
Power loss	
• Power loss, typ.	0.6 W
Address area	
Occupied address area	
• Inputs	8 bytes
Interfaces	
1. Interface	
Interface hardware	
• RS 422	Yes
• RS 485	Yes

	6ES7541-1AB00-0AB0
Interface hardware	
RS 485	
• Transmission rate, max.	115.2 kbps
• Max. cable length	1200 m
RS 422	
• Transmission rate, max.	115.2 kbps
• Max. cable length	1200 m
• 4-wire full duplex connection	Yes
• 4-wire multipoint connection	No
Protocols	
Integrated protocols	
Freeport	
• Frame length, max.	4 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
3964 (R)	
• Frame length, max.	4 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
Modbus RTU master	
Address area	1 to 247, extended 1 to 65,535
• Max. number of slaves	32
Modbus RTU slave	
Address area	1 to 247, extended 1 to 65,535
Frame buffer	
• Buffer memory for frames	8 kbyte
• Number of frames which can be buffered	255

	6ES7541-1AB00-0AB0
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes
• Wire break	Yes
Diagnostics display LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Receive RxD	Yes; yellow LED
• Send TxD	Yes; yellow LED
Electrical isolation	
• between backplane bus and interface	Yes
Insulation	
Insulation tested with	707 V DC (Type Test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C
Distributed operation	
• At SIMATIC S7-300	Yes
• At SIMATIC S7-400	Yes
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes
• Supports Fast Startup	Yes
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	127 mm
Weights	
• Weight, approx.	0.22 kg

Additional general technical specifications for SIMATIC S7-1500 are available in the system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Dimensional drawing

A

This appendix contains the dimensional drawing of the communication module installed on a mounting rail and with a shield bracket. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

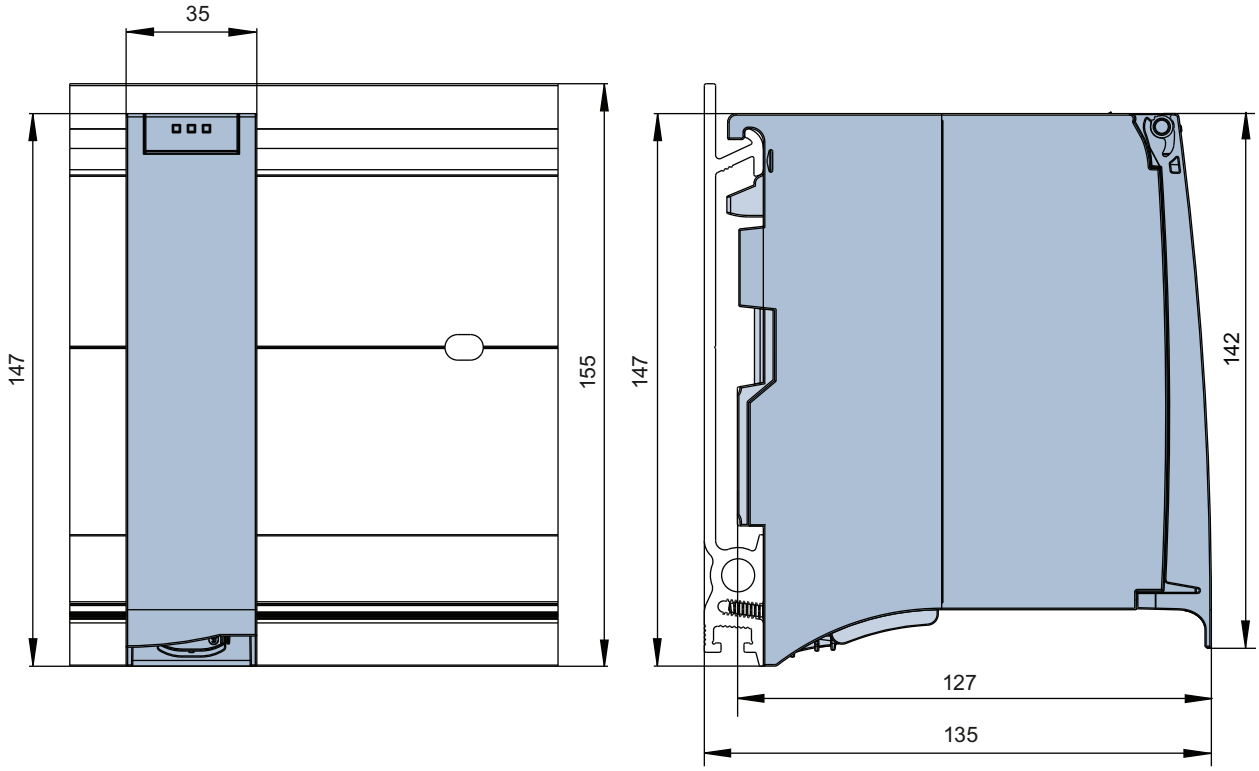


Figure A-1 Dimensional drawing of the CM PtP RS422/485 HF communication module

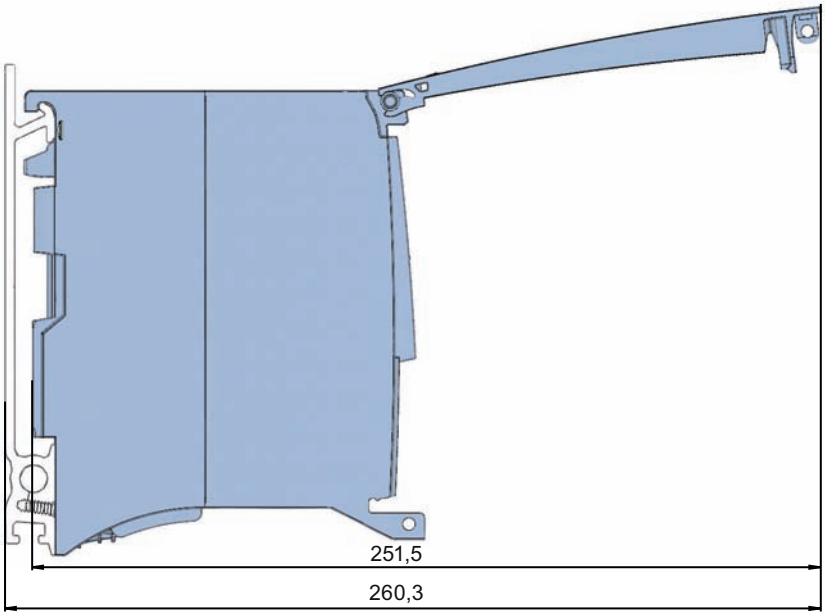


Figure A-2 Dimensional drawing of the CM PtP RS422/485 HF communication module with open front panel

SIEMENS

SIMATIC

S7-1500/ET 200MP Technology module TM Count 2x24V (6ES7550-1AA00-0AB0)

Manual

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Parameter data records B

06/2013

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Legal information

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding design and commissioning of the S7-1500 or ET 200MP is available in the S7-1500 or ET 200MP system manuals.

The counting and measuring functions of the TM Count 2x24V technology module are described in more detail in the Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820) Function Manual.

Conventions

Please observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you configure and program your automation system.

Overview of the documentation provided for technology module TM Count 2x24V

The following table lists further documentation that you will need when using the TM Count 2x24V technology module.

Table 1- 1 Documentation for technology module TM Count 2x24V

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual	• Application planning • Installation • Wiring • Commissioning
	ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) System Manual	
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual	• Basics • Electromagnetic compatibility • Lightning protection
Counting and measuring	Counting, measurement and position input (http://support.automation.siemens.com/WW/view/en/59709820) Function Manual	• Counting functions • Measuring functions • Position input • Control and feedback interface
Motion Control	S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) Function Manual	• Configuration • Programming • Commissioning • Diagnostics

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7550-1AA00-0AB0

View of the module

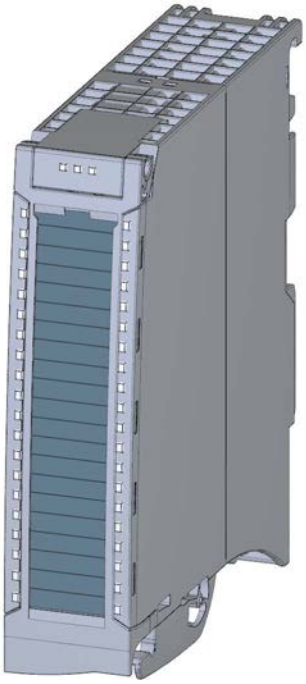


Figure 2-1 View of the TM Count 2x24V module

Properties

The TM Count 2x24V technology module has the following properties:

- Technical properties
  - Width: 35 mm
  - Two channels
  - Interfaces:

    24 V encoder signals A, B and N from sourcing, sinking or push pull encoders and sensors

    24 V encoder supply output, short-circuit proof

    DI0, DI1 and DI2 digital input signals (per channel)

    DQ0 and DQ1 digital output signals (per channel)

    L+ supply voltage
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break channel by channel
  - Hardware interrupts can be configured channel by channel
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - 24 V incremental encoder with and without signal N
  - 24 V pulse encoder with direction signal
  - 24 V pulse encoder without direction signal
  - 24 V pulse encoders for up & down pulses
- Supported functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following components are supplied with the technology module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strip
- U-connector

Other components

The following component needs to be ordered separately:

- Front connectors, including potential jumpers and cable ties

2.2 Functions

2.2.1 Counting

Counting refers to the recording and adding up of events. The counters of the technology module capture encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs. You can switch the digital outputs exactly at defined counter values, independently of the user program.

You can specify the response of the counters using the functionalities described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can configure the response of the counter at the counting limits:

- Continue or stop counting upon violation of a counting limit (automatic gate stop)
- Set counter value to start value or to other counting limit upon violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Depending on the parameter assignment, the technology module can set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counting limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The control of the hardware gate takes place externally via the digital inputs of the technology module. Control of the software gate takes place via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current counter value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input

You can configure whether counting continues from the current counter value or from the start value after the Capture function.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.2 Measuring

The following measuring functions are available:

Measurement type	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses and returned in hertz as the floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses and returned in seconds as the floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses and other parameters, and returned in the configured unit of measurement.

The measured value and the counter value are available concurrently in the feedback interface.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After closing, the last measured value captured continues to be returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	800 kHz*
Period measurement	1.25 µs*	25 s
Velocity measurement	Depends on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

2.2.3 Position input for Motion Control

You can use the technology module with an incremental encoder for position input with S7-1500 Motion Control . Position input is based on the counting function of the technology module which evaluates the captured encoder signals and sends them to the S7-1500 Motion Control.

To do this, select "Position input for Motion Control" in the device configuration of the technology module in STEP 7 (TIA Portal). This mode will automatically apply to all channels of the technology module.

Additional information

A detailed description of the use of Motion Control and its configuration is available in the function manual S7-1500 Motion Control as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279).

2.2.4 Additional functions

Synchronization

You can configure the edge of an external reference signal to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Comparison values

You can specify two comparison values to control the two digital outputs of the channel. If the counter or measured value meets the configured comparison condition, the corresponding digital output can be set to initiate control processes directly in the process. The comparison values are configurable and can be modified during runtime with the user program.

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU, for example, if a compare event occurs, in the event of overflow or underflow, in the event of a zero crossing of the counter and/or of a change of count direction (direction reversal). You can specify which events (Page 40) are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt in the event of a missing supply voltage or an error at the digital outputs, for example. Select the diagnostic interrupts (Page 39) in the device configuration freely.

Input filter

To suppress interference, you can configure an input filter for the 24 V encoder inputs and for the digital inputs.

Centralized application

You can use the technology module centrally in the S7-1500 automation system.

Distributed application

You can use the technology module in a distributed system by means of an interface module in the ET 200MP distributed I/O device. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-300/400 system
- Distributed operation in a third-party system

Isochronous mode

The technology module supports the system function "Isochronous mode". This system function enables position, counter and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met.

Wiring 3

3.1 Pin assignment

The encoder signals, the digital input and output signals and the encoder supplies are connected to the 40-pin front connector of the technology module. The supply voltage to supply the module and the digital outputs and generate the encoder supply voltages is connected to the 4-pin power supply element.

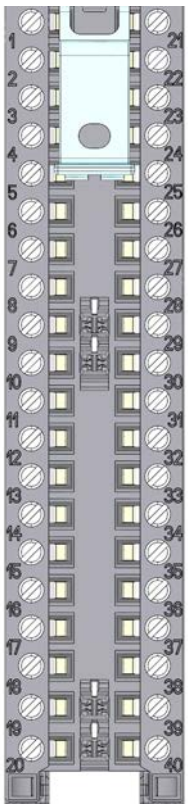
The next two sections detail the pin assignment for the front connector and the power supply element.

Information on wiring the front connector, creating the cable shield, etc. is available in the Connecting chapter of the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Pin assignment for the front connector

The table below shows the pin assignment of the front connector.

Table 3- 1 Pin assignment of the front connector

View	Signal name		Designation				
			24 V incremental encoder		24 V pulse encoder		
			With signal N	Without signal N	with direction signal	without direction signal	up/down
	Counter channel 0						
	1	CH0.A	Encoder signal A		Counting signal A		Up counting signal A
	2	CH0.B	Encoder signal B		Direction signal B	—	Down counting signal B
	3	CH0.N	Encoder signal N	—			
	4	DI0.0	Digital input DI0				
	5	DI0.1	Digital input DI1				
	6	DI0.2	Digital input DI2				
	7	DQ0.0	Digital output DQ0				
	8	DQ0.1	Digital output DQ1				
	Encoder supply and ground of both counter channels						
	9	24VDC	24 V encoder supply				
	10	M	Ground for encoder supply, digital inputs and digital outputs				
	Counter channel 1						
	11	CH1.A	Encoder signal A		Counting signal A		Up counting signal A
	12	CH1.B	Encoder signal B		Direction signal B	—	Down counting signal B
	13	CH1.N	Encoder signal N	—			
	14	DI1.0	Digital input DI0				
	15	DI1.1	Digital input DI1				
	16	DI1.2	Digital input DI2				
	17	DQ1.0	Digital output DQ0				
	18	DQ1.1	Digital output DQ1				
	19 - 40	—	—				

Pin assignment for the power supply element

The power supply element is plugged onto the front connector and serves to supply the technology module. For this purpose, you need to connect the supply voltage to terminal 41 (L+) and terminal 44 (M). Use terminal 42 (L+) and terminal 43 (M) to loop the supply voltage to the next module.

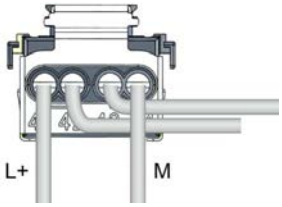


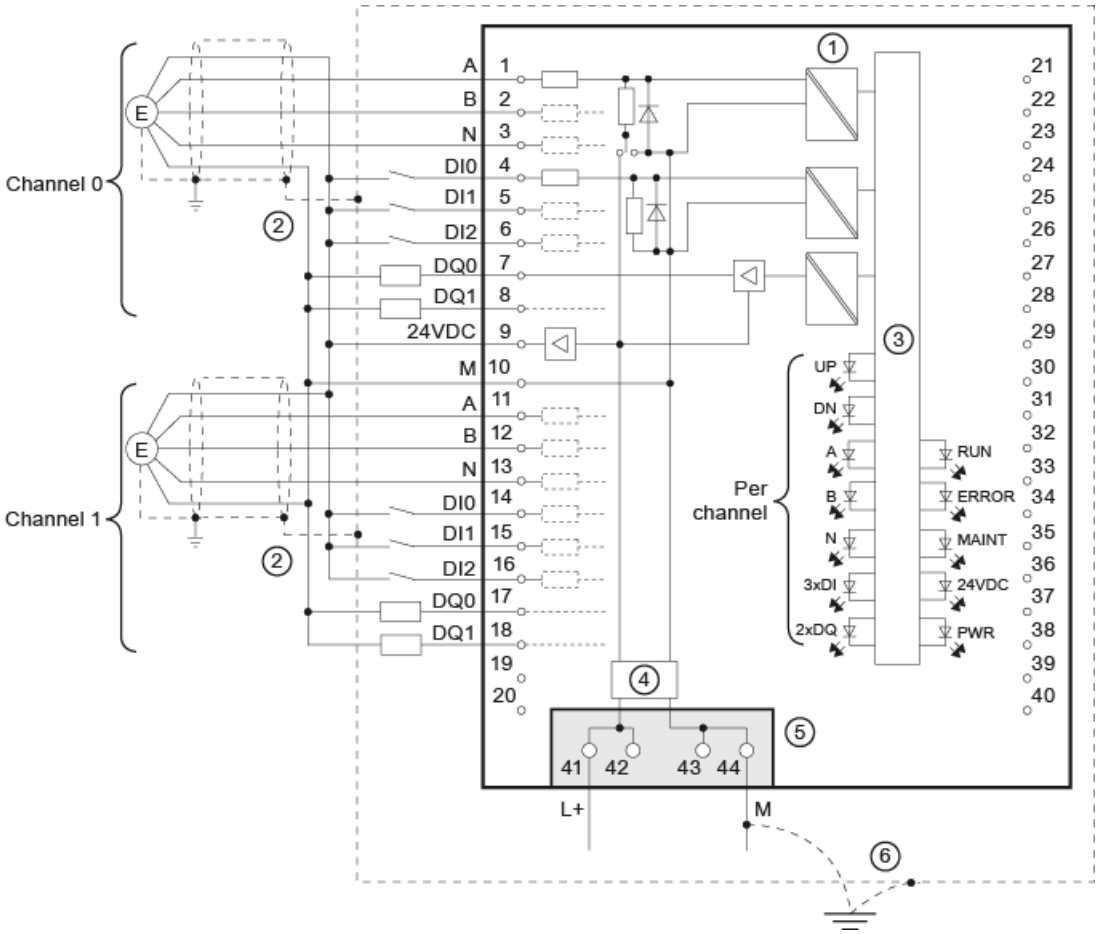
Figure 3-1 Power supply element wiring

L+	DC 24V supply voltage
M	Ground for supply voltage

Block diagram

You must ground the shields of the cables between encoder and technology module both through the shield support at the front connector (shield bracket and terminal) and at the encoder.

The figure below shows the block diagram of the technology module with two connected incremental encoders.



① Electrical isolation
② Shield support at the front connector
③ Technology and backplane bus interface
④ Input filter
⑤ Supply voltage via power supply element
⑥ Equipotential bonding

Figure 3-2 Block diagram with two incremental encoders

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors the connection of the supply voltage.

24VDC encoder supply

To supply the encoders and sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output with reference to M. Voltage is supplied from the L+/M supply voltage and monitored for short circuits and overload.

24 V encoder signals/counting signals

The 24 V encoder signals are designated A, B and N. You can connect the following encoder types:

- Incremental encoder with signal N:

  The signals A, B and N are connected by means of the correspondingly labeled terminals. Signals A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal which returns one pulse per revolution.

- Incremental encoder without signal N:

  The signals A and B are connected by means of the correspondingly labeled terminals. Signals A and B are the two incremental signals phase-shifted by 90°. The N terminal remains disconnected.

- Pulse encoders without direction signal:

  The counting signal is connected to the A terminal. The count direction is specified via the control interface. The B and N terminals remain disconnected.

- Pulse encoders with direction signal:

  The counting signal is connected to the A terminal. The direction signal is connected to the B terminal. The N terminal remains disconnected.

- Pulse encoders with up counting signal/down:

  The up counting signal is connected to the A terminal. The down counting signal is connected to the B terminal. The N terminal remains disconnected.

The inputs of the two counting channels are not isolated from each other. The inputs are isolated against the backplane bus.

You can connect the following encoders or sensors at inputs A, B and N:

- Sourcing output:
  The inputs A, B and N are switched by the encoder or sensor after 24VDC .
- Sinking output:
  The inputs A, B and N are switched by the encoder or sensor after ground M .
- Push pull:
  The inputs A, B and N are switched by the encoder or sensor alternately after 24VDC and ground M . Monitoring for wire break is possible with this type of encoder/sensor. The wire break detection procedure (alternate switching) allows the counter value to change in the event of an error (wire break) even without count pulses until the wire break is detected.

Input filter for 24 V encoder signals

To suppress interferences, you can configure an input filter for the counting inputs A, B and N. The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This produces a set minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can specify the following values for the filter frequency:

Table 3- 2 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz (default)	2.0 µs

Digital inputs DI0, DI1 and DI2

Three digital inputs are available per counting channel. The digital inputs are used for gate control, synchronization and the Capture function. Alternatively, you can use one or more digital inputs without the functions named and read the signal state of the respective digital input via the feedback interface.

The digital inputs of the two counting channels are not isolated from each other.

Input filters for digital inputs

To suppress interferences, you can configure an input filter for the digital inputs.

You can specify the following values for the filter time:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

Two digital outputs are available per counting channel. The two digital outputs DQ0 and DQ1 can be activated/switched directly by the specified comparison values or by the user program.

The digital outputs of the two counting channels are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A. They are protected from overload and short-circuit.

Note

Relays and contactors can be connected direct without external circuitry. Information on the maximum possible operating frequencies and the inductance values of the inductive loads at the digital outputs is available in the chapter Technical specifications (Page 41).

Configuring/address space 4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central and distributed operation in an S7-1500 system with a corresponding ET 200MP system	• S7-1500 automation system • ET 200MP distributed I/O system • TM Count 2x24V	STEP 7 (TIA Portal): • Device configuration with hardware configuration (HWCN) • Parameter setting with High_Speed_Counter technology object	Counting and measuring functions: High_Speed_Counter instruction for the technology object Position input: Direct access to the control and feedback interface (Page 29) of the TM Count 2x24V in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200MP distributed I/O system • TM Count 2x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 29) of the TM Count 2x24V in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200MP distributed I/O system • TM Count 2x24V	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 29) of the TM Count 2x24V in the I/O data

Additional information

A detailed description of the counting and measuring functions and their configuration is available:

- In the Counting, measurement and position input function manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position input" > Counting, measurement and position input (S7-1500)"

A detailed description of the use of Motion Control and its configuration is available:

- In the S7-1500 Motion Control Function Manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

The GSD files for the ET 200MP distributed I/O system are available for download from the Internet (http://support.automation.siemens.com/WW/view/en/68189683).

4.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module for each channel to CPU STOP in the basic parameters of the device configuration.

Table 4- 1 Response of the technology module to CPU STOP depending on parameter assignment

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.

4.3 Address space

Address space of the technology module

Table 4- 2 Range of the input addresses and output addresses of the TM Count 2x24V

	Inputs	Outputs
Range per counting channel	16 bytes	12 bytes
Total range	32 bytes	24 bytes

Table 4- 3 Range of the input addresses and output addresses of the TM Count 2x24V in "Position input for Motion Control" mode.

	Inputs	Outputs
Range per counting channel	16 bytes	4 bytes
Total range	32 bytes	8 bytes

Additional information

A description on how to use the control and feedback interface of TM Count 2x24V can be found in the chapter Control and feedback interface (Page 29).

4.4 Control and feedback interface

Information on using the control and feedback interface can be found in the section Configuring (Page 25).

A detailed description of the TM Count 2x24V control and feedback bits is available in the Counting, Measurement and Position Input function manual which can be downloaded from the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.4.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the significance of the value in Slot 0				
		Bit 3	Bit 2	Bit 1	Bit 0	
		0	0	0	0	No action, idle
		0	0	0	1	Load counter value
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1*	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load counter value
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable synchronization down				
	EN_SYNC_UP	Bit 5: Enable synchronization up				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is taken internally from Slot 0 and then the value from Slot 1 is taken. This may lead to unexpected intermediate states.

4.4.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current counter value
Bytes 4 to 7	CAPTURED VALUE	The last acquired Capture value
Bytes 8 to 11	MEASURED VALUE	Current measured value
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Incorrect encoder signal
	POWER_ERROR	Bit 0: Incorrect supply voltage L+
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate state
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and carried out (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and carried out (toggling)
	RES_EVENT_ACK	Bit 1: Resetting of status bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2	Bit 7: Status DI2
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Status of internal gate
	STS_CNT	Bit 1: Count pulse detected within the last 0.5 s
	STS_DIR	Bit 0: Direction of last counter value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse detected in previous measurement interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A zero pass has occurred

Interrupts/diagnostic messages

5

5.1 Status and error displays

LEDs

The following figure shows you the LED displays (status and error displays) of TM Count 2x24V.

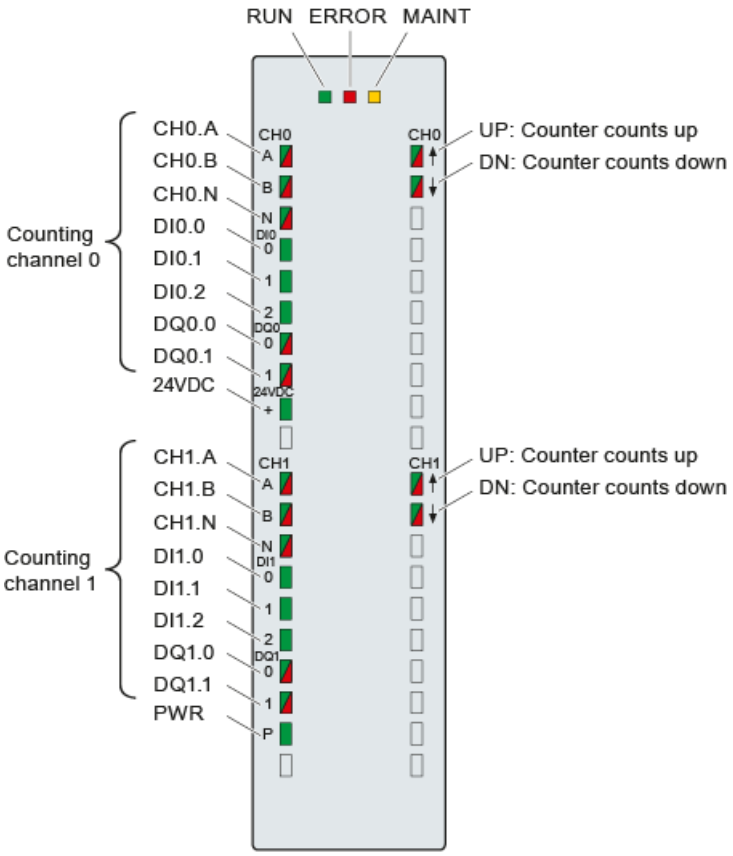


Figure 5-1 LEDs of the TM Count 2x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic messages (Page 36).

Table 5- 1 Status and error displays RUN/ERROR/MAINT

LEDs			Meaning	To correct or avoid errors
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage from CPU/power supply module not present or too low	Check or turn on the supply voltage at the PS, at the CPU or at the interface module.
Flashes	Off	Off	The technology module starts and flashes until parameter assignment is complete	---
On	Off	Off	The parameters of the technology module have been assigned.	
On	Flashes	Off	Indicates a group error (at least one active error)	Evaluate the diagnostic alarms and eliminate the error.
Flashes	Flashes	Flashes	Hardware or firmware defective	Replace the technology module.

Table 5- 2 PWR/24VDC/ERROR status displays

LEDs			Meaning	To correct or avoid errors
PWR	24VDC	ERROR		
Off	Off	Flashes	Supply voltage too low or missing	• Check the supply voltage. • Make sure that the front connector is correctly inserted.
On	On	Off	Supply voltage is present and OK	---
On	Off	Flashes	Short-circuit or overload at the encoder supply	• Correct the encoder wiring. • Check the loads connected to the encoder supply.

ChannelLEDs

The LEDs CHn.A, CHn.B, CHn.N and DIn.m indicate the current level of the associated signals. The LEDs of the digital outputs DQn.m indicate the desired state.

The LEDs UP and DN indicate the logical counting direction.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

Table 5- 3 Status displays CHn.m/DIn.m/DQn.m

LEDs CHn.m/DIn.m/DQn.m	Meaning	To correct or avoid errors
□ Off	Counter input/digital input/digital output at 0 level	---
■ On	Counter input/digital input/digital output at 1 level.	---
■ On (CHn.m/DQn.m)	Diagnostic alarm: e.g. wire break, short circuit	Check the wiring or the connected load.

Table 5- 4 Status displays CHn.UP/CHn.DN

LEDs		Meaning
CHn.UP	CHn.DN	
□ Off	□ Off	No count pulse has been detected for the last 0.5 s.
■ On	□ Off	The last count pulse has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count pulse has decremented the counter and took place no more than 0.5 s ago.
■ On	■ On	Illegal A/B signal ratio

5.2 Diagnostic messages

Diagnostic alarms

If a diagnostic alarm is pending, the ERROR-LED is flashing.

The diagnostic alarms are displayed as clear text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 5- 5 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code		Meaning	To correct or avoid errors
	Dec.	Hex.		
Hardware interrupt lost	22_D	16_H	• Technology module cannot send an interrupt because a previous interrupt has not been processed • Possible causes: – Parameter assignment error – Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-assign technology module parameters correspondingly
Internal error	256_D	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	259_D	103_H	Firmware error	Run firmware update
			Technology module defective	Replace technology module
External auxiliary voltage missing	266_D	$10A_H$	No technology module L+ supply voltage	Provide L+ supply voltage to technology module
			Front connector not inserted correctly	Insert front connector correctly
Short circuit or overload at external encoder supply	270_D	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Correction of encoder wiring • Check consumers connected to encoder supply
Error at digital outputs	271_D	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload – External feed	• Correct the wiring at the digital outputs • Check consumers connected to the digital outputs
Faulty external auxiliary voltage	272_D	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the L+ supply voltage

Diagnostic alarm	Error code		Meaning	To correct or avoid errors
	Dec.	Hex.		
Illegal A/B signal ratio	1280_D	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain specifications • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Correct the process wiring • Check encoder/sensor • Check parameter assignment
Wire break at digital input A, B or N	1285_D	505_H	Channel not connected	Connect the channel
			Resistance of encoder circuit too high	• Use a different encoder type or modify the wiring, for example, use shorter cables with larger cross-sections • Check encoders
			Interruption of the line between technology module and encoder	Correct the process wiring
			Sensor used is sourcing output or sinking output only	Correct parameter assignment
Overheating	1286_D	506_H	Possible causes: • Short circuit or overload at the digital outputs or output of the encoder supply • Ambient temperature outside specifications	• Correct the process wiring • Improve cooling • Check connected loads

5.3 Interrupts

5.3.1 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupt for wire break and the diagnostic interrupts for additional errors in the basic parameters during device configuration.

A list of all errors that can trigger a diagnostic interrupt is available at Cause of the error triggering a diagnostic interrupt (Page 39).

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The ERROR LED flashes.

  Once you have remedied the error, the ERROR LED goes out.
- The S7-1500 CPU interrupts processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

Default setting

These diagnostic interrupts are not enabled in the default setting.

5.3.2 Cause of the error triggering a diagnostic interrupt

Which errors can trigger a diagnostic interrupt?

The technology module can trigger the following diagnostic interrupts:

Table 5- 6 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Wire break at digital input A, B or N	Monitoring is active if a push-pull switching encoder has been configured. An error detected only triggers a diagnostic interrupt if "Enable diagnostic interrupt on wire break" has been enabled in the device configuration.
• Hardware interrupt lost • External auxiliary voltage missing • Short circuit or overload at external encoder supply • Error at digital outputs • Faulty external auxiliary voltage • Illegal A/B signal ratio • Overheating	Monitoring is always active. An error detected only triggers a diagnostic interrupt if "Enable additional diagnostic interrupts" has been enabled in the device configuration.

5.3.3 Triggering of a Hardware Interrupt

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a Hardware Interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Activating the hardware interrupts

You activate the hardware interrupts in STEP 7 (TIA Portal) under "Basic parameters > Channel 0 or 1 > Hardware interrupts" during device configuration of the technology module.

A list of the individual hardware interrupts is available at Events which can trigger a hardware interrupt (Page 40).

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but there is an identical, previous event which has not yet been processed, no further hardware interrupt will be triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Default setting

No hardware interrupts are activated in the default setting.

5.3.4 Events which can trigger a hardware interrupt

Which events can trigger a hardware interrupt?

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

The following two tags, among others, are entered in the start information of the assigned hardware interrupt OB when a process interrupt is triggered:

- EventType: Number of the event type to which the event triggering the interrupt belongs
- IChannel: Number of the channel that triggered the hardware interrupt

You can configure hardware interrupts to be triggered for the following event types:

Hardware interrupt	EventType number
Internal gate opening (Gate start)	1
Internal gate closing (Gate stop)	2
Overflow (high counting limit violated)	3
Underflow (low counting limit violated)	4
Compare event for DQ0 has occurred	5
Compare event for DQ1 has occurred	6
Zero pass	7
New capture value available[1)]	8
Synchronization of the counter by an external signal	9
Direction reversal[2)]	10

1) Can only be configured in Counting mode

2) The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first counter value or position value is changed immediately after switching on the technology module in *down direction*.

You can activate any combination of events to trigger hardware interrupts.

Technical specifications

6

	6ES7550-1AA00-0AB0
Product type designation	TM Count 2x24V
General information	
Product function	
• I&M data	Yes, I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
PROFINET as of GSD version/GSD revision	V2.3 / -
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• Low limit of valid range (DC)	19.2 V
• High limit of valid range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption, max.	75 mA; without load
Encoder supply	
• Number of outputs	1; one shared 24V encoder supply for both channels
24 V encoder supply	
• 24 V	Yes; L+ (-0.8 V)
• Short-circuit protection	Yes
• Output current, max.	1 A; total current of all encoders/channels
Power	
• Power from the backplane bus	1.3 W
Power loss	
• Power loss, typ.	4 W

	6ES7550-1AA00-0AB0
Address area	
Occupied address area	
• Inputs	16 bytes; per channel
• Outputs	12 bytes; per channel; 4 bytes with Motion Control
Digital inputs	
• Number of inputs	6; 3 per channel
• Digital inputs, configurable	Yes
• Input characteristics to IEC 61131, Type 3	Yes
Digital input functions, configurable	
• Gate start/stop	Yes
• Capture	Yes
• Synchronization	Yes
• Freely assignable digital input	Yes
Input voltage	
Type of input voltage	DC
• Rated value, DC	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
• Permitted voltage at input, max.	30 V
• Permitted voltage at input, min.	-30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "1" to "0", min.	6 µs; with parameter assignment "none"
For counters/technological functions	
• Configurable	Yes
Cable length	
• Cable length shielded, max.	1000 m
• Cable length unshielded, max.	600 m

	6ES7550-1AA00-0AB0
Digital outputs	
Type of digital output	Transistor
• Number of outputs	4; 2 per channel
• Digital outputs, configurable	Yes
• Short-circuit protection	Yes; electronic/thermal
Response threshold, typ.	1 A
Limiting of inductive shutdown voltage to	L+ (-33 V)
• Control of a digital input	Yes
Digital output functions, configurable	
• Switch at comparison values	Yes
• Freely assignable digital output	Yes
Output switching capacity	
• With resistive load, max.	0.5 A; per digital output
• With lamp load, max.	5 W
Load resistance range	
• Low limit	48 Ω
• High limit	12 kΩ
Output voltage	
Type of output voltage	DC
• for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
• for signal "1" rated value	0.5 A; per digital output
• for signal "1" permissible range, max.	0.6 A; per digital output
• for signal "1" minimum load current	2 mA
• for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs
• "1" to "0", max.	50 µs
Switching frequency	
• With resistive load, max.	10 kHz
• With inductive load, max.	0.5 Hz; to IEC 947-5-1, DC-13; observe derating curve
• With lamp load, max.	10 Hz
Total current of outputs	
• Max. current per module	2 A
Cable length	
• Cable length shielded, max.	1000 m
• Cable length unshielded, max.	600 m

	6ES7550-1AA00-0AB0
Encoders	
Supported encoders	
• 2-wire sensor	Yes
• Permitted quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	24 V
• Input frequency, max.	200 kHz
• Counting frequency, max.	800 kHz; with quadruple evaluation
• Signal filter, configurable	Yes
• Cable length shielded, max.	600 m; depends on input frequency, encoder and cable quality; max. 50 m with 200 kHz
• Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
• Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one pulse signal per count direction	Yes
24 V encoder signal	
• Permitted voltage at input, max.	30 V
• Permitted voltage at input, min.	-30 V
Interface hardware	
• Input characteristics to IEC 61131, Type 3	Yes
• Sinking/sourcing input	Yes
Isochronous mode	
• Isochronous mode (application synchronized until terminal)	Yes
• Filter and processing time (TWE), min.	130 µs
• Bus cycle time (TDP), min.	250 µs

	6ES7550-1AA00-0AB0
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	Yes
Diagnostic alarms	
• Monitoring of supply voltage	Yes
• Wire break	Yes
• Short circuit	Yes
• A/B transition error with incremental encoder	Yes
LED diagnostics display	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; yellow LED
• Monitoring of supply voltage	Yes; green LED
• Channel status display	Yes; green LED
• For channel diagnostics	Yes; red LED
• Count down status display (green)	Yes
• Count up status display (green)	Yes
Integrated functions	
• Number of counters	2
• Counting frequency (counters), max.	800 kHz; with quadruple evaluation
Counting functions	
• Continuous counting	Yes
• Counter response configurable	Yes
• Hardware gate by means of digital input	Yes
• Software gate	Yes
• Event-triggered stop	Yes
• Synchronization by means of digital input	Yes
• Counting range, configurable	Yes
Comparator	
• Number of comparators	2; per channel
• Direction-dependent	Yes
• Can be changed from user program	Yes

	6ES7550-1AA00-0AB0
Position detection	
• Incremental detection	Yes
• Suitable for S7-1500 Motion Control	Yes
Measuring functions	
• Measuring time, configurable	Yes
• Dyn. measuring time adjustment	Yes
• Number of threshold values, configurable	2
Measuring range	
• Frequency measurement, max.	800 kHz
• Frequency measurement, min.	0.04 Hz
• Period measurement, max.	25 s
• Period measurement, min.	1.25 µs
Accuracy	
Frequency measurement	100 ppm; depends on measuring interval and signal evaluation
Velocity measurement	100 ppm; depends on measuring interval and signal evaluation
Period measurement	100 ppm; depends on measuring interval and signal evaluation
Electrical isolation	
Electrical isolation channels	
• Between the channels	No
• Between the channels and the backplane bus	Yes
• Between the channels and load voltage L+	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C; consider derating with inductive loads
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C; consider derating with inductive loads
Distributed operation	
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes

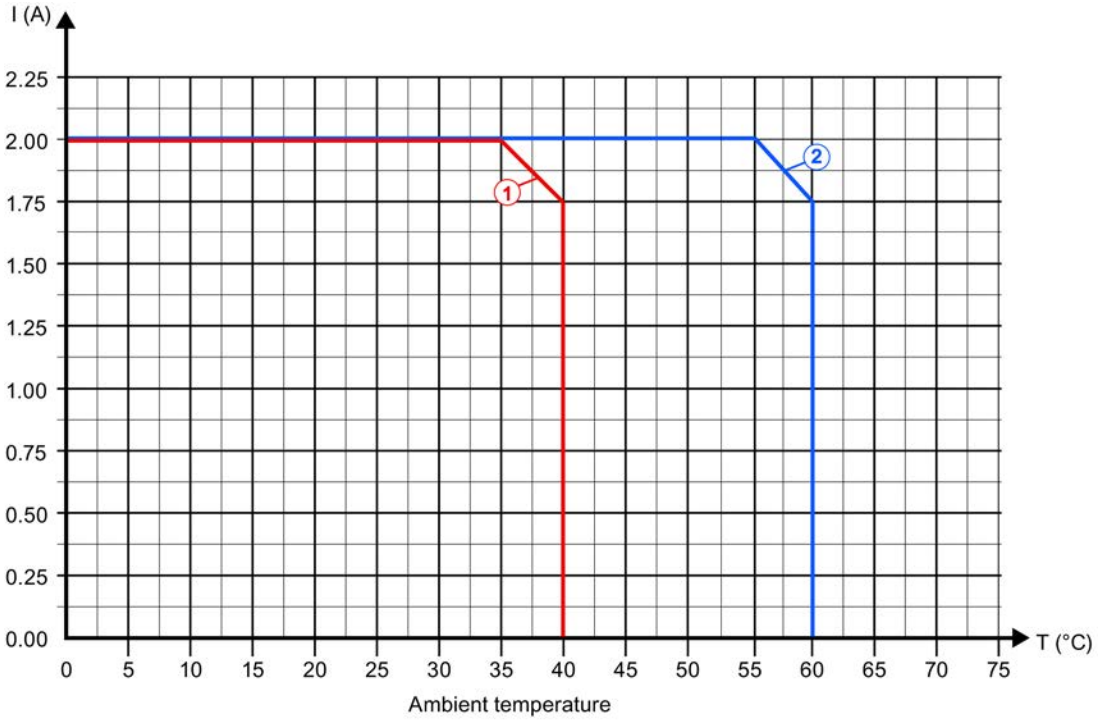
	6ES7550-1AA00-0AB0
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	250 g

Derating information for total current of outputs

If the digital outputs of the TM Count 2x24V are operated with inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (all channels, without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)



① Vertical installation of the system

② Horizontal installation of the system

Figure 6-1 Total current depending on ambient temperature and mounting position for inductive loads

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Note

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front panel, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

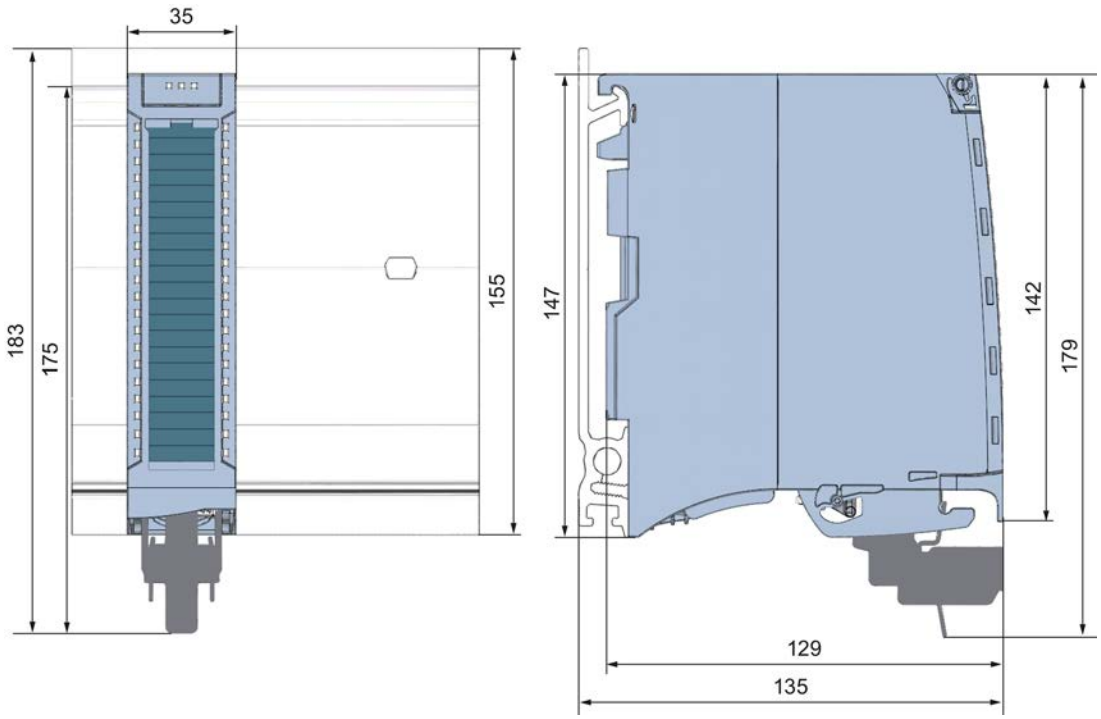

Figure A-1 Dimensional drawing of the TM Count 2x24V technology module

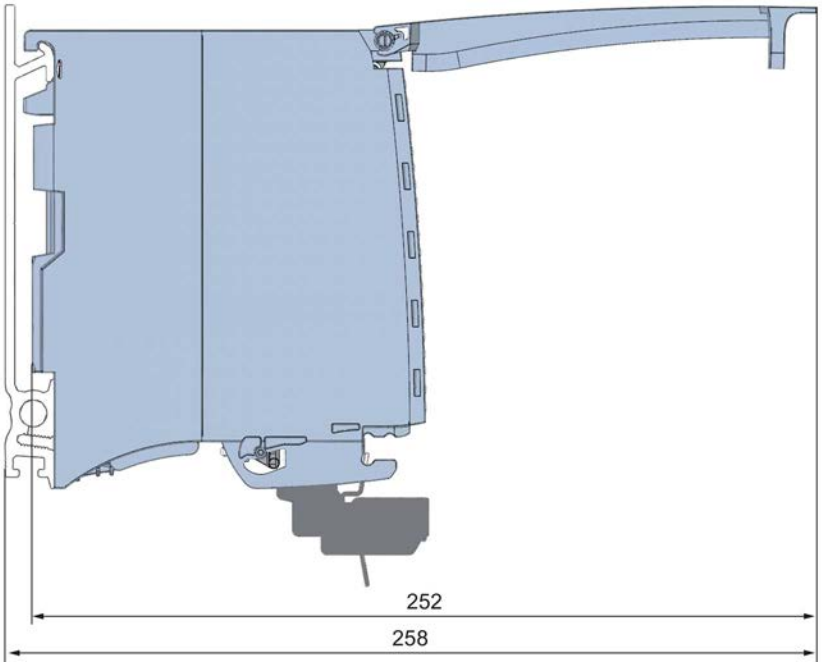

Figure A-2 Dimensional drawing of the TM Count 2x24V module, side view with open front panel

Parameter data records

B

You may edit the module parameters in RUN. The WRREC instruction is used to transfer the parameters to the module using data record 128.

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the STEP 7 (TIA Portal) Online Help.

Structure of the data record for central and distributed configuration with PROFINET

The following tables shows you the structure of data record 128 for TM Count 2x24V with 2 channels. The values in byte 0 to byte 3 are fixed and may not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode.

Table B- 1 Parameter data record 128 for central and distributed configuration with PROFINET

Bit → Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	Header							
0	Major Version = 0				Minor Version = 1			
1	Length of the parameter data per channel = 48							
2	Reserved[2)]							
3	Reserved[2)]							
4...51	Counter channel 0							
52...99	Counter channel 1							
4/52	Operating mode							
4/52	Reserved[2)]				Operating mode:			
					0000_B: Reserved			
					0001_B: Counting			
					0010_B: Measuring			
					0011 to 1111_B: Reserved			

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
5/53	**Basic parameters**							
5/53	Reserved[2]					Enable additional diagnostic interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue operation	
							11_B: Reserved	
6...7/ 54...55	**Counter inputs**							
6/54	Sensor type:		Signal evaluation:		Signal type:			
	00_B: Sourcing output		00_B: Single		0000_B: Pulse (A)			
	01_B: Sinking output		01_B: Double		0001_B: Pulse (A) and direction (B)			
	10_B: Push-pull (sinking and sourcing output)		10_B: Quadruple		0010_B: Count up (A), count down (B)			
	11_B: Reserved		11_B: Reserved		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Reserved			
7/55	Reaction to signal N:		Invert direction[1]	Enable diagnostics interrupt at wire break[1]	Filter frequency:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at signal N				0010_B: 500 Hz			
					0011_B: 1 kHz			
	10_B: Capture at signal N				0100_B: 2 kHz			
	11_B: Reserved				0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011 to 1111_B: Reserved			

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
8...9/ 56...57	**Hardware interrupts**[1)]							
8/56	Reserved[2)]	Reserved[2)]	Reserved[2)]	Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop	Gate start
9/57	Synchronization of the counter by an external signal	New Capture value available	Reserved[2)]	Zero pass	Reserved[2)]	Comparison event for DQ1 has occurred	Reserved[2)]	Comparison event for DQ0 has occurred
10...15/ 58...63	**Behavior of DQ0/1**							
10/58	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value				0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value			
	0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value				0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Reserved			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Reserved			
	0111 to 1111_B: Reserved							
11/59	Count direction (DQ1):		Count direction (DQ0):		Reserved[2)]	Reserved[2)]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Forward		01_B: Forward					
	10_B: Backward		10_B: Backward					
	11_B: In both directions		11_B: In both directions					
12/60	Pulse duration (DQ0):							
13/61	WORD: Value range in ms/10: 0 to 65535_D							
14/62	Pulse duration (DQ1):							
15/63	WORD: Value range in ms/10: 0 to 65535_D							

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
16/64	**Behavior of DI0**							
16/64	Behavior of counter value after Capture (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2)]	Set function of DI (DI0):		
		00_B: Reserved				000_B: Gate start/stop (level-triggered)		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization		
						100_B: Enable synchronization at signal N		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Reserved		
17/65	**Behavior of DI1**: See Byte 16							
18/66	**Behavior of DI2**: See Byte 16							
19/67	Frequency:	Reserved[2)]			Filter time:			
	0_B: Once				0000_B: None			
					0001_B: 0.05 ms			
	1_B: Periodic				0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Reserved			

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
20...43/ 68...91	**Values**							
20...23/ 68...71	High counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
24...27/ 72...75	Comparison value 0: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
28...31/ 76...79	Comparison value 1: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D: or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
32...35/ 80...83	Start value: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36...39/ 84...87	Low counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
40...43/ 88...91	"Position input for Motion Control" mode: **Reference speed**: DWORD: Value range in 10^{-2} rpm: 600 to 21000000_D; Other mode: **Update time**: DWORD: Value range in µs: 0 to 25000000_D							
44/92	**Counter behavior at limits and gate start**							
44/92	Reaction to gate start:		Reaction to violation of a counting limit:			Reset when counting limit is violated:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Reserved		010 to 111_B: Reserved			010 to 111_B: Reserved		

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
45/93	**Specify measured value**							
45/93	Reserved[2]			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Reserved	
				100_B: 60 s/1 min				
				101 to 111_B: Reserved				
46/94	Increments per unit:							
47/95	WORD: Value range: 1 to 65535_D							
48/96	Set the hysteresis range: Value range: 0 to 255_D							
49...51/ 97...99	Reserved[2]							

[1] You enable a specific parameter by setting the corresponding bit to 1.

[2] Reserved bits must be set to 0

SIEMENS

SIMATIC

S7-1500/ET 200MP Technology module TM PosInput 2 (6ES7551-1AB00-0AB0)

Manual

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Legal information

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding design and commissioning of the S7-1500 or ET 200MP is available in the S7-1500 and ET 200MP System Manuals.

The counting and measuring functions and position input of the TM PosInput 2 technology module are described in more detail in the Counting, measurement and position input (http://support.automation.siemens.com/WW/view/en/59709820) Function Manual.

Conventions

Please observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200MP systems consists of the respective system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you configure and program your automation system.

Overview of the documentation provided for technology module TM PosInput 2

The following table lists further documentation that you will need when using the TM PosInput 2 technology module.

Table 1- 1 Documentation for technology module TM PosInput 2

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual	• Application planning • Installation • Wiring • Commissioning
	ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) System Manual	
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual	• Basics • Electromagnetic compatibility • Lightning protection
Counting, measurement and position input	Counting, measurement and position input (http://support.automation.siemens.com/WW/view/en/59709820) Function Manual	• Counting functions • Measuring functions • Position input • Control and feedback interface
Motion Control	S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) Function Manual	• Configuration • Programming • Commissioning • Diagnostics

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7551-1AB00-0AB0

View of the module

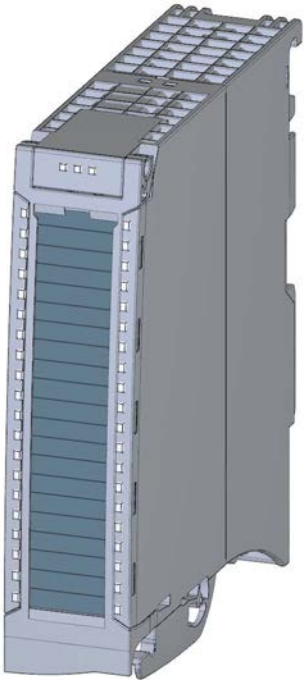


Figure 2-1 View of the TM PosInput 2 module

Properties

The TM PosInput 2 technology module has the following properties:

- Technical properties
  - Width: 35 mm
  - Two channels
  - Interfaces:

    SSI encoder signals DAT and CLK or RS422/TTL encoder signals A, B and N

    5 V and 24 V encoder supply output, short-circuit proof

    DI0 and DI1 digital input signals (per channel)

    DQ0 and DQ1 digital output signals (per channel)

    L+ supply voltage
  - Position value range: 31 bits
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break, short-circuits and faulty voltages channel by channel
  - Hardware interrupts can be configured channel by channel
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - SSI absolute encoder
  - RS422/TTL incremental encoder with and without signal N
  - RS422/TTL pulse encoder with direction signal
  - RS422/TTL pulse encoder without direction signal
  - RS422/TTL pulse encoders for up & down pulses
- Supported functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following components are supplied with the technology module and can also be ordered separately as spare parts:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strip
- U-connector

Other components

The following component needs to be ordered separately:

- Front connectors, including potential jumpers and cable ties

2.2 Functions

2.2.1 Position input with SSI absolute encoder

You can use the TM PosInput 2 technology module with an SSI absolute encoder for position input. The technology module reads the position via a synchronous, serial interface from the SSI absolute encoder and sends it to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, independently of the user program. Position input with an SSI absolute encoder does not involve gate control. Due to system constraints, synchronization is not possible with an SSI absolute encoder.

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read in a position value with a maximum length of 31 bits and transfer it to the PLC. The position value is treated as unsigned positive value and can assume values between "0" and "$2^{(MSB-LSB+1)-1}$".

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bit of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

Monitoring of the encoder signals and the SSI frames

The technology module monitors signals of an SSI absolute encoder for wire breaks, short-circuits and faulty voltages. The technology module also monitors SSI frames for errors.

If you enable the diagnostic interrupts, the technology module triggers a diagnostic interrupt in the event of an error at the encoder signals or the SSI frame.

2.2.2 Counting

Counting refers to the recording and adding up of events. The counters of the technology module capture encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs. You can switch the digital outputs exactly at defined counter values, independently of the user program.

You can specify the response of the counters using the functionalities described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can configure the response of the counter at the counting limits:

- Continue or stop counting upon violation of a counting limit (automatic gate stop)
- Set counter value to start value or to other counting limit upon violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Depending on the parameter assignment, the technology module can set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counting limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The control of the hardware gate takes place externally via the digital inputs of the technology module. Control of the software gate takes place via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current counter value or position value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input

For incremental and pulse encoders, you can configure whether counting continues from the current counter value or from the start value after the Capture function.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value or position value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.3 Measuring

The following measuring functions are available:

Measurement type	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position values and returned in hertz as the floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position values and returned in seconds as the floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position values and other parameters, and returned in the configured unit of measurement.

The measured value and the counter value are available concurrently in the feedback interface. Instead of having a measured variable returned, you can choose to have the least significant 32 bit of the current unprocessed SSI frame returned when using an SSI absolute encoder.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control for incremental and pulse encoders

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After closing, the last measured value captured continues to be returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	4 MHz*
Period measurement	0.25 µs*	25 s
Velocity measurement	Depends on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to RS422/TTL incremental encoders and "Quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

2.2.4 Position input for Motion Control

You can use the technology module for position input with S7-1500 Motion Control .

To do this, select "Position input for Motion Control" in the device configuration of the technology module in STEP 7 (TIA Portal). This mode will automatically apply to both channels of the technology module.

When using an incremental encoder or pulse encoder, the position input is based on the counting function of the technology module. With an SSI absolute encoder, the absolute value is read in via a synchronous, serial interface and prepared according to the parameter assignment to be made available for S7-1500 Motion Control.

Additional information

A detailed description of the use of Motion Control and its configuration is available in the function manual S7-1500 Motion Control as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279).

2.2.5 Additional functions

Synchronization for incremental encoders and pulse encoders

You can configure the edge of an external reference signal to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Comparison values

You can specify two comparison values to control the two digital outputs of the channel. If the position, counter or measured value meets the configured comparison condition, the corresponding digital output can be set to initiate control processes directly in the process. The comparison values are configurable and can be modified during runtime with the user program.

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU, for example, if a compare event occurs, in the event of a zero crossing and/or a change of count direction (direction reversal). You can specify which events (Page 44) are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt in the event of a missing supply voltage or an error at the digital outputs, for example. Select the diagnostic interrupts (Page 43) in the device configuration freely.

Input filter

To suppress interference, you can configure an input filter for the RS422/TTL encoder inputs and for the digital inputs.

Centralized application

You can use the technology module centrally in the S7-1500 automation system.

Distributed application

You can use the technology module in a distributed system by means of an interface module in the ET 200MP distributed I/O device. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-300/400 system
- Distributed operation in a third-party system

Isochronous mode

The technology module supports the system function "Isochronous mode". This system function enables position, counter and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met.

Wiring 3

3.1 Pin assignment

The encoder signals, the digital input and output signals and the encoder supplies are connected to the 40-pin front connector of the technology module. The supply voltage to supply the module and the digital outputs and generate the encoder supply voltages is connected to the 4-pin power supply element.

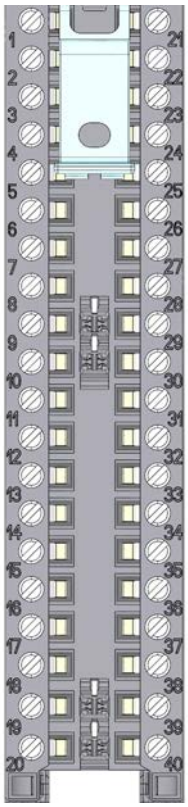
The next two sections detail the pin assignment for the front connector and the power supply element.

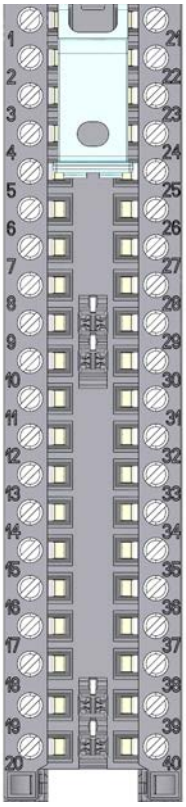
Information on wiring the front connector, creating the cable shield, etc. is available in the Connecting chapter of the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

Pin assignment for the front connector

The table below shows the pin assignment of the front connector.

Table 3- 1 Pin assignment of the front connector

View	Signal name		Designation					
			RS422/TTL incremental encoder		RS422/TTL pulse encoder			SSI absolute encoder
			with signal N	without signal N	with direction signal	without direction signal	up/down	
	Channel 0							
	1	CH0.A or CH0.D	Encoder signal A		Counting signal A		Up counting signal A	SSI data signal DAT
	2	/CH0.A or /CH0.D	Encoder signal /A (RS422 only)		Counting signal /A (RS422 only)		Up counting signal /A (RS422 only)	SSI data signal /DAT
	3	CH0.B or CH0.C	Encoder signal B		Direction signal B	—	Down counting signal B	SSI clock signal CLK
	4	/CH0.B or /CH0.C	Encoder signal /B (RS422 only)		Direction signal /B (RS422 only)		Down counting signal /B (RS422 only)	SSI clock signal /CLK
	5	CH0.N	Encoder signal N	—				
	6	/CH0.N	Encoder signal /N (RS422 only)	—				
	7	5VDC	5 V encoder supply					
	8	M	Ground for encoder supplies and digital inputs					
	9	24VDC	24 V encoder supply					
	10	M	Ground for encoder supplies and digital inputs					
	11	DI0.0	Digital input DI0					
	12	DI0.1	Digital input DI1					
	13	—	—					
	14	—	—					
	15	DQ0.0	Digital output DQ0					
	16	DQ0.1	Digital output DQ1					
	17	—	—					
	18	M	Digital output ground					
	19 - 20	—	—					

View	Signal name		Designation					
			RS422/TTL incremental encoder		RS422/TTL pulse encoder			SSI absolute encoder
			with signal N	without signal N	with direction signal	without direction signal	up/down	
	Channel 1							
	21	CH1.A or CH1.D	Encoder signal A		Counting signal A		Up counting signal A	SSI data signal DAT
	22	/CH1.A or /CH1.D	Encoder signal /A (RS422 only)		Counting signal /A (RS422 only)		Up counting signal /A (RS422 only)	SSI data signal /DAT
	23	CH1.B or CH1.C	Encoder signal B		Direction signal B	—	Down counting signal B	SSI clock signal CLK
	24	/CH1.B or /CH1.C	Encoder signal /B (RS422 only)		Direction signal /B (RS422 only)		Down counting signal /B (RS422 only)	SSI clock signal /CLK
	25	CH1.N	Encoder signal N	—				
	26	/CH1.N	Encoder signal /N (RS422 only)	—				
	27	5VDC	5 V encoder supply					
	28	M	Ground for encoder supplies and digital inputs					
	29	24VDC	24 V encoder supply					
	30	M	Ground for encoder supplies and digital inputs					
	31	DI1.0	Digital input DI0					
	32	DI1.1	Digital input DI1					
	33	—	—					
	34	—	—					
	35	DQ1.0	Digital output DQ0					
	36	DQ1.1	Digital output DQ1					
	37	—	—					
	38	M	Digital output ground					
	39 - 40	—	—					

Note

Potential jumpers may not be inserted in the front connector.

Pin assignment for the power supply element

The power supply element is plugged onto the front connector and serves to supply the technology module. For this purpose, you need to connect the supply voltage to terminal 41 (L+) and terminal 44 (M). Use terminal 42 (L+) and terminal 43 (M) to loop the supply voltage to the next module.

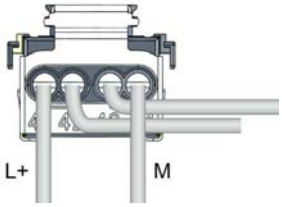


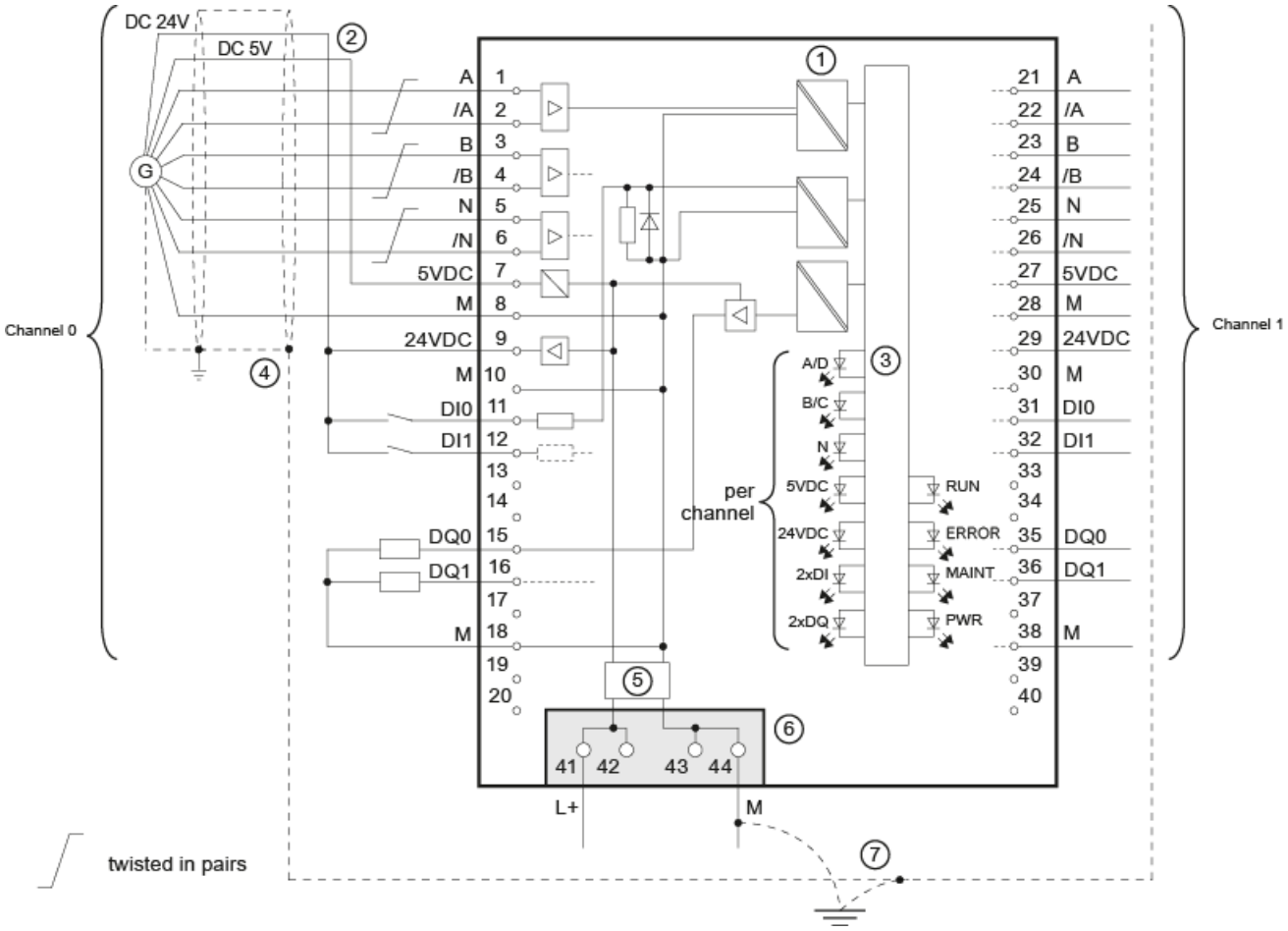
Figure 3-1 Power supply element wiring

L+	DC 24V supply voltage
M	Ground for supply voltage

Block diagrams

You must ground the shields of the cables between encoder and technology module both through the shield support at the front connector (shield bracket and terminal) and at the encoder.

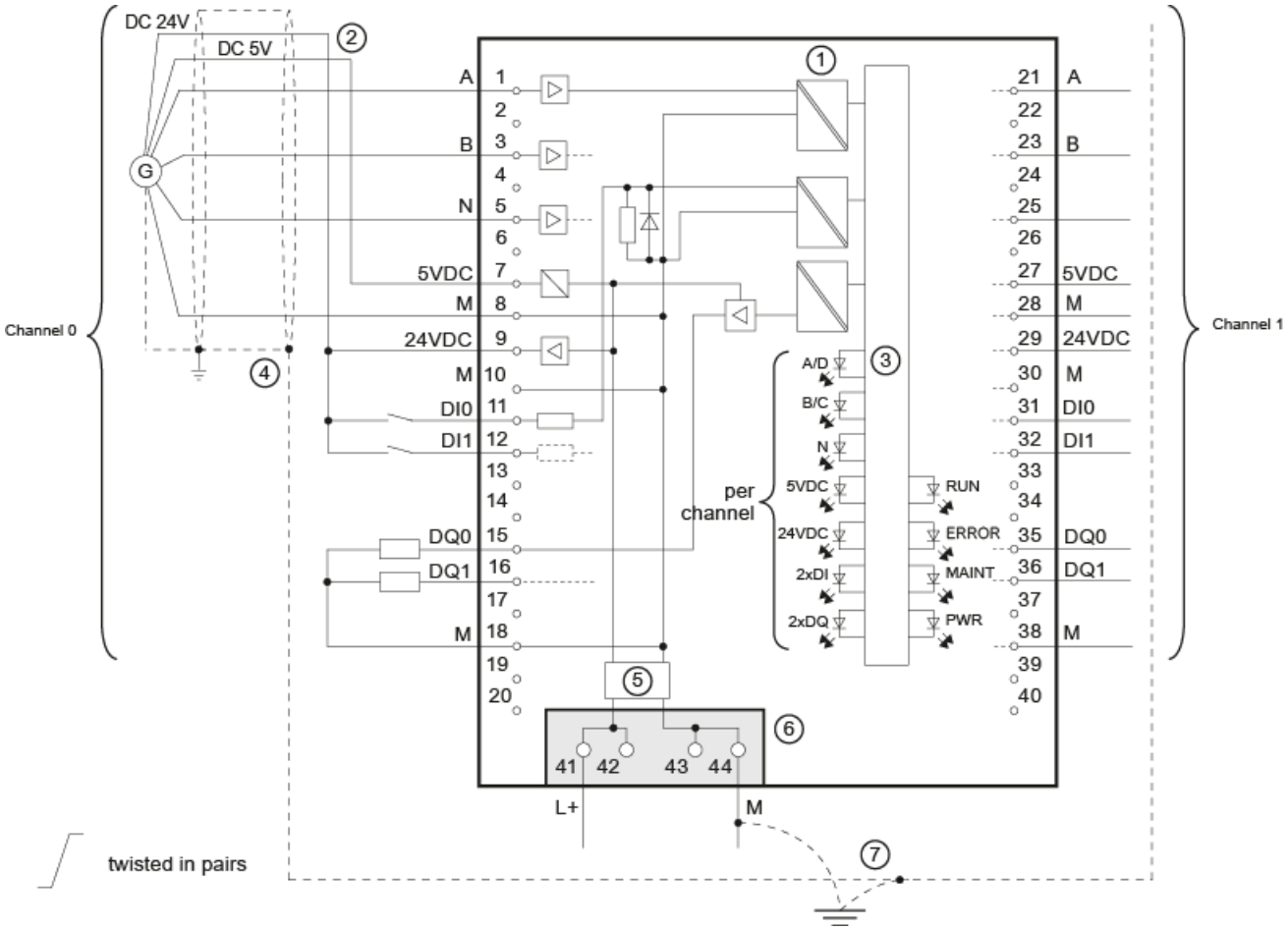
The figure below shows the block diagram of the technology module with one connected RS422 incremental encoder.



① Electrical isolation
② Encoder supply either DC 5V or DC 24V as per encoder manufacturer instructions
③ Technology and backplane bus interface
④ Shield support at the front connector
⑤ Input filter
⑥ Supply voltage via power supply element
⑦ Equipotential bonding

Figure 3-2 Block diagram with RS422 incremental encoder

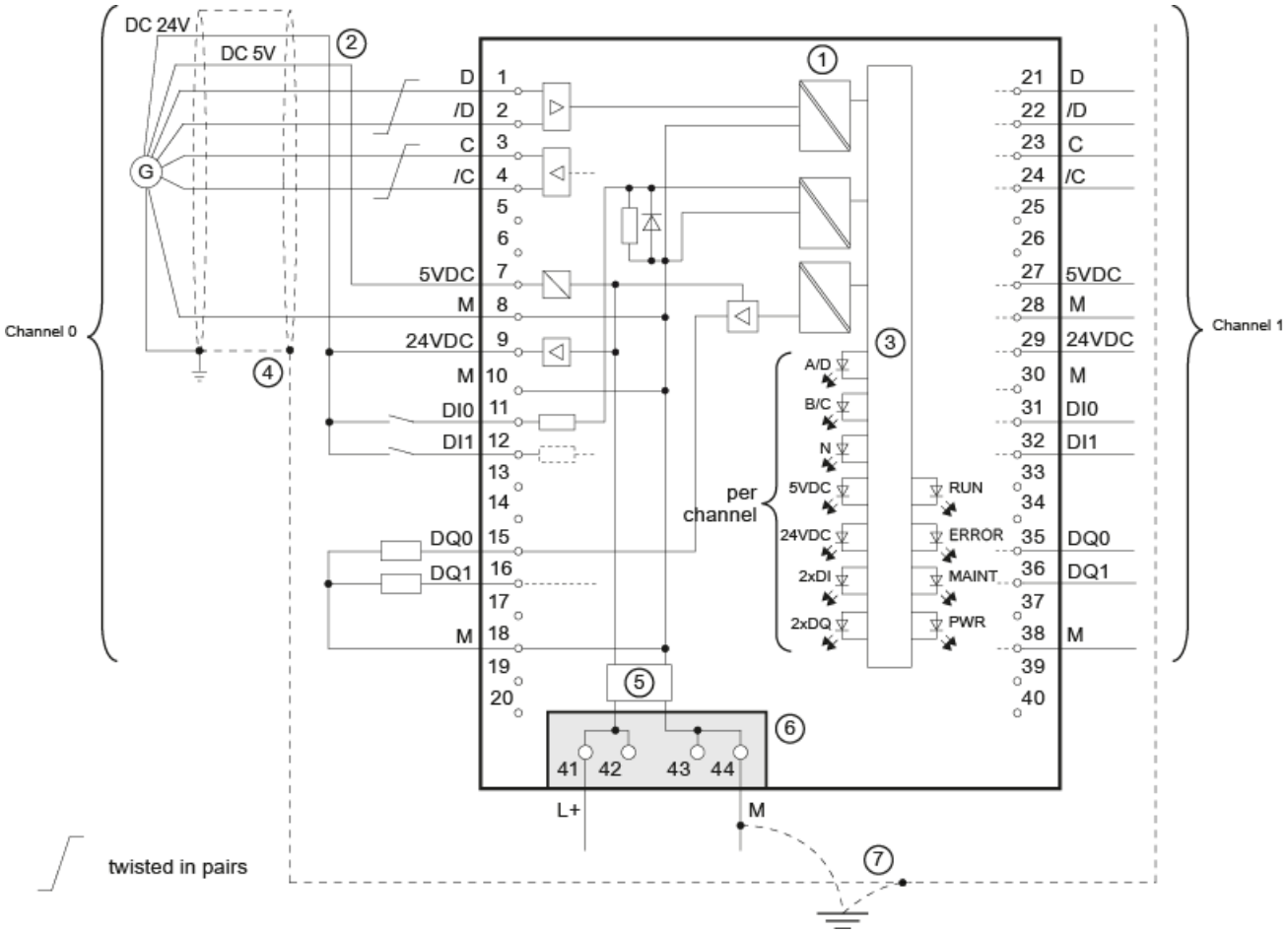
The figure below shows the block diagram of the technology module with one connected TTL incremental encoder.



① Electrical isolation
② Encoder supply either DC 5V or DC 24V as per encoder manufacturer instructions
③ Technology and backplane bus interface
④ Shield support at the front connector
⑤ Input filter
⑥ Supply voltage via power supply element
⑦ Equipotential bonding

Figure 3-3 Block diagram with TTL incremental encoder

The figure below shows the block diagram of the technology module with one connected SSI absolute encoder.



① Electrical isolation
② Encoder supply either DC 5V or DC 24V as per encoder manufacturer instructions
③ Technology and backplane bus interface
④ Shield support at the front connector
⑤ Input filter
⑥ Supply voltage via power supply element
⑦ Equipotential bonding

Figure 3-4 Block diagram with SSI absolute encoder

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors the connection of the supply voltage.

Encoder supplies 24VDC and 5VDC

To supply the encoders, the technology module supplies the DC 24V and DC 5V supply voltage at the 24VDC and 5VDC outputs with reference to M. To supply the sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output. Voltage is supplied from the L+/M supply voltage and monitored for short circuits and overload.

RS422/TTL counting signals and SSI encoder signals

The TM PosInput can process either counting or SSI encoder signals. The counting encoder signals are designated A, B and N and use either the RS422 or TTL signal standard. The SSI encoder signals are designated DAT (letter D) and CLK (letter C) and use the RS422 signal standard.

An encoder signal with TTL standard uses a single cable. An RS422 encoder signal uses one cable pair and the count/SSI information is transmitted as differential voltage. This ensures interference-free transmission of RS422 encoder signals even with high frequencies over long distances. The RS422 line pairs must be twisted together in the cable.

You can connect the following encoder types:

- SSI absolute encoder:

  The SSI encoder signals CLK and DAT are connected via the C and D terminals. The N terminals remain disconnected.

- RS422/TTL incremental encoder with signal N:

  The encoder signals A, B and N are connected using the terminals labeled accordingly. A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal which returns one pulse per revolution.

- RS422/TTL incremental encoder without signal N:

  The encoder signals A and B are connected via the terminals labeled accordingly. A and B are the two incremental signals phase-shifted by 90°. The N terminals remain disconnected.

- RS422/TTL pulse encoder without direction signal:

  The counting signal is connected at the A terminals. The count direction is specified via the control interface. The B and N terminals remain disconnected.

- RS422/TTL pulse encoder with direction signal:

  The counting signal is connected at the A terminals. The direction signal is connected at the B terminals. The N terminals remain disconnected.

- RS422/TTL pulse encoder with up/down counting signal:

  The up counting signal is connected at the A terminals. The down counting signal is connected at the B terminals. The N terminals remain disconnected.

The inputs of the two channels are not isolated from each other. The inputs are isolated against the backplane bus.

Note

The RS422 signal standard offers greater interference immunity than the TTL signal standard. If your incremental encoder or pulse encoder supports the RS422 **and** the TTL signal standard, we recommend using the RS422 signal standard.

Input filter for RS422/TTL signals from incremental encoders and pulse encoders

To suppress interference, you can configure an input filter for the encoder inputs A, B and N. The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This produces a set minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can specify the following values for the filter frequency:

Table 3- 2 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz	2.0 µs
500 kHz	0.8 µs
1 MHz (default)	0.4 µs

Digital inputs DI0 and DI1

Two digital inputs are available per counting channel. The digital inputs are used for gate control, synchronization and the Capture function. Alternatively, you can use one or both digital inputs without the functions named and read the signal state of the respective digital input via the feedback interface.

The digital inputs of the two counting channels are not isolated from each other.

Input filters for digital inputs

To suppress interferences, you can configure an input filter for the digital inputs.

You can specify the following values for the filter time:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

Two digital outputs are available per channel. The two digital outputs DQ0 and DQ1 can be activated/switched directly by the specified comparison values or by the user program.

The digital outputs of the two channels are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A. They are protected from overload and short-circuit.

Note

Relays and contactors can be connected direct without external circuitry. Information on the maximum possible operating frequencies and the inductance values of the inductive loads at the digital outputs is available in the chapter Technical specifications (Page 45).

Configuring/address space 4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central and distributed operation in an S7-1500 system with a corresponding ET 200MP system	• S7-1500 automation system • ET 200MP distributed I/O system • TM PosInput 2	STEP 7 (TIA Portal): • Device configuration with hardware configuration (HWCN) • Parameter setting with High_Speed_Counter technology object	Position input: Direct access to the control and feedback interface (Page 33) of the TM PosInput 2 in the I/O data Counting and measuring functions: High_Speed_Counter instruction for the technology object
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200MP distributed I/O system • TM PosInput 2	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 33) of the TM PosInput 2 in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200MP distributed I/O system • TM PosInput 2	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 33) of the TM PosInput 2 in the I/O data

Additional information

A detailed description of the counting and measuring functions and their configuration is available:

- In the Counting, measurement and position input function manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position input" > Counting, measurement and position input (S7-1500)"

A detailed description of the use of Motion Control and its configuration is available:

- In the S7-1500 Motion Control function manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

The GSD files for the ET 200MP distributed I/O system are available for download from the Internet (http://support.automation.siemens.com/WW/view/en/68189683).

4.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module for each channel to CPU STOP in the basic parameters of the device configuration.

Table 4- 1 Response of the technology module to CPU STOP depending on parameter assignment

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the position value is read in. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

4.3 Address space

Address space of the technology module

Table 4- 2 Range of the input addresses and output addresses of the TM PosInput 2

	Inputs	Outputs
Range per counting channel	16 bytes	12 bytes
Total range	32 bytes	24 bytes

Table 4- 3 Range of the input and output addresses of the TM PosInput 2 in the "Position input for Motion Control" mode

	Inputs	Outputs
Range per counting channel	16 bytes	4 bytes
Total range	32 bytes	8 bytes

Additional information

A description on how to use the control and feedback interface of TM PosInput 2 can be found in the chapter Control and feedback interface (Page 33).

4.4 Control and feedback interface

Information on using the control and feedback interface can be found in the chapter Configuring (Page 29).

A detailed description of the TM PosInput 2 control and feedback bits is available in the Counting, measurement and position input function manual which can be downloaded from the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.4.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0	Specifies the significance of the value in Slot 0				
		Bit 3	Bit 2	Bit 1	Bit 0	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load Start value (with incremental encoder or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load Low counting limit (with incremental encoder or pulse encoder)
		0	1	1	1	Load High counting limit (with incremental encoder or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load Start value (with incremental encoder or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load Low counting limit (with incremental encoder or pulse encoder)
		0	1	1	1	Load High counting limit (with incremental encoder or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable synchronization down (with incremental encoder or pulse encoder)				
	EN_SYNC_UP	Bit 5: Enable synchronization up (with incremental encoder or pulse encoder)				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate (with incremental encoder or pulse encoder)				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

4.4.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current counter value or position value
Bytes 4 to 7	CAPTURED VALUE	The last acquired Capture value
Bytes 8 to 11	MEASURED VALUE	Current measured value or complete SSI frame
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Faulty encoder signal or SSI frame
	POWER_ERROR	Bit 0: Incorrect supply voltage L+
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status (with incremental encoder or pulse encoder)
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and carried out (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and carried out (toggling)
	RES_EVENT_ACK	Bit 1: Resetting of status bits active
	–	Bit 0: Reserve; set to 0
Byte 14	–	Bit 7: Reserve; set to 0
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Internal gate status (with incremental encoder or pulse encoder)
	STS_CNT	Bit 1: Count pulse or position value change detected within the last 0.5 s
	STS_DIR	Bit 0: Direction of last counter value or position value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse or position value change detected in previous measurement interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred (with incremental encoder or pulse encoder)
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A zero pass has occurred

Interrupts/diagnostic messages

5

5.1 Status and error displays

LEDs

The following figure shows you the LED displays (status and error displays) of TM PosInput 2.

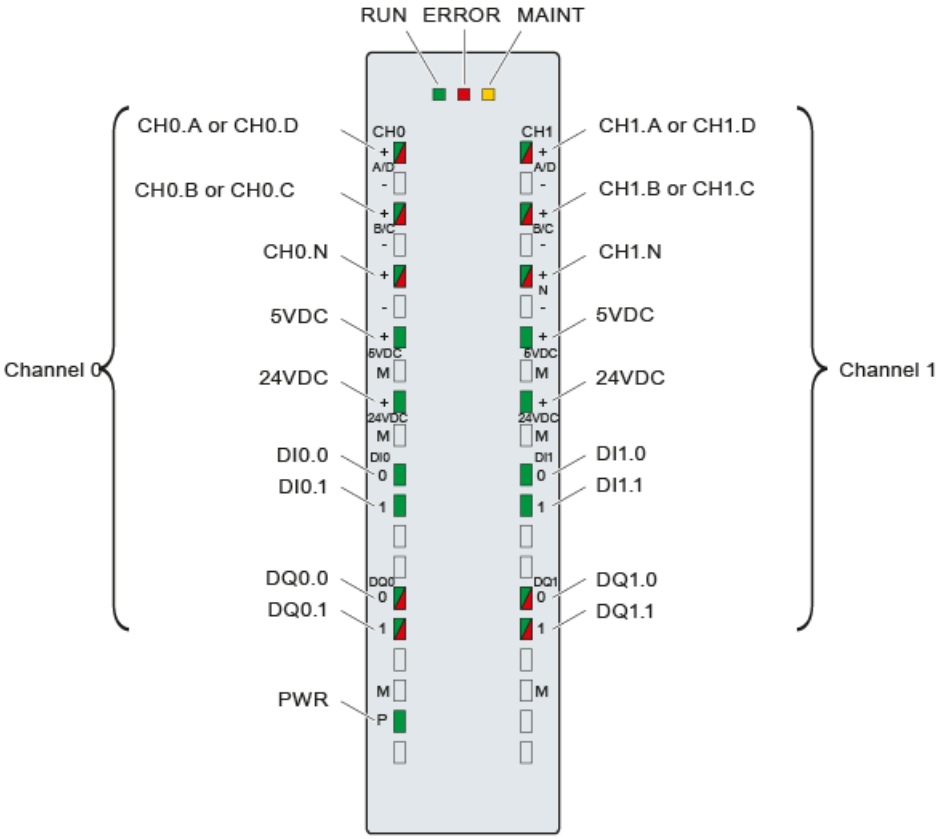


Figure 5-1 LEDs of the TM PosInput 2

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic messages (Page 40).

Table 5- 1 Status and error displays RUN/ERROR/MAINT

LEDs			Meaning	To correct or avoid errors
RUN	ERROR	MAINT		
Off	Off	Off	Supply voltage from CPU/power supply module not present or too low	Check or turn on the supply voltage at the PS, at the CPU or at the interface module.
Flashes	Off	Off	The technology module starts and flashes until parameter assignment is complete	---
On	Off	Off	The parameters of the technology module have been assigned.	
On	Flashes	Off	Indicates a group error (at least one active error)	Evaluate the diagnostic alarms and eliminate the error.
Flashes	Flashes	Flashes	Hardware or firmware defective	Replace the technology module.

ChannelLEDs

The LEDs CHn.A, CHn.B, CHn.N andDIn.m indicate the current level of the associated signals. The LEDs of the digital outputs DQn.m indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

If you are using an SSI absolute encoder, the LEDs CHn.D and CHn.C light up in green during transmission of the encoder frame and in red if an error has occurred. The LEDs CHn.D and CHn.C are off if an encoder frame is not transmitted or if an error has occurred for which the diagnostic interrupt has not been enabled.

Table 5- 2 Status displays CHn.m/DIn.m/DQn.m

LEDs CHn.m/DIn.m/DQn.m	Meaning	To correct or avoid errors
Off	Counter input/digital input/digital output at 0 level	---
On	Counter input/digital input/digital output at 1 level.	---
On (CHn.m/DQn.m)	Diagnostic alarm: for example, wire break, short-circuit, faulty voltage	Check the wiring or the connected load.

Table 5- 3 PWR/24VDC/5VDC/ERROR status displays

LEDs			Meaning	To correct or avoid errors
PWR	24VDC/ 5VDC	ERROR		
Off	Off	Flashes	Supply voltage too low or missing	• Check the supply voltage. • Make sure that the front connector is correctly inserted.
On	On	Off	Supply voltage is present and OK	---
On	Off	Flashes	Short-circuit or overload at the encoder supply	• Correct the encoder wiring. • Check the loads connected to the encoder supply.

5.2 Diagnostic messages

Diagnostic alarms

If a diagnostic alarm is pending, the ERROR-LED is flashing.

The diagnostic alarms are displayed as clear text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 5- 4 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code		Meaning	To correct or avoid errors
	Dec.	Hex.		
Hardware interrupt lost	22_D	16_H	• Technology module cannot send an interrupt because a previous interrupt has not been processed • Possible causes: – Parameter assignment error – Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-assign technology module parameters correspondingly
Internal error	256_D	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	259_D	103_H	Firmware error	Run firmware update
			Technology module defective	Replace technology module
External auxiliary voltage missing	266_D	$10A_H$	No technology module L+ supply voltage	Provide L+ supply voltage to technology module
			Front connector not inserted correctly	Insert front connector correctly
Short circuit or overload at external encoder supply	270_D	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Correction of encoder wiring • Check consumers connected to encoder supply
Error at digital outputs	271_D	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload – External feed	• Correct the wiring at the digital outputs • Check consumers connected to the digital outputs
Faulty external auxiliary voltage	272_D	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the L+ supply voltage

Diagnostic alarm	Error code		Meaning	To correct or avoid errors
	Dec.	Hex.		
Illegal A/B signal ratio	1280_D	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain specifications • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Correct the process wiring • Check encoder/sensor • Check parameter assignment
RS422/TTL error	1282_D	502_H	• Error at RS422 or TTL encoder connection • Possible causes: – Wire break – No encoder connected – Cable too long – Short circuit – Overload – External voltage – Overheating – Parameter assignment error	• Correct the process wiring • Check encoder/sensor • Check parameter assignment
Error at SSI encoder	1283_D	503_H	• Error at SSI absolute encoder connection • Possible causes: – Wire break – Cable too long – Frame error (error of the start bit or stop bit) – Parity error – Parameter assignment error	• Correct the process wiring • Check encoder/sensor • Check parameter assignment
Overheating	1286_D	506_H	• Short circuit or overload at the digital outputs or outputs of the encoder supplies • Ambient temperature outside specifications	• Correct the process wiring • Improve cooling • Check connected loads

5.3 Interrupts

5.3.1 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupt for wire break and the diagnostic interrupts for additional errors in the basic parameters during device configuration.

A list of all errors that can trigger a diagnostic interrupt is available at Cause of the error triggering a diagnostic interrupt (Page 43).

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The ERROR LED flashes.

  Once you have remedied the error, the ERROR LED goes out.
- The S7-1500 CPU interrupts processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

Default setting

These diagnostic interrupts are not enabled in the default setting.

5.3.2 Cause of the error triggering a diagnostic interrupt

Which errors can trigger a diagnostic interrupt?

The technology module can trigger the following diagnostic interrupts:

Table 5- 5 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• RS422/TTL error	Monitoring is always active. An error detected only triggers a diagnostic interrupt if "Enable diagnostic interrupt on wire break" has been enabled in the device configuration.
• Hardware interrupt lost • External auxiliary voltage missing • Short circuit or overload at external encoder supply • Error at digital outputs • Faulty external auxiliary voltage • Error at SSI encoder • Illegal A/B signal ratio • Overheating	Monitoring is always active. An error detected only triggers a diagnostic interrupt if "Enable additional diagnostic interrupts" has been enabled in the device configuration.

5.3.3 Triggering of a Hardware Interrupt

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a Hardware Interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Activating the hardware interrupts

You activate the hardware interrupts in STEP 7 (TIA Portal) under "Basic parameters > Channel 0 or 1 > Hardware interrupts" during device configuration of the technology module.

A list of the individual hardware interrupts is available at Events which can trigger a hardware interrupt (Page 44).

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but there is an identical, previous event which has not yet been processed, no further hardware interrupt will be triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Default setting

No hardware interrupts are activated in the default setting.

5.3.4 Events which can trigger a hardware interrupt

Which events can trigger a hardware interrupt?

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

The following two tags, among others, are entered in the start information of the assigned hardware interrupt OB when a process interrupt is triggered:

- EventType: Number of the event type to which the event triggering the interrupt belongs
- IChannel: Number of the channel that triggered the hardware interrupt

You can configure hardware interrupts to be triggered for the following event types:

Hardware interrupt	EventType number
Internal gate opening (Gate start)[1]	1
Internal gate closing (Gate stop)[1]	2
Overflow (high counting limit violated)	3
Underflow (low counting limit violated)	4
Compare event for DQ0 has occurred	5
Compare event for DQ1 has occurred	6
Zero pass	7
New Capture value available[2]	8
Synchronization of the counter by an external signal[1]	9
Direction reversal[3]	10

1) Not for SSI absolute encoder

2) Can only be configured in Counting mode

3) The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first counter value or position value is changed immediately after switching on the technology module in *down direction*.

You can activate any combination of events to trigger hardware interrupts.

Technical specifications

6

	6ES7551-1AB00-0AB0
Product type designation	TM PosInput 2
General information	
Product function	
• I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 SP1 / V12.0 SP1
STEP 7 can be configured/integrated as of version	as of V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	V1.0 / 5.0
PROFINET as of GSD version/GSD revision	V2.3 / -
Installation type/mounting	
• Rail mounting possible	Yes; S7-1500 mounting rail
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• Low limit of valid range (DC)	19.2 V
• High limit of valid range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption, max.	75 mA; without load
Encoder supply	
• Number of outputs	4; one 5V and one 24V encoder supply per channel
5 V encoder supply	
• 5 V	Yes; 5.2 V +/-2%
• Short-circuit protection	Yes
• Output current, max.	300 mA; per channel
24 V encoder supply	
• 24 V	Yes; L+ (-0.8 V)
• Short-circuit protection	Yes
• Output current, max.	300 mA; per channel

	6ES7551-1AB00-0AB0
Power	
• Power from the backplane bus	1.3 W
Power loss	
• Power loss, typ.	5.5 W
Address area	
Occupied address area	
• Inputs	16 bytes; per channel
• Outputs	12 bytes; per channel; 4 bytes with Motion Control
Digital inputs	
• Number of inputs	4; 2 per channel
• Digital inputs, configurable	Yes
• Input characteristics to IEC 61131, Type 3	Yes
Digital input functions, configurable	
• Gate start/stop	Yes; (only with pulse & incremental encoder)
• Capture	Yes
• Synchronization	Yes; (only with pulse & incremental encoder)
• Freely assignable digital input	Yes
Input voltage	
Type of input voltage	DC
• Rated value, DC	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
• Permitted voltage at input, max.	30 V
• Permitted voltage at input, min.	-30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "1" to "0", min.	6 µs; with parameter assignment "none"
For counters/technological functions	
• Configurable	Yes
Cable length	
• Cable length shielded, max.	1000 m
• Cable length unshielded, max.	600 m

	6ES7551-1AB00-0AB0
Digital outputs	
Type of digital output	Transistor
• Number of outputs	4; 2 per channel
• Digital outputs, configurable	Yes
• Short-circuit protection	Yes; electronic/thermal
Response threshold, typ.	1 A
Limiting of inductive shutdown voltage to	L+ (-33 V)
• Control of a digital input	Yes
Digital output functions, configurable	
• Switch at comparison values	Yes
• Freely assignable digital output	Yes
Output switching capacity	
• With resistive load, max.	0.5 A; per digital output
• With lamp load, max.	5 W
Load resistance range	
• Low limit	48 Ω
• High limit	12 kΩ
Output voltage	
Type of output voltage	DC
• for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
• for signal "1" rated value	0.5 A; per digital output
• for signal "1" permissible range, max.	0.6 A; per digital output
• for signal "1" minimum load current	2 mA
• for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs
• "1" to "0", max.	50 µs
Switching frequency	
• With resistive load, max.	10 kHz
• With inductive load, max.	0.5 Hz; to IEC 947-5-1, DC-13; observe derating curve
• With lamp load, max.	10 Hz
Total current of outputs	
• Max. current per module	2 A
Cable length	
• Cable length shielded, max.	1000 m
• Cable length unshielded, max.	600 m

	6ES7551-1AB00-0AB0
Encoders	
Supported encoders	
• 2-wire sensor	Yes
• Permitted quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoder (symmetrical)	
Input voltage	RS 422
• Input frequency, max.	1 MHz
• Counting frequency, max.	4 MHz; with quadruple evaluation
• Signal filter, configurable	Yes
• Cable length shielded, max.	32 m; with 1 MHz
• Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
• Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one pulse signal per count direction	Yes
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	TTL 5 V
• Input frequency, max.	1 MHz
• Counting frequency, max.	4 MHz; with quadruple evaluation
• Signal filter, configurable	Yes
• Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
• Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one pulse signal per count direction	Yes

	6ES7551-1AB00-0AB0
Encoder signals, absolute encoder (SSI)	
Input signal	to RS 422
Frame length, configurable	10 to 40 bits
• Clock frequency, max.	2 MHz; 125 kHz, 250 kHz, 500 kHz, 1 MHz, 1.5 MHz or 2 MHz
Binary code	Yes
Gray code	Yes
• Cable length shielded, max.	320 m; Cable length, RS-422 SSI absolute encoders, Siemens type 6FX2001-5, 24 V supply: 125 kHz, 320 meters shielded, max.; 250 kHz, 160 meters shielded, max.; 500 kHz, 60 meters shielded, max.; 1 MHz, 20 meters shielded, max.; 1.5 MHz, 10 meters shielded, max.; 2 MHz, 8 meters shielded, max.
• Parity bit, configurable	Yes
Monoflop time	16, 32, 48, 64 µs & automatic
• Multi-turn	Yes
• Single-turn	Yes
Interface hardware	
• RS422	Yes
• TTL 5 V	Yes
Isochronous mode	
• Isochronous mode (application synchronized until terminal)	Yes
• Filter and processing time (TWE), min.	130 µs; (only with pulse & incremental encoder)
• Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	Yes
Diagnostic alarms	
• Monitoring of supply voltage	Yes
• Wire break	Yes
• Short circuit	Yes
• A/B transition error with incremental encoder	Yes
• Frame error with SSI encoder	Yes

	6ES7551-1AB00-0AB0
LED diagnostics display	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; yellow LED
• Monitoring of supply voltage	Yes; green LED
• Channel status display	Yes; green LED
• For channel diagnostics	Yes; red LED
Integrated functions	
• Number of counters	2
• Counting frequency (counters), max.	4 MHz; with quadruple evaluation
Counting functions	
• Can be used with TO High_Speed_Counter	Yes; (only with pulse & incremental encoder)
• Continuous counting	Yes
• Counter response configurable	Yes
• Hardware gate by means of digital input	Yes
• Software gate	Yes
• Event-triggered stop	Yes
• Synchronization by means of digital input	Yes
• Counting range, configurable	Yes
Comparator	
• Number of comparators	2; per channel
• Direction-dependent	Yes
• Can be changed from user program	Yes
Position detection	
• Incremental detection	Yes
• Absolute detection	Yes
• Suitable for S7-1500 Motion Control	Yes

	6ES7551-1AB00-0AB0
Measuring functions	
• Measuring time, configurable	Yes
• Dyn. measuring time adjustment	Yes
• Number of threshold values, configurable	2
Measuring range	
• Frequency measurement, max.	4 MHz
• Frequency measurement, min.	0.04 Hz
• Period measurement, max.	25 s
• Period measurement, min.	0.25 µs
Accuracy	
Frequency measurement	100 ppm; depends on measuring interval and signal evaluation
Velocity measurement	100 ppm; depends on measuring interval and signal evaluation
Period measurement	100 ppm; depends on measuring interval and signal evaluation
Electrical isolation	
Electrical isolation channels	
• Between the channels	No
• Between the channels and the backplane bus	Yes
• Between the channels and load voltage L+	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C; consider derating with inductive loads
• Vertical installation, min.	0 °C
• Vertical installation, max.	40 °C; consider derating with inductive loads
Storage/transport temperatures	
• Min.	-40 °C
• Max.	70 °C

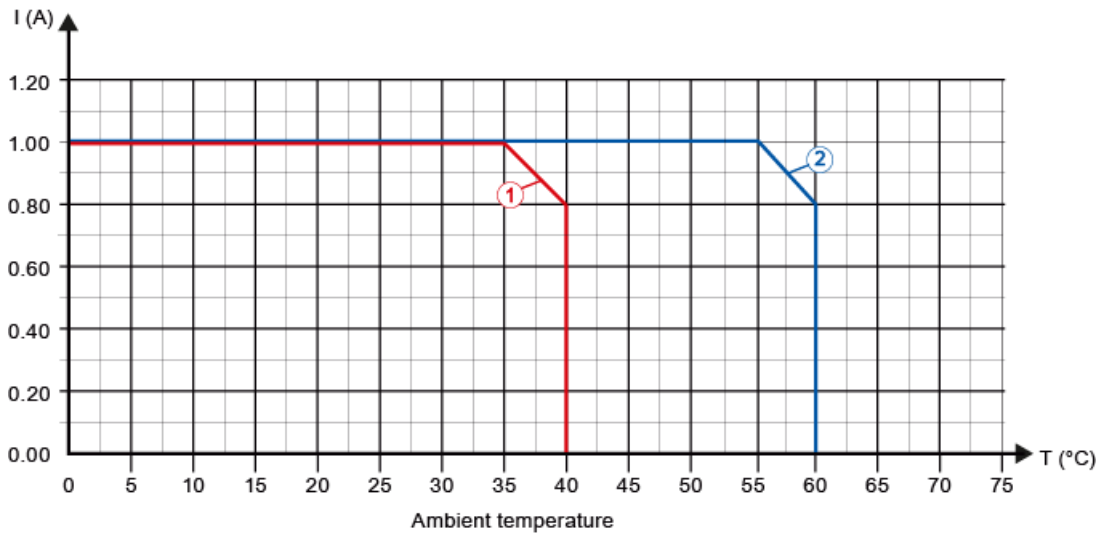
	6ES7551-1AB00-0AB0
Air pressure	
• Operation, min.	795 hPa
• Operation, max.	1080 hPa
• Transport/storage, min.	660 hPa
• Transport/storage, max.	1080 hPa
Distributed operation	
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes
Dimensions	
• Width	35 mm
• Height	147 mm
• Depth	129 mm
Weights	
• Weight, approx.	325 g

Derating information for total current of outputs

If the digital outputs of the TM PosInput 2 are operated with inductive loads, you should derate the total current of the loads at the digital outputs of the respective channel. The total current is the sum of the load currents at all digital outputs of a channel (without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)



① Vertical installation of the system

② Horizontal installation of the system

Figure 6-1 Total current depending on ambient temperature and mounting position for inductive loads

---

Note

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimensional drawing

A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front panel, are provided in the appendix. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

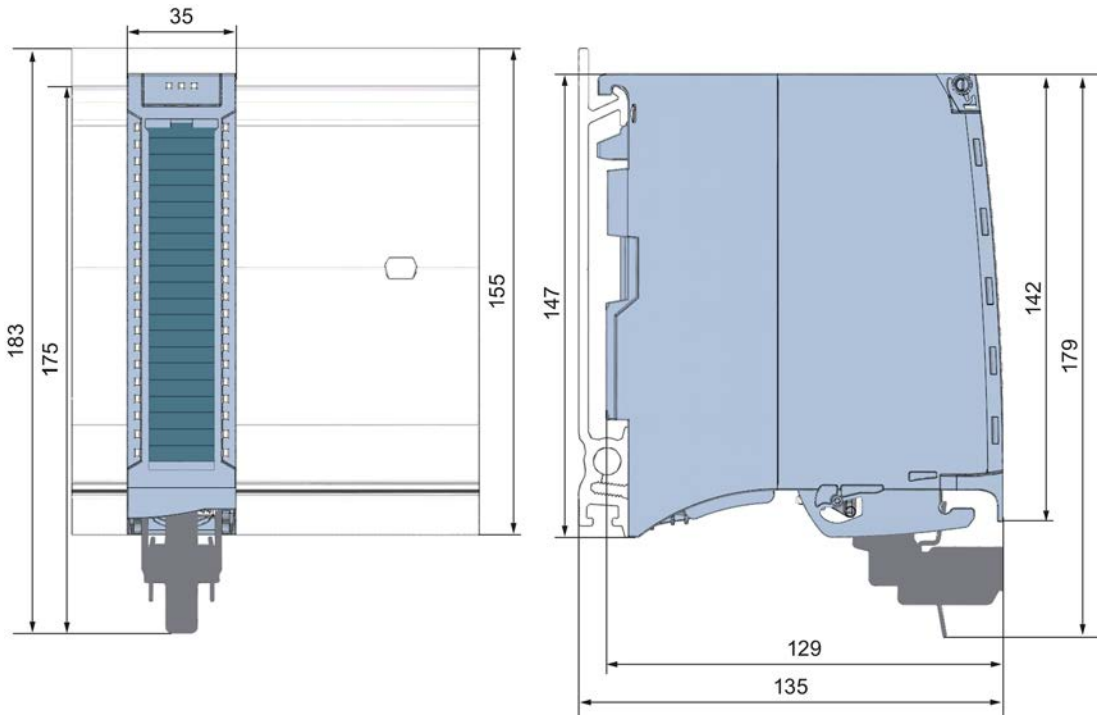


Figure A-1 Dimensional drawing of the TM PosInput 2 technology module

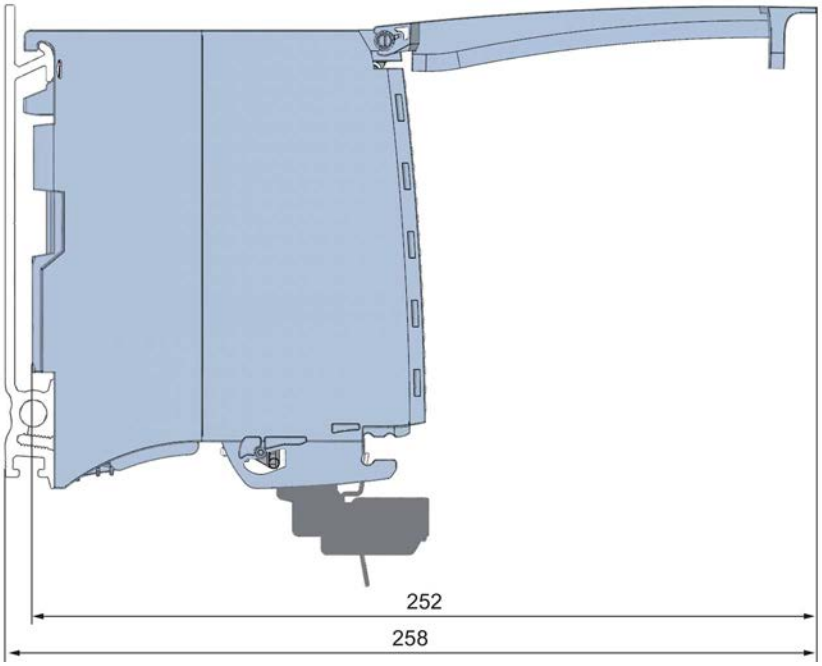


Figure A-2 Dimensional drawing of the TM PosInput 2 module, side view with open front panel

Parameter data records

B

You may edit the module parameters in RUN. The WRREC instruction is used to transfer the parameters to the module using data record 128.

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the STEP 7 (TIA Portal) Online Help.

Structure of the data record for central and distributed configuration with PROFINET

The following table shows you the structure of data record 128 for TM PosInput 2 with 2 channels. The values in byte 0 to byte 3 are fixed and may not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode of the CPU.

Table B- 1 Parameter data record 128 for central and distributed configuration with PROFINET

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of the parameter data per channel = 48							
2	Reserved[2)]							
3	Reserved[2)]							
4...51	**Channel 0**							
52...99	**Channel 1**							
4/52	**Operating mode**							
4/52	Reserved[2)]				Operating mode:			
					0000_B: Reserved			
					0001_B: Counting/Position input			
					0010_B: Measuring			
					0011 to 1111_B: Reserved			

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
5/53	**Basic parameters**							
5/53	Interface standard:	Reserved[2]				Enable additional diagnostic interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
	00_B: RS422, symmetrical						10_B: Continue operation	
	01_B: TTL (5 V), asymmetrical						11_B: Reserved	
6...7/ 54...55	**Counter inputs** (parameters for incremental encoders and pulse encoders)							
6/54	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Reserved		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Reserved			
7/55	Reaction to signal N:		Invert direction[1]	Enable diagnostics interrupt at wire break[1]	Filter frequency:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
	01_B: Synchronization at signal N				0001_B: 200 Hz			
	10_B: Capture at signal N				0010_B: 500 Hz			
	11_B: Reserved				0011_B: 1 kHz			
					0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011_B: 500 kHz			
					1100_B: 1 MHz			
					1101 to 1111_B: Reserved			

Bit → Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6...7/ 54...55	**Counter inputs** (parameters for SSI absolute encoder)							
6/54	Monoflop time:			Code type:	Signal type:			
	000_B: Automatically			0_B: Gray	0000_B: Pulse (A)			
	001_B: 16 µs			1_B: Dual	0001_B: Pulse (A) and direction (B)			
	010_B: 32 µs				0010_B: Count up (A), count down (B)			
	011_B: 48 µs				0011_B: Incremental encoder (A, B phase-shifted)			
	100_B: 64 µs				0100_B: Incremental encoder (A, B, N)			
	101 to 111_B: Reserved				0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Reserved			
7/55	Parity:		Invert direction[1]	Enable diagnostics interrupt at wire break[1]	Reserved[2]	Transmission rate:		
	00_B: None					000_B: 125 kHz		
	01_B: Even					001_B: 250 kHz		
	10_B: Odd					010_B: 500 kHz		
	11_B: Reserved					011_B: 1 MHz		
						100_B: 1.5 MHz		
						101_B: 2 MHz		
						110 to 111_B: Reserved		
8...9/ 56...57	**Hardware interrupts**[1]							
8/56	Reserved[2]	Reserved[2]	Reserved[2]	Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop[3]	Gate start[3]
9/57	Synchronization of the counter by an external signal[3]	New Capture value available	Reserved[2]	Zero pass	Reserved[2]	Comparison event for DQ1 has occurred	Reserved[2]	Comparison event for DQ0 has occurred

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
10...15/ 58...63	**Behavior of a DQ**							
10/58	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value				0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value			
	0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value				0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Reserved			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Reserved			
	0111 to 1111_B: Reserved							
11/59	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Forward		01_B: Forward					
	10_B: Backward		10_B: Backward					
	11_B: In both directions		11_B: In both directions					
12/60	Pulse duration (DQ0):							
13/61	WORD: Value range in ms/10: 0 to 65535_D							
14/62	Pulse duration (DQ1):							
15/63	WORD: Value range in ms/10: 0 to 65535_D							
16/64	**Behavior of DI0**							
16/64	Behavior of counter value after Capture[3] (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Reserved				000_B: Gate start/stop (level-triggered)[3]		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)[3]		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)[3]		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization[3]		
						100_B: Enable synchronization at signal N[3]		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Reserved		

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
17/65	**Behavior of DI1**: See Byte 16							
18/66	Reserved[2)]							
19/67	Frequency:	Reserved[2)]			Filter time:			
	0_B: Once				0000_B: None			
	1_B: Periodic				0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Reserved			
20...43/ 68...91	**Values**							
20...23/ 68...71	High counting limit[3)]: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
24...27/ 72...75	Comparison value 0: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
28...31/ 76...79	Comparison value 1: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
32...35/ 80...83	Start value[3)]: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36...39/ 84...87	Low counting limit[3)]: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
40...43/ 88...91	"Position input for Motion Control" mode: **Reference speed**: DWORD: Value range in 10^{-2} rpm: 600 to 21000000_D; Other mode: **Update time**: DWORD: Value range in µs: 0 to 25000000_D							
44/92	**Counter behavior at limits and gate start**							
44/92	Reaction to gate start[3)]:	Reaction to violation of a counting limit[3)]:	Reset when counting limit is violated[3)]:					
	00_B: Set to start value	000_B: Stop counting	000_B: To other counting limit					
	01_B: Continue with current value	001_B: Continue counting	001_B: To start value					
	10 to 11_B: Reserved	010 to 111_B: Reserved	010 to 111_B: Reserved					

Bit → / Byte channel 0/1 ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
45/93	**Specify measured value**							
45/93	Reserved[2]			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Complete SSI frame	
				100_B: 60 s/1 min				
				101 to 111_B: Reserved				
46/94	Increments per unit:							
47/95	DWORD: Value range: 1 to 65535_D							
48/96	Set the hysteresis range: Value range: 0 to 255_D							
49...51/ 97...99	**Parameters for SSI absolute encoder**							
49/97	Reserved[2]		Frame length: Value range: 10 to 40_D					
50/98	Reserved[2]		Bit number LSB of the position value: Value range: 0 to 38_D					
51/99	Reserved[2]		Bit number MSB of the position value: Value range: 1 to 39_D					

1) You enable a specific parameter by setting the corresponding bit to 1.

2) Reserved bits must be set to 0

3) For signal type"Absolute encoder (SSI)": Reserved[2]

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SIMATIC NET

S7-1500 - PROFIBUS CP 1542-5

Manual

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07/2013

C79000-G8976-C326-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Order number: C79000-G8976-C326
Ⓟ 07/2013 Technical data subject to change

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Preface

Purpose of the documentation

This device manual supplements the system manual of the S7-1500 automation system and the function manuals. All functions that go beyond the system are described in the system manual.

With the information in this manual and the system manual, you will be able to commission the CP 1542-5.

See also Guide to the documentation (Page 7)

Conventions

Make sure you read the special notices below:

Note

A notice contains important information on the product described in the documentation, handling the product or about parts of the documentation you should pay particular attention to.

Names

- In this document, the term "CP" is also used instead of the full product name.
- The name STEP 7 is used to mean the TIA Portal/STEP 7 Professional configuration tool.

SIMATIC NET glossary

Explanations of the specialist terms used in this documentation can be found in the SIMATIC NET glossary.

You will find the SIMATIC NET glossary here:

- SIMATIC NET Manual Collection

  The DVD ships with certain SIMATIC NET products.
- On the Internet under the following entry ID:

  50305045 (http://support.automation.siemens.com/WW/view/en/50305045)

Note on the OSS license readme - S7 CP

License conditions

Note

Open source software

Read the license conditions for open source software carefully before using the product. The acceptance of the disclaimers of liability and warranty it contains is a clear precondition of the use of open source software.

You will find the license conditions on the same data medium as this manual under the following file name:

DOC_OSS-S7-CM-CP_74.pdf

Note on IT security

Siemens offers security mechanisms for its automation and drive product portfolio to support the safe operation of the plant/machine. Our products are continuously being further developed also taking into account the aspect of industrial security. We therefore recommend that you regularly check for updates of our products and that you only use the latest versions. You can find information on this on the Internet.

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet.

Products used from other manufacturers should also be taken into account here.

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Guide to the documentation 1

Introduction

The documentation of the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (online help) also supports you when configuring and programming your automation system.

Overview of the documentation on communication with S7-1500

The following table lists additional documents that supplement this description of the CP 1542-5 and are available in the Internet.

Table 1- 1 Documentation for the CP 1542-5

Topic	Documentation	Most important contents
System description	System manual: S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
Module properties	Device manual: Power supplies (http://support.automation.siemens.com/WW/view/en/57251228)	• Connecting • Parameter assignment/ addressing • Interrupts, error messages, diagnostics and system alarms • Technical specifications • Dimensional drawing
	Device manual: Signal modules (http://support.automation.siemens.com/WW/view/en/59174020)	
System diagnostics	Function manual: System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation for hardware/software
Communication	Function manual: Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Overview
	Function manual: PROFINET with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)	• PROFINET basics • PROFINET functions • PROFINET diagnostics

Topic	Documentation	Most important contents
	Function manual: PROFIBUS with STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/59193579)	• PROFIBUS basics • PROFIBUS functions • PROFIBUS diagnostics
	Function manual: Web Server (http://support.automation.siemens.com/WW/view/en/59193560)	• Function • Operation
Interference-free installation of control systems	Function Manual: Interference-free installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Memory concept	Function manual: Structure and Use of the CPU Memory (http://support.automation.siemens.com/WW/view/en/59193101)	• Design • Principle of operation • Use
Cycle and response times	Function manual: Cycle and Response Times (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Calculations
Analog value processing	Function manual: Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559)	• Wiring options • Tables of measured values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

CP/CM documentation in the Manual Collection (order no. A5E00069051)

The "SIMATIC NET Manual Collection" DVD contains the device manuals and descriptions of all SIMATIC NET products current at the time it was created. It is updated at regular intervals.

Version History / Current Downloads for the SIMATIC NET S7 CPs/CMs

The "Version History/Current Downloads for SIMATIC NET S7 CPs (PROFIBUS)" provides information on all CPs available up to now for SIMATIC S7 (PROFIBUS).

An up-to-date version of this document can be found on the Internet (http://support.automation.siemens.com/WW/view/en/9836605)

Product overview

2

2.1 Properties

Order number, validity and product names

This description contains information on the following product

Communications processor CP 1542-5
Order number:6GK7 542-5FX00-0XE0
Hardware product version 1
Firmware version V1.0
CP for SIMATIC S7-1500

View of the CP

CP 1542-5

① LEDs
② Type plate
③ PROFIBUS interface: 1 x 9-pin D-sub female connector (RS-485)

Figure 2-1 View of the CP 1542-5 with closed (left) and open (right) front cover

Application

The communications processor CP 1542-5 is intended for operation in an S7-1500 automation system. The CP 1542-5 allows the connection of an S7-1500 station to a PROFIBUS field system.

Supported communications services

In its current configuration, the CP 1542-5 supports the following communications services:

- **PROFIBUS DP master (class 1)**
  - PROFIBUS DP according to EN 50170 DPV1, DP master
  - DP master mode for DP slaves complying with the PROFIBUS DPV0 and DPV1 standard
  - DP master mode for Siemens DP slaves
  - Direct data exchange (DP slave to DP slave)

    As a DP master, the CP 1542-5 is capable of enabling direct data exchange for "its" DP slaves.
  - SYNC / FREEZE

    The outputs or inputs can be synchronized by the user program using system function DPSYNC_FR.
- **PROFIBUS DP slave**

  PROFIBUS DP according to EN 50170 DPV1, DP slave

  Note

  DP master or DP slave

  Please note, however: The CP 1542-5 only supports operation either as DP master or DP slave.

- **S7 communication**
  - PG communication for uploading / downloading of S7 configuration, diagnostics and routing
  - Operator control and monitoring functions (HMI communication)

The services of the CP 1542-5 listed above can be used independently at the same time.

2.2 Further functions

Enabling /disabling DP slave - in the standard system

DP slaves can be activated and deactivated by the user program using system function D_ACT_DP.

Diagnostics requests

As a DP master (class 1), the CP 1542-5 supports diagnostics requests of a DP master (class 2).

Getting the bus topology in a DP master system

The CP 1542-5 operating as DP master supports the measurement of the PROFIBUS bus topology in a DP master system using a diagnostics repeater (DP slave).

System function DP_TOPOL in the user program can instruct diagnostics repeaters to measure the PROFIBUS BUS topology in a DP master system.

Time-of-day synchronization - time master or time slave

The CP 1542-5 can be enabled for time-of-day synchronization. As an alternative, the CP can be configured as time master or time slave on PROFIBUS.

- Time master: The CP is synchronized using the time of day in the S7-1500 station and outputs the time of day on PROFIBUS. The output interval can be set.
- Time slave: The CP receives time-of-day frames on PROFIBUS and outputs the time within the S7-1500 station. The output interval within the S7-1500 station is set permanently to 10 seconds.

Note

Recommendation for setting the time

It is advisable to set the time-of-day master so that time-of-day frames are sent at intervals of approximately 10 seconds. This achieves as small a deviation as possible between the internal time and the absolute time.

Web diagnostics

With the aid of Web diagnostics of the CPU, you read the diagnostics data from an S7 station via the Web browser on the PG/PC.

In terms of the CP, the Web pages provide the following information:

- Module and status information
- Special information on the DP master system (status of the DP slaves)

Functional characteristics 3

Note

Measured values of transfer or reaction times

Measurements of transfer and reaction times in Ethernet, PROFIBUS and PROFINET networks for a series of configurations can be found on the Internet (http://support.automation.siemens.com/WW/view/en/25209605)

3.1 Transmission speeds supported

The transmission speed is set with the SIMATIC STEP 7 configuration software.

Note

Remember the cable length

The permitted cable length must be kept to depending on the transmission speed.

Refer to the information in the section Technical specifications (Page 33)

3.2 Characteristic data of the DP interface

General characteristic data

No special program blocks are required for DP mode. The interfacing to the distributed I/O is by direct I/O access or using program blocks (SFCs/SFBs) of the CPU.

Table 3- 1 General characteristic data of DP mode

Characteristic	Explanation / values
Number of operable DP slaves	32
Max. size of the input area of all DP slaves	2 Kbytes
Max. size of the output area of all DP slaves	2 Kbytes
Maximum size of the input area per DP slave	244 bytes
Maximum size of the output area per DP slave	244 bytes
Max. size of the consistent area for a module	128 bytes

Diagnostics requests

As a DP master (class 1), the CP 1542-5 supports diagnostics requests of a DP master (class 2).

DP startup behavior

Note

Increasing the default value for startup parameters - configuration of the CPU

In some situations, it is necessary to increase the default value for the startup parameter "Parameter assignment time for the distributed I/O" in the configuration of the CPU:

- When there is a large number of modules (DP slaves) configured that can be assigned parameters

- When a high value is configured for the constant bus cycle time in the network properties of the PROFIBUS DP line.

3.3 Characteristics of S7 communication

General characteristic data

The following information is important when operating S7 connections:

Table 3- 2 General characteristics of S7 connections

Characteristic	Explanation / values
Number of S7 connections that can be operated via PROFIBUS	• Total that can be operated: 16 max. • Configurable: None (The value depends on the S71500 CPU being used.)

Requirements for use 4

4.1 Configuration limits

When using the CP type described here, the following limits apply:

- The number of CPs that can be operated in a rack depends on the CPU type being used.

  Note the information in the documentation of the CPU, see Guide to the documentation (Page 7)

4.2 Project engineering

Configuration and downloading the configuration data

When the configuration data is downloaded to the CPU, the CP 1542-5 is supplied with the relevant information. The configuration data can be downloaded to the CPU via any PROFIBUS or any PROFINET interface of the S7-1500 station;

The following version of STEP 7 is required:

STEP 7 version and additional modules	Functions of the CP
TIA Portal / STEP 7 Professional V12 SP1	The full functionality of the CP 1542-5 (6GK7 542 5FX00 0XE0) can be configured

4.3 Programming

Program blocks

For communications services, there are preprogrammed program blocks (instructions) available as the interface in your STEP 7 user program.

Table 4- 1 Instructions for PROFIBUS DP

System blocks and system functions	Meaning when used with CP
DPSYC_FR	DP slaves synchronize / freeze inputs (SYNC/FREEZE instruction)
DPNRM_DG	Reading the diagnostics data of a DP slave
DP_TOPOL	Detecting the topology for the DP master system
WRREC	Writing the data record of a DP slave

System blocks and system functions	Meaning when used with CP
RDREC	Reading the data record of a DP slave
GETIO	Reading the process image of a DP standard slave
SETIO	Transferring the process image of a DP standard slave
GETIO_PART	Reading the process image partition of a DP standard slave
SETIO_PART	Transferring the process image partition of a standard DP slave
D_ACT_DP	Disable / enable DP slaves
DPRD_DAT	Reading consistent data of a DP standard slave
DPWR_DAT	Writing consistent data of a DP standard slave
RALRM	Event-driven reading of interrupt information (diagnostics, pull/plug, hardware interrupt) and DPV1-specific interrupts (update, status, vendor-specific interrupt)

Refer to the documentation of the program blocks in the online help of STEP 7

Calling program blocks (instructions) for distributed I/O

Several calls are necessary for the instructions of the distributed I/O.

The time required to process the job depends on load, round-trip time and transmission speed. If these instructions are called in a loop within one cycle, the cycle time could be exceeded.

Exceptions:

- Only one call is required for the RALRM instruction "receive alarm".

Program blocks for DPV1 (according to the PNO standard) [1]:

- Instruction RDREC "Read data record from a DP slave" corresponds to SFC59 in terms of function
- Instruction WRREC "Write data record to a DP slave" corresponds to SFC58 in terms of function
- Instruction RALRM "Read interrupt information from a DP slave" - call in an interrupt OB

[1] PNO: PROFIBUS Users Organization

See also

8797900 (http://support.automation.siemens.com/WW/view/en/8797900)

Connecting up / commissioning 5

5.1 Important notes on using the device

Safety notices on the use of the device

The following safety notices must be adhered to when setting up and operating the device and during all associated work such as installation, connecting up, replacing devices or opening the device.

General notices

⚠ WARNING

Safety extra low voltage

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) by a Limited Power Source (LPS). (This does not apply to 100 V...240 V devices.)

This means that only SELV / LPS complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 must be connected to the power supply terminals. The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

General notices on use in hazardous areas

⚠ WARNING

Risk of explosion when connecting or disconnecting the device

EXPLOSION HAZARD

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

WARNING

Replacing components

EXPLOSION HAZARD

SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2 OR ZONE 2.

WARNING

Requirements for the cabinet/enclosure

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or a suitable enclosure.

WARNING

Restricted area of application

This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

WARNING

Restricted area of application

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

WARNING

LAN attachment

A LAN or LAN segment with the attachments belonging to it should be within a single low-voltage supply system and within a single building. Make sure that the LAN is in an of type A environment according to IEEE 802.3 or in a type 0 environment according to IEC TR 62101.

Never establish a direct electrical connection to TNV networks (telephone network) or WANs (Wide Area Network).

General notices on use in hazardous areas according to ATEX

WARNING

Requirements for the cabinet/enclosure

To comply with EU Directive 94/9 (ATEX95), this enclosure must meet the requirements of at least IP54 in compliance with EN 60529.

WARNING

Suitable cables for temperatures in excess of 70 °C

If the cable or conduit entry point exceeds 70°C or the branching point of conductors exceeds 80°C, special precautions must be taken. If the device is operated at ambient temperatures above 50°C, the permitted temperature range of the selected cable must be suitable for the temperatures actually measured.

WARNING

Protection against transient voltage surges

Provisions shall be made to prevent the rated voltage from being exceeded by transient voltage surges of more than 40%. This criterion is fulfilled, if supplies are derived from SELV (Safety Extra-Low Voltage) only.

5.2 Installing and commissioning the CP 1542-5

WARNING

Read the system manual "S7-1500 Automation System"

Prior to installation, connecting up and commissioning, read the relevant sections in the system manual "S7-1500 Automation System" (references to documentation, refer to the section Guide to the documentation (Page 7)).

Make sure that the power supply is turned off when installing/uninstalling the devices.

Configuration

Commissioning the CP fully is only possible if the STEP 7 project data is complete.

Procedure for installation and commissioning

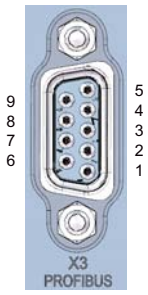
Step	Execution	Notes and explanations
1	When installing and connecting up, keep to the procedures described for installing I/O modules in the system manual "S7-1500 Automation System".	
3	Connect the CP to PROFIBUS via the RS-485 socket.	Underside of the CP
4	Turn on the power supply.	

Step	Execution	Notes and explanations
5	Close the front covers of the module and keep them closed during operation.	
6	The remaining steps in commissioning involve downloading the STEP 7 project data.	The STEP 7 project data of the CP is transferred when you download to the station. To load the station, connect the engineering station on which the project data is located to the Ethernet/MPI interface of the CPU. You will find more detailed information on loading in the following sections of the STEP 7 online help: • Downloading project data • Using online and diagnostics functions

PROFIBUS interface

The table below shows the terminal assignment of the PROFIBUS interface. The assignment corresponds to the standard assignment of RS485 interface.

Table 5- 1 Terminal assignment PROFIBUS interface

View	Signal name		Designation
	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	Data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

Note

PROFIBUS interface

The CP provides no 24 VDC power supply on the PROFIBUS interface. I/O devices (for example, PC adapter 6ES7972-0CB20-0XA0) are therefore not operational on the interface).

5.3 Replacing a module without a programming device

General procedure

The configuration data of the CP is stored on the CPU. This means that this module can be replaced by a module of the same type (identical order number) without using a PG.

5.4 Mode of the CPU - effect on the CP

You can change the mode of the CPU between RUN and STOP using the STEP 7 configuration software.

Depending on the operating status of the CPU, the CP behaves as described below.

Changing the CPU from STOP to RUN:

The CP loads configured and/or downloaded data into the work memory and then changes to RUN mode.

Changing the CPU from RUN to STOP:

The reaction is as follows in STOP:

- DP master mode: Change to the CLEAR mode.
- DP slave mode: Input data is sent to the DP master with the value "0" and a DP diagnostics alarm is sent.
- The following functions remain enabled:
  - The configuration and diagnostics of the CP (system connections for configuration, diagnostics, and PG channel routing are retained);
  - S7 routing function
  - Time-of-day synchronization

Interrupts, diagnostics messages, error and system alarms

6

The status and error displays of the CP 1542-5 are described below.

You can find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on "Diagnostics" and "System alarms" in the System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

6.1 Status and error display of the CP

LED display

The following figure shows the LEDs of the CP 1542-5 .

① RUN/STOP LED
② ERROR LED
③ MAINT LED

Figure 6-1 LED display of the CP 1542-5 (without front cover)

Meaning of the LED displays

The CP 1542-5 has 3 LEDs to display the current operating status and the diagnostics status and these have the following meanings:

- RUN/STOP LED (one-color LED: green)
- ERROR LED (one-color LED: red)
- MAINT LED (one-color LED: yellow)

The following table shows the meaning of the various combinations of colors of the RUN/STOP, ERROR and MAINT LEDs.

Table 6- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	No supply voltage on the CP or supply voltage too low.
LED lit green	LED lit red	LED lit yellow	LED test during startup
LED lit green	LED lit red	LED off	Startup (booting the CP)
LED lit green	LED off	LED off	CP is in RUN mode. No disruptions
LED flashing green	LED off	LED off	No CP configuration exists Loading firmware
LED lit green	LED flashing red	LED off	A diagnostics event has occurred.
LED lit green	LED off	LED lit yellow	Maintenance, maintenance is demanded.
LED lit green	LED off	LED flashing yellow	Maintenance is required. Downloading the user program
LED flashing green	LED flashing red	LED flashing yellow	Module fault

Diagnostics with LEDs

Diagnostics using the LEDs is the first means of narrowing down errors/faults. To narrow the error/fault down even further, evaluate the message on the display of the S7-1500 CPU. If errors/faults occur, you can also identify them using the Web server or by evaluating the diagnostics buffer of the CPU. The diagnostics buffer of the CPU contains plain language information about the error/fault that has occurred. The diagnostics buffer is accessible via the TIA Portal, the display and the Web server.

6.2 Diagnostics options

Diagnostics options

You have the following diagnostics options available for the module:

- The LEDs of the module

  For information on the LED displays, refer to the section Status and error display of the CP (Page 23).
- STEP 7: The "Diagnostics" tab in the Inspector window

  Here, you can obtain the following information on the selected module:
  - Entries in the diagnostics buffer of the CPU
  - Information on the online status of the module
- STEP 7: Diagnostics functions in the "Online > Online and diagnostics" menu

  Here, you can obtain static information on the selected module:
  - General information on the module
  - Diagnostics status
  - Information on the PROFIBUS interface

  You can obtain further information on the diagnostics functions of STEP 7 in the STEP 7 online help.
- DP diagnostics

  The DP diagnostics of the CP is described below.

  The evaluation of diagnostics data records requested by the DP master and the diagnostics interrupts or diagnostics alarms of the DP slaves is handled in the user program of the DP master station.

6.3 DP slave diagnostics

DP-V1 slave: Diagnostics interrupt

The diagnostics data is transferred as a diagnostics interrupt. Diagnostics interrupts must be acknowledged by the DP master.

Supported diagnostics functions

The CP 1542-5 supports the following blocks of DP diagnostics:

- Standard diagnostics (6 bytes)
- Device-specific diagnostics (6 bytes)

User program (DP master)

To read out the diagnostics data of the DP slave (DP single diagnostics), use the "DPNRM_DG" instruction on the DP master.

Diagnostics interrupts of DP-V1 slaves are evaluated in the user program of the master using the "RALRM" instruction.

You will find the required parameter assignment for the instructions in the STEP 7 online help.

Below, there is an overview of the structure of the diagnostics data.

Overview of standard diagnostics

Standard diagnostics	
Byte	**Meaning**
0	Station status 1
1	Station status 2
2	Station status 3
3	Master address
4...5	Vendor ID of the slave

Overview of device-specific diagnostics

The device-specific diagnostics data depends on the protocol variant operating on the DP slave:

- **DP-V1 slave**

Table 6- 2 Overview of device-specific diagnostics of the CP with DP-V1 slaves

Device-specific diagnostics		
Byte	**Meaning**	
0	Header	
1	Variant Interrupt type	Variant Status type
2	Slot number	
3	Variant Interrupt specifier	Variant Status specifier
4...62	Module-specific diagnostics data	

6.4 Standard diagnostics

The coding of the standard diagnostics bytes is explained below.

Byte 0: Station status 1

Table 6- 3 Structure of station status byte 1

Bit no.	Name	Explanation
7	Master_Lock	The DP slave was assigned parameters by a different DP master. The DP slave can only be read by the configured productive DP master. This bit is set by the DP master when its bus address differs from the configured address.
6	Parameter_Fault	The last received parameter assignment frame was bad or not permitted. The DP slave sets this bit. Solution: Check the parameter settings for illegal parameters.
5	Invalid_Slave_Response	This bit is set by the DP master when no plausible response has been received from the DP slave.
4	Service_Not_Supported	This bit is set by the DP master when the master has requested a function that is not supported by the DP slave. Solution: Change the parameter setting to disable the function on the master.
3	Ext_Diag	This bit is set by the slave. • Bit =1: There is diagnostics data in the slave-specific diagnostics area. The diagnostics data can be evaluated in the user program of the master. • Bit =0: There may be status information in the slave-specific diagnostics area. The status information can be evaluated in the user program of the master.
2	Slave_Config_Check_Fault	The configuration data sent by the DP master is rejected by the DP slave. Cause: Configuration error. Solution: Change configuration.
1	Station_Not_Ready	The DP slave is not ready for productive data exchange. This is a temporary status that cannot be influenced by the DP master.
0	Station_Non_Existent	The DP slave is not reacting on the bus. This bit is set by the DP master 1 (the slave sets this bit permanently to 0). If the bit is set, the diagnostic bits have the state of the last diagnostics alarm or the initial value.

Byte 1: Station status 2

Table 6- 4 Structure of station status byte 2

Bit no.	Name	Explanation
7	Deactivated	The DP slave was identified as being not active in the local parameter record and it is not polled cyclically.
6	Reserved	- reserved -
5	Sync_Mode	The DP slave is in SYNC mode. The bit is set by the slave. The bit is always = 0 on the CP 1542-5 (function not supported).
4	Freeze_Mode	The DP slave is in FREEZE mode. The bit is set by the slave. The bit is always = 0 on the CP 1542-5 (function not supported).
3	Watchdog_On	Watchdog monitoring is active on the DP slave. The bit is set by the slave.

Bit no.	Name	Explanation
2	Status_From_Slave	Bit =1: The diagnostics information comes from the DP slave. The bit is set permanently to 1 by the slave.
1	Static_Diag	Static diagnostics If the DP slave sets this bit, the DP master must fetch diagnostics data from the DP slave until the DP slave resets the bit. The DP slave sets this bit, for example when it is not capable of data transfer.
0	Parameter_Request	The DP slave sets this bit when it needs to have new parameters assigned and be reconfigured. If bit 0 and bit 1 are both set, bit 0 has the higher priority.

Byte 2: Station status 3

Table 6- 5 Structure of station status byte 3

Bit no.	Name	Explanation
7	Ext_Data_Overflow	If this bit is set, there is more diagnostics information available than indicated in the diagnostics data. This data cannot be displayed.
6...0	Reserved	- reserved -

Byte 3: Master address

The address of the DP master that assigned parameters to this DP slave is entered in the "Master_Add" byte.

If the DP slave did not have parameters assigned to it by any DP master, the DP slave sets the address 255 in this byte.

Bytes 4 and 5: Vendor ID of the slave ("Ident_Number")

The vendor ID ("Ident_Number") for the DP slave type is entered in bytes 4 and 5. This identifier can be used to identify the slave.

The more significant part of the value is in byte 5 (big endian format).

6.5 Device-specific diagnostics in DP-V1

There are two variants of device-specific diagnostics with DP-V1 slaves:

- Interrupt type
- Status type

The two variants differ from each other in the coding of byte 1, bit 6 of the device-specific diagnostics data. The difference is component-specific.

Byte 0: Header

The two most significant bits have the value 00. This identifies the "module-specific diagnostics data" field (see bytes 4... 62) as a whole.

The remaining six bits indicate the length of the data field including byte 0.

Byte 1: Variant "Interrupt type"

Table 6- 6 Structure of byte 1 of the device-specific diagnostics (variant "interrupt type")

Bit no.	Meaning	
7	Value	Meaning
	0	**Interrupt**
6...0	**Alarm_Type**	
	0	- reserved -
	1	Diagnostics interrupt
	2	Hardware interrupt
	3	Pull interrupt
	4	Plug interrupt
	5	Status interrupt
	6	Update interrupt
	7...31	- reserved -
	32...126	Vendor-specific
	127	- reserved -

If status interrupts are received in quick succession, older status interrupts may be overwritten by newer interrupts.

Byte 1: Variant "Status type"

Table 6- 7 Structure of byte 1 of the device-specific diagnostics (variant "status type")

Bit no.	Meaning	
7	Value	Meaning
	1	**Status information**
6...0	**Status_Type**	
	0	- reserved -
	1	Status information
	2	Modul_Status (see also bytes 4...62)
	3...31	- reserved -
	32...126	Vendor-specific
	127	- reserved -

Byte 2: Slot number

Slot number (1...n) of the slave module

0 is the placeholder for the entire device.

Byte 3: Variant "Interrupt specifier"

Table 6- 8 Structure of byte 3 of the device-specific diagnostics (variant "interrupt specifier")

Bit no.	Meaning	
7...3	Seq_No	Unique identifier of an interrupt alarm
2	Add_Ack	If this bit is set, the DP-V1 master is indicating that this interrupt expects an acknowledgement in the form of a WRITE job.
1...0	Alarm_Specifier	
	0	No further distinction
	1	Interrupt appears, slot disrupted The slot generates an interrupt due to an error.
	2	Interrupt disappears, slot OK The slot generates the interrupt and indicates that it has no further errors
	3	Interrupt disappears, slot still disrupted The slot generates the interrupt and indicates that it has further errors

Byte 3: Variant "Status specifier"

Table 6- 9 Structure of byte 3 of the device-specific diagnostics (variant "status specifier")

Bit no.	Meaning	
7...2	- reserved -	
1...0	Status_Specifier	
	0	No further distinction
	1	Status appears
	2	Status disappears
	3	- reserved -

Bytes 4...62: Module-specific diagnostics: General coding

This byte contains data with module-specific information that is described in the relevant module documentation. The relevant module is identified by the slot (byte 2).

Bytes 4...62: Module-specific diagnostics with "status type" and "module status"

With the variant "status type" of the device-specific diagnostics of DP-V1 slaves (see byte 1, bit 7) and the setting "Modul_Status" (see byte 1, bits 0...6), there are two status bits here for each slot (= module). Bits not required are set to 0.

Table 6- 10 Structure of the bytes for module-specific diagnostics data

Byte	Bit assignment							
Bit	7	6	5	4	3	2	1	0
4	Module status 4		Module status 3		Module status 2		Module status 1	
5	Module status 8		Module status 7		Module status 6		Module status 5	
...	...		...		...		...	
62	Module status 236		Module status 235		Module status 234		Module status 233	

The status bits are coded as follows:

Table 6- 11 Meaning of the values of the status bits

Value	Meaning
00	Data valid
01	Data invalid - error (for example short-circuit)
10	Data invalid - wrong module
11	Data invalid - no module plugged in

6.6 DP diagnostics frames when the CPU is in STOP

DP diagnostics frames when the CPU is in STOP

All diagnostics frames from DPV0 standard slaves and all DP interrupt frames from DP-S7/DPV1 standard slaves arriving when the CPU is in STOP are forwarded to the CPU. During module startup, the diagnostics frames must then be evaluated by a suitable user program.

Technical specifications 7

Note the information in the System description of SIMATIC S7-1500 (Page 7).

In addition to the information in the system description, the following technical specifications apply to the module.

	6GK7 542-5FX00-0XE0
Product type name	CP 1542-5
Connection to PROFIBUS	
• Number	1 x PROFIBUS interface
Design of the PROFIBUS interface	
• Connector	1 x D-sub female connector (RS-485)
• Transmission speed	9.6 Kbps, 19.2 Kbps, 45.45 Kbps 93.75 Kbps, 187.5 Kbps, 500 Kbps 1.5 Mbps, 3 Mbps, 6 Mbps, 12 Mbps
Electrical data	
Power supply	
• via S7-1500 backplane bus	15 V
Current consumption	
• From backplane bus	100 mA
• Power dissipation	1.5 W
Insulation	
Insulation tested with	707 VDC (type test)
Design, dimensions and weight	
Module format	Compact module S7-1500, single width
Degree of protection	IP20
Weight	Approx. 270 g
Dimensions (W x H x D)	35 x 142 x 129 mm
Installation options	Mounting in an S7-1500 rack
Product functions *	

* You will find the product functions in the section Functional characteristics (Page 13).

Approvals 8

Approvals issued

Note

Issued approvals on the type plate of the device

The specified approvals - with the exception of the certificates for shipbuilding - have only been obtained when there is a corresponding mark on the product. You can check which of the following approvals have been granted for your product by the markings on the type plate. The approvals for shipbuilding are an exception to this.

Certificates for shipbuilding and national approvals

The device certificates for shipbuilding and special national approvals can be found on the pages of Siemens Automation Customer Support on the Internet (http://support.automation.siemens.com/WW/news/en/10805878)

Under this entry, go to the required product and select the following settings: "Entry list" tab > entry type "Certificates".

Standards and test specifications

The device meets the following standards and test specifications. The test criteria for the module are based on these standards and test specifications.

IEC 61131–2

The SIMATIC NET S7 CPs described in this manual fulfill the requirements and criteria of the IEC 61131-2 standard (Programmable Logic Controllers, Part 2: equipment requirements and verifications).

CE mark

The SIMATIC NET S7-CPs described in this manual fulfill the requirements and protection goals of the following EC directives and meet the harmonized European standards (EN) that have been published for the programmable logic controllers in the official journals of the European communities:

- 2004/108/EEC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)

The EC Declarations of Conformity are available for the responsible authorities according to the above-mentioned EC Directive at the following address:

- Siemens Aktiengesellschaft
  Industry Automation
  Industrielle Kommunikation SIMATIC NET
  Postfach 4848
  D-90327 Nürnberg

You will find the EC Declaration of Conformity at the following address / under the following entry ID on the Internet (http://support.automation.siemens.com/WW/view/en/16689636)

EMC directive

The SIMATIC NET S7 CPs listed above are designed for use in an industrial environment.

Field of application	Requirements	
	Emission	Immunity to interference
Industry	EN 61000–6–4	EN 61000–6–2

Explosion Protection Directives

Complying with EN 60079 (electrical apparatus for potentially explosive atmospheres; Type of protection "n")

EN 60079-15, EN 60079-0

II 3 G Ex nA IIC T4 Gc

DEKRA 12 ATEX 0240X

Note

When using (installing) SIMATIC NET products in hazardous area zone 2, make absolutely sure that the associated conditions are adhered to!

You will find these conditions here:

- In the SIMATIC NET Manual Collection under
  "All Documents" > "Use of subassemblies/modules in a Zone 2 Hazardous Area"

Notice for Australia - C-TICK

The above listed SIMATIC NET S7 CPs meet the requirements of the standard AS/NZS 2064 (Class A).

Notices for Canada

This class A digital device meets the requirements of the Canadian standard ICES-003.

AVIS CANADIEN

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

UL and CSA approval

Note

You will recognize the approval, UL/CSA or cULus, assigned to your product from the mark on the rating plate.

UL approval

UL Recognition Mark Underwriters Laboratories (UL) nach Standard UL 508:

- Report E 85972

CSA approval

CSA Certification Mark Canadian Standard Association (CSA) nach Standard C 22.2 No. 142:

- Certification Record 063533–C-000

cULus Approval, Hazardous Location

CULUS Listed 7RA9 IND. CONT. EQ. FOR HAZ. LOC.

Underwriters Laboratories Inc. complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI ISA 12.12.01, CSA C22.2 No. 213-M1987 (Hazardous Location)
- CSA–213 (Hazardous Location)

APPROVED for Use in

- Cl. 1, Div. 2, GP. A, B, C, D T3...T6
- Cl. 1, Zone 2, GP. IIC T3...T6

You will find the temperature class on the type plate on the module.

WARNING

Explosion Hazard -

Do not disconnect while circuit is live unless area is known to be non hazardous.

Explosion Hazard -

Substitution of components may impair suitability for Class I, Division 2.

Note

This equipment is suitable for use in Class I, Division 2, Group A, B, C, D or non-hazardous locations only.

Note

For devices with C-PLUG memory: The C-PLUG memory module may only be inserted or removed when the power is off.

Note

This plant has to be mounted according to the NEC (National Electrical Code) stipulations.

When used in environments according to class I, division 2 (see above) , the SIMATIC NET S7 CPs must be mounted in an enclosure.

FM approval

Factory Mutual Approval Standard Class Number 3611,

Class I, Division 2, Group A, B, C, D, T3...T6 or

Class I, Zone 2, Group IIC, T3...T6.

You will find the temperature class on the type plate on the module.

WARNING

Personal injury and damage to property may occur.

In hazardous areas, personal injury or property damage can result if you create or break an electrical circuit during operation of a SIMATIC NET S7 CP (for example, by means of plug-in connections, fuses, switches).

WARNING - EXPLOSION HAZARD: DO NOT DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

When used in hazardous locations (division 2 or zone 2), the device must be installed in an enclosure.

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