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SINAMICS G110M, G120C, G120, G120D, SIMATIC ET 200pro FC-2 inverters

Safety functions integrated in the drive - Safety Integrated

Function Manual

Answers for industry.

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SINAMICS G120
Safety Integrated - SINAMICS
G110M, G120, G120C, G120D and
SIMATIC ET 200pro FC-2

Function Manual

Edition 04/2014, firmware V4.7

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.

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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.

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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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.

Change history

Important changes with respect to the Manual, Edition 01/2013

New functions in firmware V4.7	In Chapter
---	---

Corrections	In Chapter
The forced checking procedure (test stop) starts after selecting STO, however, not after a power-on reset.	Testing the basic functions (Page 162)
Assignment of the signal states in control word 1, bit 0 (basis functions) has been corrected.	Control word 1 and status word 1 (basic functions) (Page 47)
Connecting an actuator without feedback signal to the safety output of the SINAMICS G120 with CU250S-2 does not comply with SIL 2. The connection example has been removed.	Connecting the safety output for SINAMICS G120 (Page 73)
The worst-case response times for the extended STO function have been corrected for an inverter fault/error: When controlled via PROFIBUS: 56 ms instead of 58 ms. When controlled via PROFINET: 56 ms instead of 58 ms (+ bus cycle time).	Response times (Page 269)
Worst-case response time for the STO basis function when controlled via a safety input has been corrected: 6 ms + t_E instead of 14 ms + t_E. Worst-case response time for the extended STO function when controlled via a safety input: 52 ms + t_E instead of 54 ms + t_E. When debounce time > 0: t_E = debounce time + 3 ms instead of debounce time + 1 ms When debounce time = 0: t_E = 4 ms instead of 2 ms	

Supplements and revised descriptions	In Chapter
New SINAMICS G110M inverters	Description (Page 19) Installing (Page 41)
New SIMATIC ET 200pro FC-2 inverter	Description (Page 19) Installing (Page 41)
Overview, preconditions and restrictions when using the safety functions have been revised.	Description (Page 19)
The description of the time response of active safety functions is now sorted according to functions.	Operation (Page 159)
The test of the safety inputs has been supplemented.	Regularly testing the safety functions (Page 161)
The "Startdrive" commissioning tool is mentioned.	Commissioning tools (Page 84)

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Supplements and revised descriptions	In Chapter
The probability of failure PFD has been supplemented.	Probability of failure of the safety functions (PFH value) (Page 267)
Error response of the SBC function has been supplemented.	Response to faults in the brake control (Page 176)

Table of contents

Fundamental safety instructions

<div style="text-align: right; font-size: large;">1</div>

1.1 General safety instructions

⚠ WARNING
Risk of death if the safety instructions and remaining risks are not carefully observed If the safety instructions and residual risks are not observed in the associated hardware documentation, accidents involving severe injuries or death can occur. • Observe the safety instructions given in the hardware documentation. • Consider the residual risks for the risk evaluation.

⚠ WARNING
Danger to life or malfunctions of the machine as a result of incorrect or changed parameterization As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death. • Protect the parameterization (parameter assignments) against unauthorized access. • Respond to possible malfunctions by applying suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

1.2   Industrial security

Note

Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. For more information, visit Hotspot-Text (http://support.automation.siemens.com).

⚠ **WARNING**

Danger as a result of unsafe operating states resulting from software manipulation

Software manipulation (e.g. by viruses, Trojan horses, malware, worms) can cause unsafe operating states to develop in your installation which can result in death, severe injuries and/or material damage.

- Keep the software up to date.

  You will find relevant information and newsletters at this address (http://support.automation.siemens.com).

- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.

  You will find further information at this address (http://www.siemens.com/industrialsecurity).

- Make sure that you include all installed products into the holistic industrial security concept.

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Introduction

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2.1 About this manual

Who requires this manual and why?

This manual describes the safety functions integrated in the inverter for variable-speed applications.

The manual is aimed primarily at machine and plant manufacturers, commissioning engineers, and service personnel.

What are drive-integrated safety functions?

"Safety" functions have, in comparison to "standard" drive functions, an especially low error rate. Performance level (PL) and safety integrity level (SIL) of the corresponding standards are a measure of the error rate.

As a consequence, the safety functions are suitable for use in safety-related applications to minimize risk. An application is safety-related if the risk analysis of the machine or the system indicates a special hazard potential in the application.

"Integrated in the drive" means that the safety functions are integrated in the inverter and can be executed without requiring additional external components.

What inverters are described?

	Fixed speed applications		Variable speed applications								Motion control applications		
	SIMATIC		SIMATIC	SINAMICS					SINAMICS		SINAMICS		
	ET 200S	ET 200pro Motor starter	ET 200pro FC-2	G110M	G120C	G120	G120D	G110D	G130	G150	S110	S120	S150
Integrated safety functions according to IEC 61800-5-2													
STO Safe Torque Off	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SS1 Safe Stop 1	-	-	-	-	-	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
SBC Safe Brake Control	-	-	-	-	-	Yes 2)	-	-	Yes 3)	Yes 3)	Yes 4)	Yes 3)	Yes 3)
SBT Safe Brake Test	-	-	-	-	-	-	-	-	Yes 6)	Yes 6)	-	Yes 6)	Yes 6)
SLS Safely-Limited Speed	-	-	-	-	-	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
SSM Safe Speed Monitor	-	-	-	-	-	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
SDI Safe Direction	-	-	-	-	-	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
SOS Safe Operating Stop	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
SS2 Safe Stop 2	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
SLP Safely-Limited Position	-	-	-	-	-	-	-	-	Yes	Yes	-	Yes	Yes
Fail-safe interfaces													
PROFIBUS / PROFIsafe	Yes	Yes 5)	Yes 5)	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
PROFINET / PROFIsafe	Yes	Yes 5)	Yes 5)	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
Safety inputs	Yes 5)	Yes 5)	Yes 5)	Yes	Yes	Yes	Yes	Yes 5)	Yes	Yes	Yes, external components required in certain cases		
Safety outputs	-	-	-	-	-	Yes	Yes	-	Yes, with TM54F	Yes, with TM54F	Yes	Yes, with TM54F	Yes, with TM54F
Certifications													
EN ISO 13849-1:2006	Cat. 4 / PL e		Cat. 3 / PLd					-	Cat. 3 / PLd	Cat. 3 / PLd	Cat. 3 / PL d		
EN 61508	SIL 3		SIL 2					-	SIL 2	SIL 2	SIL 2		
NFPA 79	Yes	Yes	-	-	-	-	-	-	-	-	Yes	Yes	-
NRTL listed	Yes	Yes	-	-	-	-	-	-	-	-	-	Yes 1)	-

Contents of the manual

1) Only for SINAMICS S120 Booksize
2) Only for CU250S-2 with Safe Brake Relay
3) For Chassis and Cabinet Modules with Safe Brake Adapter
4) With Safe Brake Relay
5) With external components
6) EN ISO 13894-1, PL d/Kat. 2 EN 61508 SIL 1

Figure 2-1   Products with drive-integrated safety functions

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What applications are described?

This manual covers all the information, procedures, and operations for the following scenarios:

- Introductory and simplified description of the inverter safety functions

- Controlling the safety functions via safety inputs or PROFIsafe

- Commissioning and acceptance test of the safety functions

- Response of the inverter with active safety functions

- Replacing an inverter where the safety functions are enabled.

- Diagnostics of the safety functions

The appendix contains an overview of the applicable regulations and standards for using the safety functions.

What other information do you need?

This manual alone is not sufficient for installing or commissioning the standard inverter functions. An overview of the documentation available and the associated applications is provided in the sectionManuals for your inverter (Page 334).

What is the meaning of the symbols in the manual?

An operating instruction starts here.

This concludes the operating instruction.

2.2　Guide through the manual

Chapter	In this chapter, you will find answers to the following questions:
Description (Page 19)	• What safety functions does my inverter have? • How do the safety functions basically work? • What are typical applications for the safety functions of the inverter? • In which applications are the safety functions of my inverter not permitted?
Installing (Page 41)	• How many safety inputs and outputs does my inverter have? • How do I wire up the safety inputs and outputs of my inverter? • What do I have to observe if the wiring extends beyond the control cabinet? • How are the PROFIsafe control words and status words assigned?
Commissioning (Page 77)	• How do I configure the communication of my inverter via PROFIsafe? • How do I start commissioning the safety functions? • What tool do I need for commissioning? • How do I transfer the parameters of the safety functions to other inverters? • How do I reset my inverter to the factory setting?
Operation (Page 159)	• How must I select and deselect the safety function? • How do the inverter and motor respond when the safety function is active? • How do the safety functions mutually influence one another? • What happens in the event of a limit violation of the safety functions? • What happens in the event of a wire breakage at a safety input? • How do I acknowledge safety function faults?
Corrective maintenance (Page 251)	• How do I replace defective components of the inverter or the inverter itself? • How do I ensure that the safety functions are still working correctly after making a replacement? • What do I have to check after making a replacement? • What is the meaning of the alarms and faults, which are assigned to the safety functions?
System properties (Page 267)	• How long does it take for my drive to respond when selecting a safety function? • How long does it take for my drive to respond when the safety function is active and the motor malfunctions? • What are the probabilities of failure of the safety functions of my inverter? • According to which standards are the safety functions of my inverter certified?
Appendix (Page 277)	• How do I check the safety functions after commissioning? • How do I document the settings of the safety functions? • As machine manufacturer or company operating a machine, what standards and regulations must I observe? • Where can I find more information on my inverter?

Description

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3.1   About this chapter

This section provides an overview of the principle mode of operation of safety functions integrated in the drive.

What can you find in this Chapter?

- Preconditions and restrictions when using the safety functions
- The principle mode of operation of safety functions integrated in the drive
- Application examples
- The assignment as to which inverters have which safety functions

3.2   Overview of the safety functions

Basic functions and extended functions

The safety functions integrated in the drive are split up according to basic functions and extended functions.

Safety functions integrated in the drive	
Basic functions	Extended functions
The basic functions prevent hazardous motion using one or several of the following measures: • The energy feed to the motor is safely switched off • The motor holding brake solenoid is safely deenergized The following basic functions are available: • Safe Torque Off (STO) • Safe Brake Control (SBC) • Safe Stop 1 (SS1) without speed monitoring Each of the inverters described in this manual has one or several of the basic functions.	Extended functions include several basic functions and additional functions to safely monitor the motor speed: • STO and SBC basic functions • Safe Stop 1 (SS1) with speed monitoring • Safely Limited Speed (SLS) • Safe Direction (SDI) • Safe Speed Monitor (SSM) Whether an inverter has extended functions generally depends on the Control Unit hardware. The corresponding inverters have an "F" at the end of the product name, e.g. Control Unit CU240E-2 F. For SINAMICS G120 with a CU250S-2 Control Unit, you require a license for the extended functions.

Table 3- 1   Inverters with safety functions integrated in the drive

Inverter	Basic functions		Extended functions	
	STO	SS1, SBC	SS1, SDI, SSM, SLS	SLS levels
SINAMICS G110M	Available with all product versions	--- [1]	---	
SINAMICS G120C	Available with all product versions	---	---	
SINAMICS G120	Available with all CU240E-2 and CU250S-2 Control Units	Available with all CU250S-2 Control Units	Available with the following Control Units: CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F CU250S-2 [2] CU250S-2 DP [2] CU250S-2 PN [2] CU250S-2 CAN [2]	Available with the following Control Units: CU240E-2 DP-F CU240E-2 PN-F CU250S-2 DP [2] CU250S-2 PN [2]
SINAMICS G120D	Available with all Control Units	---	Available with the following Control Units: CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU240D-2 PN-F FO CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP CU250D-2 PN-F FO	
SIMATIC ET 200pro FC-2	Available	---	---	

[1] ---: Not available

[2] Requires a license for the safety functions

3.3 Overview of the safety-related inverter interfaces

Depending on the particular inverter, the interfaces of the safety functions are safety inputs and outputs (F-DI, F-DO), the safety-related PROFIsafe fieldbus communication and a safety output to control a brake.

Inverter		F-DI	F-DO	PROFIsafe	Safety output for a brake
	SINAMICS G110M with Control Unit …				
	CU240M USS	1	--- [1]	---	---
	CU240M DP CU240M PN	1	---	Telegram 30 [3]	---
	SINAMICS G120C USS SINAMICS G120C CAN	1	---	---	---
	SINAMICS G120C DP SINAMICS G120C PN	1	---	Telegram 30 [3]	---
	SINAMICS G120 with Control Unit …				
	CU240E-2	1	---	---	---
	CU240E-2 DP CU240E-2 PN	1	---	Telegram 30 [3]	---
	CU240E-2 F	3	---	---	---
	CU240E-2 DP-F CU240E-2 PN-F	3	---	Telegram 30 [3], Telegram 900 [4]	---
	CU250S-2 CU250S-2 CAN	3	1	---	Available with Safe Brake Relay
	CU250S-2 DP CU250S-2 PN	3	1	Telegram 30 [3], Telegram 900 [4]	Available with Safe Brake Relay
	SINAMICS G120D with Control Unit …				
	CU240D-2 DP CU240D-2 PN	1	---	Telegram 30 [3]	---
	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU240D-2 PN-F FO CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP CU250D-2 PN-F FO	3	1	Telegram 30 [3], Telegram 900 [4]	---
	SIMATIC ET 200pro FC-2	ET 200pro [2]	---	ET 200pro [2]	---

[1] --- Not available

[2] The inverter evaluates the F0 rail in the backplane bus of the ET 200pro system using an internal safety input. The ET-200pro F-RSM and F-Switch modules control the F0 rail.

[3] Telegram 30 for control and for the status feedback signal from the safety functions

[4] Telegram 900: Function as for telegram 30 and additional feedback signal of the F-DI status

3.4 Preconditions when using the safety functions

Risk assessment

A risk analysis and assessment of the plant or machine is required before using the safety functions integrated in the drive.

The risk analysis and assessment must show that the safety functions integrated in the drive are suitable as protective measure to reduce risks associated with the machine. The required probability of failure of the protective measure must not exceed SIL 2 or PL d.

Motors and control modes

You can use the basic functions without any restrictions:

- For all control modes: U/f control and speed control with and without encoder

- With synchronous and induction motors

- For group drives, which involves the simultaneous operation of several motors connected to one inverter

It is only permissible that you use the extended functions under the following preconditions:

- With induction motors for all control modes

- With SIEMOSYN synchronous motors only with U/f control

- For group drives

Encoderless safety functions

The safety functions integrated in the drive do not use an encoder.

"Encoderless" means the following:

- You do not require an encoder to use the safety functions integrated in the drive.

- If the inverter has an encoder connection, the inverter uses the encoder signal to control (closed loop) the motor. The safety functions ignore the encoder signal.

Taking into account the slip of induction motors

The speed of the motor shaft is relevant for the functional safety in or on a machine. However, the extended functions monitor the electrical speed of the motor against the limit values that have been set.

If you use encoderless safety functions with an induction motor, you must take into account the motor slip when setting the speed monitoring.

3.5 Restrictions when using safety functions

Not permitted: Operation with pulling loads

> ⚠ **WARNING**
>
> **Death or severe injury when the motor speed is not monitored**
>
> The encoderless actual value sensing does not identify all faults and errors in the closed-loop motor control. As a consequence, the encoderless safety functions cannot identify whether a pulling load unintentionally accelerates due to a fault or error in the closed-loop motor control.
>
> - Do not use any of the extended encoderless safety functions in a drive with a pulling load.

It is not permissible that you use the encoderless safety functions in applications involving pulling loads, e.g. in hoisting gear, elevators and unwinders.

Speed monitoring options for pulling loads

- You can implement speed monitoring in machines with pulling loads in one the following ways:
  - Select a drive with safety functions that use an encoder, for example SINAMICS S120.
  - Implement the speed monitoring in the higher-level control by using a suitable measuring system to acquire the speed/velocity.
- Coupled electric drives, e.g. test stands and winders/unwinders comprise a driving and a driven drive. Using the extended functions in the drive that has a driving function in a coupled drive system. In the case of a fault, the drive with the driving function identifies when a limit value is violated.

Not permitted: Motors with different pole pair numbers

> ⚠ **WARNING**
>
> **Death or serious injury due to unexpected high speeds**
>
> If you use the "Drive data set" function to switch over motors with different pole pair numbers, then the calculated, safety-related speed differs from the mechanical speed of the motor shaft. As a consequence, the motor shaft can accelerate above the configured monitoring limits of the safety function. This can result in death or severe injury.
>
> - When using the "drive data set" function, only switch between motors with the same pole pair number.

Monitoring the speed of motors with different pole pair numbers

Implement the speed monitoring in the higher-level control by using a suitable measuring system to acquire the velocity or speed.

Critical applications

For safety functions that have not been enabled, you can use the following applications without any restrictions.

For active safety functions, several applications can result in errors in the safety-related actual value sensing. For active or enabled safety functions, faults and errors in the safety-related actual value sensing initiate a stop response: Messages C01711, C30711 with default values 1040 ff.

The stop response does not result in an unsafe drive state, but in a lower drive availability.

Critical application	Remedy
Motor data identification during commissioning	Only commission the safety functions after the motor data identification has been completed.
Setpoint change as step function	Set the ramp-function generator times to values > 0.5 s.
Reversing the speed	If you are using an inverter with position control, then you must set the position controller and the travel profile so that there is absolutely no overshoot in the speed/velocity characteristic.
	Within 1 s, only one acceleration and one braking ramp are permitted. The cycle $0 \rightarrow n_{set} \rightarrow -n_{set} \rightarrow 0$ must be at least 2 s long.
Load change as step function	Do not use the safety functions.
Continuous operation at speeds < 5 % of the rated speed	
Switching-on the inverter with the motor rotating ("flying restart" function)	Avoid using the "flying restart" function when a safety function is active.
	Temporarily deactivate the safety function until the "flying restart" function has been successfully completed.
	It is not permissible that you use the "flying restart" function if you are using the SSM function. It is not possible to deactivate SSM using a control signal.
Operating an inverter at the current limit	Select and dimension the drive so that the inverter current limit does not respond. After commissioning, check that the inverter does not reach its current or torque limits – even at full load.
Braking a motor using the "DC braking" or "Compound braking" functions	Avoid using the "DC braking" or "Compound braking" functions when a safety function is active.
	If you require one of these two braking functions, then in the risk assessment, you must carefully check as to whether you may deactivate the safety function while braking. If yes, then deactivate the safety function until braking has been completed.
	It is not permissible that you use the braking functions if you are using the SSM function. It is not possible to deactivate SSM using a control signal.

Inadmissible SINAMICS G120 Power Modules

When using the following Power Modules, it is not it permissible to use the safety functions nor are you able to:

Power Module	Restriction
PM230	The PM230 Power Modules of the SINAMICS G120 do not support any safety functions.
PM240 FSGX	With the PM240 Power Module frame size GX, only the STO, SBC and SS1 basic functions without speed monitoring are permitted.

3.6 Recommendations for stable operation

The following preconditions must be satisfied to ensure disturbance-free inverter operation with the extended functions enabled:

- Motor and inverter are adequately dimensioned for this application:
  - The inverter is operated below its current limit.
  - The rated currents of the motor and inverter must not differ by more than a factor of 5:

    Inverter rated current/motor rated current < 5 (r0207[0] / p0305 < 5).

- Before commissioning the safety functions, optimally set the closed-loop control:
  - Carry out motor data identification at standstill.
  - Carry out a rotating measurement.
  - Avoid multiple speed overshoots when settling after a setpoint change.
  - Avoid reversing the motor within less than 2 s.

3.7   Safe Torque Off (STO)

How does the STO safety function work?
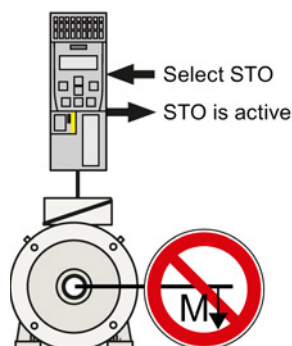
The inverter with active STO function prevents machine components from inadvertently starting.

Table 3- 2   The principle of operation of STO

	Safe Torque Off (STO)	Standard inverter functions linked with STO
1.	The inverter recognizes the selection of STO via a safety-relevant input or via the PROFIsafe safe communication.	---
2.	The inverter prevents energy from being fed to the motor. When STO is active, the motor does not generate any torque.	If you use a motor holding brake, the inverter closes the brake.
3.	The inverter signals that "STO is active" via a safety-relevant output or via the PROFIsafe safe communication.	---
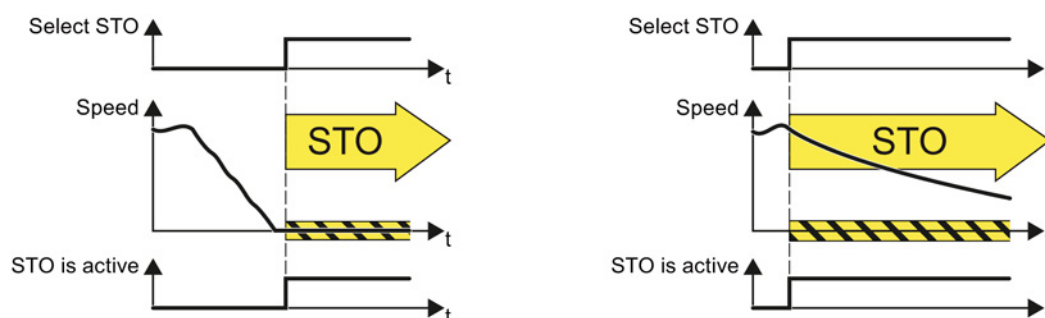
Figure 3-1   Functionality of STO when motor is rotating and at a standstill

If the motor is still rotating when STO is selected, then it coasts down to standstill.

The STO safety function is standardized

The STO function is defined in IEC/EN 61800-5-2:

"[…] [The inverter] does not supply any energy to the motor which can generate a torque (or for a linear motor, a force)."
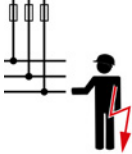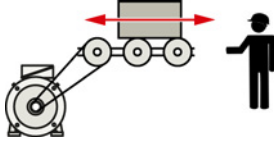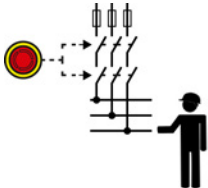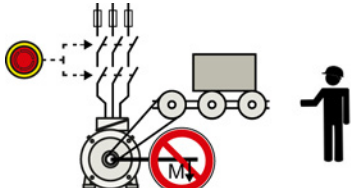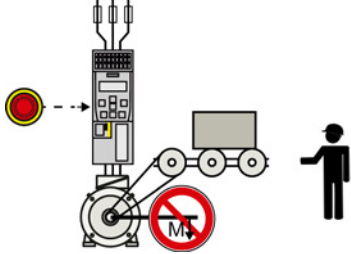
The STO inverter function complies with what is defined in the standard.

The distinction between Emergency Off and Emergency Stop

"Emergency Off" and "Emergency Stop" are commands that minimize different risks in the machine or plant.

The STO function is suitable for achieving an emergency stop but not an emergency off.

Risk:	Risk of electric shock:	Risk of unexpected motion:
Measure to minimize risk:	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Command:	**Emergency Off**	**Emergency Stop**
Classic solution:	Switch of the power supply: 	Switch-of the drive power supply:
Solution with the STO safety function integrated in the drive:	STO is not suitable for safely switching of an electric voltage.	Select STO: It is permissible that you switch of the inverter supply voltage as well. However, switching off the voltage is not required as a risk-reduction measurement.

Application examples for the STO function

The STO function is suitable for applications where the motor is already at a standstill or will come to a standstill in a short, safe period of time through friction. STO does not shorten the run-on of machine components with high inertia.

Examples	Possible solution
When the Emergency Stop button is pressed, a stationary motor should not unintentionally start.	• Wire the Emergency Stop button to a safety-related input of the inverter. • Select STO via the safety-related input.
A central emergency stop button must prevent the unintentional acceleration of several motors that are at a standstill.	• Evaluate the Emergency Stop button in a central control. • Select STO via PROFIsafe.

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3.8 Safe Brake Control (SBC)

How does the SBC safety function work?

An inverter equipped with the SBC function monitors the cables to an electromagnetic brake and when requested, safely shuts down the 24 V control of the brake.

You must supplement the inverter with a Safe Brake Relay for the SBC function.
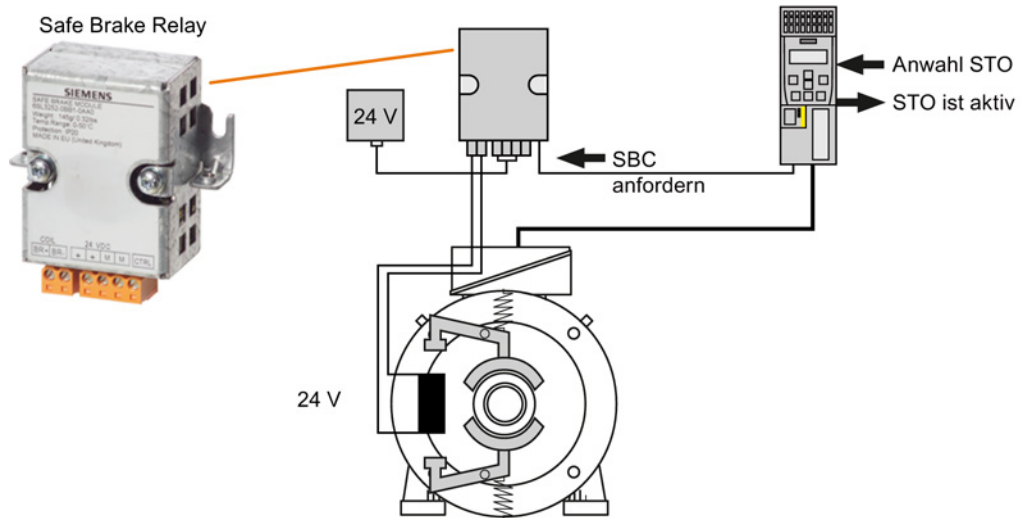
The brake can be integrated in the motor or externally mounted.

Table 3- 3   The principle of operation of SBC

	Safe Brake Control (SBC)		Standard brake functions
1.	When the STO function is active, the inverter requests the SBC function via the connecting cable to the Safe Brake Relay. The Safe Brake Relay safely switches off the supply voltage for the connected brake.		The brake closes. The brake maintains the motor shaft in position.
2.	The inverter signals that "STO is active" via a safety output or via the PROFIsafe safe communication.		---

The safety-related brake control does not mean that the brake keeps the load in position. The SBC function is not able to identify as to whether the brake is mechanically worn, for example.

The SBC safety function is standardized

The SBC function is defined in IEC/EN 61800-5-2:

"The SBC function supplies a safe output signal to control an external brake."

The SBC inverter function complies with what is defined in the standard.

Application example for the SBC function

Example	Possible solution
After a hoisting gear stops, the inverter must close the brake in order to minimize the risk of the load falling.	• Connect the motor holding brake to the inverter via Safe Brake Relay. • Select STO when the drive stops.

3.9 Safe Stop 1 (SS1)

How does SS1 function?
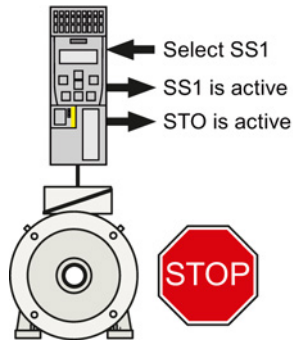
When the SS1 function is active, the inverter reduces the kinetic energy of the machine components to the lowest possible level.

The principle of operation of SS1 differs depending on whether you use SS1 with basic functions or with extended functions.

SS1 of the basic functions

Table 3- 4   Principle of operation of SS1, selected when the motor is rotating

	Safe Stop 1 (SS1)		Standard inverter functions linked with SS1
1.	The inverter recognizes the selection of SS1 via a safety input or via the PROFIsafe safe communication.		---
2.	SS1 starts a safety timer T. The inverter signals "SS1 is active".		The inverter brakes the motor along the OFF3 ramp.
3.	After the timer expires, the inverter safely switches off the motor torque with the STO function. The inverter signals that "STO is active" via a safety output or via the PROFIsafe safe communication.		---
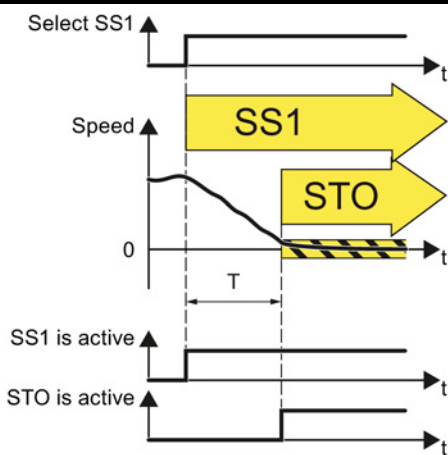
SS1 of the extended functions

Table 3- 5   Principle of operation of SS1, selected when the motor is rotating

	Safe Stop 1 (SS1)		Standard inverter functions linked with SS1
1.	The inverter recognizes the selection of SS1 via a safety input or via the PROFIsafe safe communication.		---
2.	The inverter monitors as to whether the motor speed decreases. The inverter signals "SS1 is active".		The inverter brakes the motor along the OFF3 ramp.
3.	If the motor speed is low enough, the inverter safely switches off the motor torque using STO. The inverter signals that "STO is active" via a safety output or via the PROFIsafe safe communication.		---
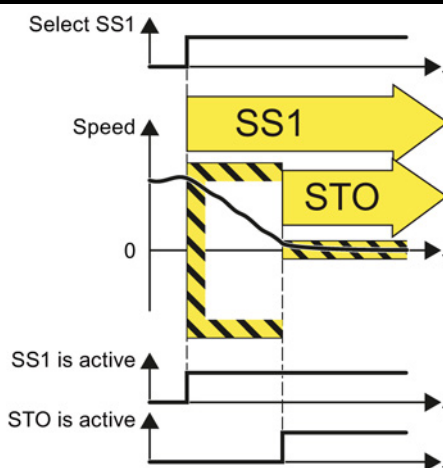
The SS1 safety function is standardized

The SS1 function is defined in IEC/EN 61800-5-2:

"[…] [1] Initiate and monitor the magnitude of the motor deceleration within the defined limits and initiate the STO function if the motor speed falls below a defined limit value.

or

[2] Initiate motor deceleration and activate the STO function after an application-specific time delay."

The inverter function SS1 of the extended functions complies with the first definition of the standard.

The inverter function SS1 of the basic functions complies with the second definition of the standard.

Application example

Example	Possible solution
The drive must brake as quickly as possible after the Emergency Stop button has been pressed. It is not permissible that the stationary motor undesirably restarts.	• Select SS1 in the inverter using a safety input or via PROFIsafe.

3.10 Safely Limited Speed (SLS)

How does SLS function?
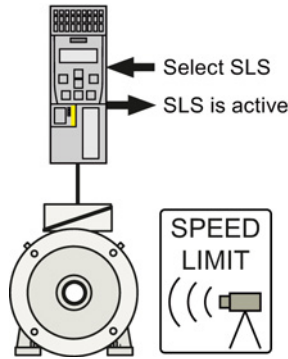
An inverter with active SLS function can reduce the velocity or speed of a machine component and monitor it without having to interrupt machining operation.

Table 3- 6   Principle of operation of SLS, selected when the motor is rotating

	Safely Limited Speed (SLS)		Standard inverter functions linked with SLS
1.	The inverter recognizes the selection of SLS via a safety input or via the PROFIsafe safe communication.		---
2.	SLS allows a motor to reduce its possibly inadmissibly high speed within a defined time – or to reduce it along a defined braking ramp.		The inverter limits the speed setpoint to values below the SLS monitoring. If the motor rotates faster than the SLS monitoring value, then the inverter brakes the motor along the OFF3 ramp.
3.	The inverter monitors the absolute actual speed against the set SLS monitoring. The inverter signals that "SLS is active" via a safety output or via the PROFIsafe safe communication. If the motor speed exceeds the SLS monitoring, the inverter responds with a "safe stop" and brakes the motor as quickly as possible.		The inverter limits the speed setpoint to values below the SLS monitoring.
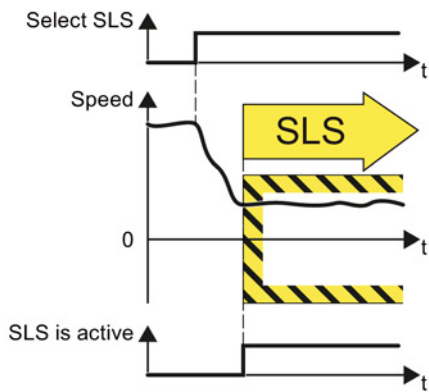
The SLS safety function is standardized

The SLS function is defined in IEC/EN 61800-5-2:

"The SLS function prevents the motor from exceeding the defined speed limit."

The SLS inverter function complies with what is defined in the standard.

Application examples for the SLS function

| Examples	Possible solution
Setup mode: The machine operator must enter the dangerous area of a machine and manually introduce material into a machine part.	• Select SSL in the inverter via a safety input or via PROFIsafe.
A turning machine must not exceed a specific maximum torque in order to protect the drill chuck from damage.	• The inverter limits and monitors the speed of the machine part.

Functional expansion: selecting SLS levels
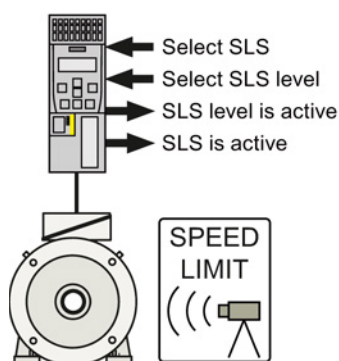
Expansion of the SLS function to include several SLS levels:

• The speed monitoring of the SLS function can be extended to include a maximum of 4 different SLS levels.

• The inverter requires additional safety-related signals to select an SLS level and to signal back which SLS level is active.

The switchover from a higher SLS level 2 to a lower SLS level 1 is described as example.

Table 3- 7   Switching over from SLS level 2 to SLS level 1

	Safely Limited Speed (SLS)		Standard inverter functions linked with SLS
1.	The inverter signals "SLS level 2 is active" via the safety-related PROFIsafe communication.		The inverter limits the speed setpoint to values below SLS level 2.
2.	The inverter recognizes the selection of SLS level 1 via the safety-related PROFIsafe communication.		
3.	SLS allows a motor to reduce its possibly inadmissibly high speed within a defined time – or to reduce it along a defined braking ramp.		The inverter limits the speed setpoint to values below SLS level 1. If the motor rotates faster than the SLS monitoring value, then the inverter brakes the motor along the OFF3 ramp.
4.	The inverter monitors the absolute actual speed against SLS level 1. The inverter signals "SLS level 1 is active" via the safety-related PROFIsafe communication.		The inverter limits the speed setpoint to values below SLS level 1.

Application example for selecting SLS levels

Examples	Possible solution
Depending on the diameter of the saw blade, a circular saw must not exceed a specific maximum speed.	• Select SLS and the corresponding SLS level in the inverter via PROFIsafe.

3.11 Safe Direction (SDI)

How does SDI function?
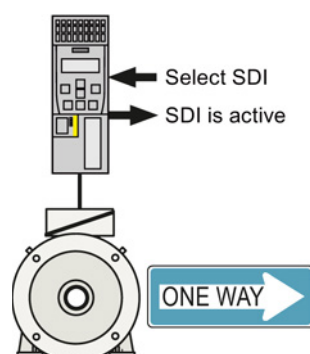
The inverter with active SDI function prevents that a machine component moves in the inhibited direction.

Table 3- 8   Principle of operation of SDI, selected when the motor is rotating

	Safe Direction (SDI)		Standard inverter functions linked with SDI
1.	The inverter recognizes the selection of SDI via a safety input or via the PROFIsafe safe communication.		---
2.	SDI allows a motor to stop moving in the inhibited direction of rotation within a defined time – or along a defined braking ramp.		The inverter limits the speed setpoint to values in the selected direction of rotation. If the motor rotates in the inhibited direction, then the inverter brakes the motor along the OFF3 ramp.
3.	The inverter monitors the direction of the actual speed. The inverter signals that "SDI is active" via a safety output or via the PROFIsafe safe communication. If the motor rotates in the inhibited direction, the inverter responds with a "safe stop" and brakes the motor as quickly as possible.		The inverter limits the speed setpoint to values in the selected direction of rotation.

The SDI safety function is standardized

The SDI function is defined in IEC/EN 61800-5-2:

"The SDI function prevents the motor shaft moving in the wrong direction."

The SDI inverter function complies with what is defined in the standard.

Application examples

Example	Possible solution
When replacing the pressure cylinders of the plates, it is only permissible that the drive moves in the safe direction.	• Select SDI in the inverter via a safety input or via PROFIsafe. • In the inverter, inhibit the direction of rotation that is not permitted.
After a protective device to detect a jammed door responds, a rolling shutter gate may only move in the opening direction.	
When a crane trolley is at the operating limit switch then it may only start in the opposite direction.	
To manually clean the roller in a printing machine, the roller must only turn in a specific direction.	

3.12   Safe Speed Monitoring (SSM)

How does SSM function?
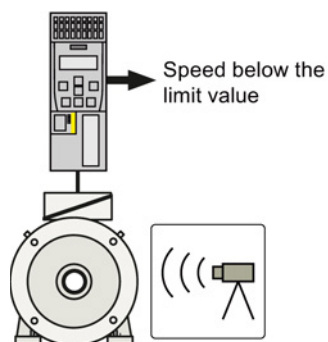
The inverter with active SSM function signals whether the velocity or speed of a machine component is above or below a limit value.

Table 3- 9   The principle of operation of SSM

	Safe Speed Monitoring (SSM)		Standard inverter functions linked with SSM
1.	The SSM function cannot be selected or deselected using external control signals, in the appropriate setting, it is always active.		---
2.	The inverter compares the motor speed with an adjustable limit value.		
3.	If the speed is less than the limit value, the inverter signals "Speed below limit value" via a safety output or via safety-related PROFIsafe communication.		

The SSM safety function is standardized

The SSM function is defined in IEC/EN 61800-5-2:

"The SSM function supplies a safe output signal to indicate whether the motor speed is below a specified limit value."

The SSM inverter function complies with what is defined in the standard.

Application example

Example	Possible solution
A centrifuge may only filled below a certain minimum velocity.	The inverter safely monitors the centrifuge speed and enables the process to advance to the next step using the status bit "Speed below limit value" via PROFIbus.

Installing 4

4.1 Installing the inverter

Procedure

The following overview shows the procedure for installing integrated safety functions in an inverter. The step selected in gray is described in this manual. For information on the steps that are not selected, you will need to consult descriptions in other manuals.

Proceed as follows:

1. If you are using a higher-level control system (PLC), then create the control program first.
2. Install the inverter.

   → operating instructions of your inverter.
3. Connect the inverter to the line supply, and wire the standard inputs and outputs of the inverter.

   → operating instructions of your inverter.
4. Connect the safety inputs and outputs

   → in this manual: Activation via F-DI (Page 51).

   → in this manual: Evaluating via F-DO (Page 71).
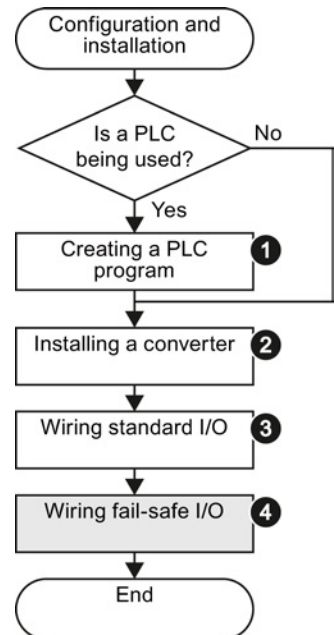
You have installed the inverter and prepared it for commissioning.

4.2 Connection via PROFIsafe

4.2.1 Overview of PROFIsafe connections

Communication via PROFIsafe

For communication via PROFIsafe, you must connect the inverter to a central fail-safe control (F-CPU) via either PROFIBUS or PROFINET.
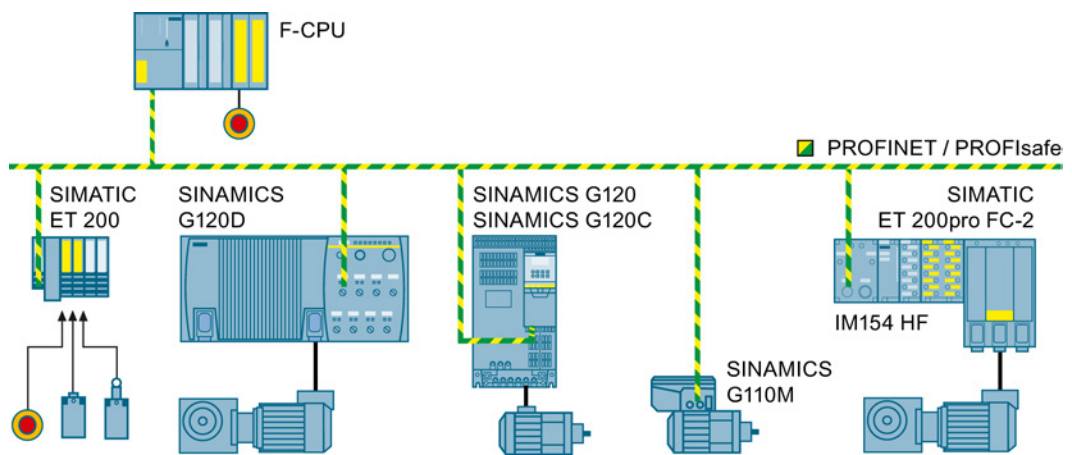
Figure 4-1   PROFIsafe communication between an F-CPU and an inverter, e.g. via PROFINET

The SIMATIC ET 200pro FC-2 converter does not have its own PROFIsafe interface. The central F-CPU controls the safety functions of the ET 200pro FC-2 via a "High Feature" interface module and the PROFIsafe "F-Switch" module.

The F-Switch module switches the "F0" and "F1 rails" in the backplane bus of the ET-200pro system. The inverter evaluates the F0 rail using an internal, safety input.
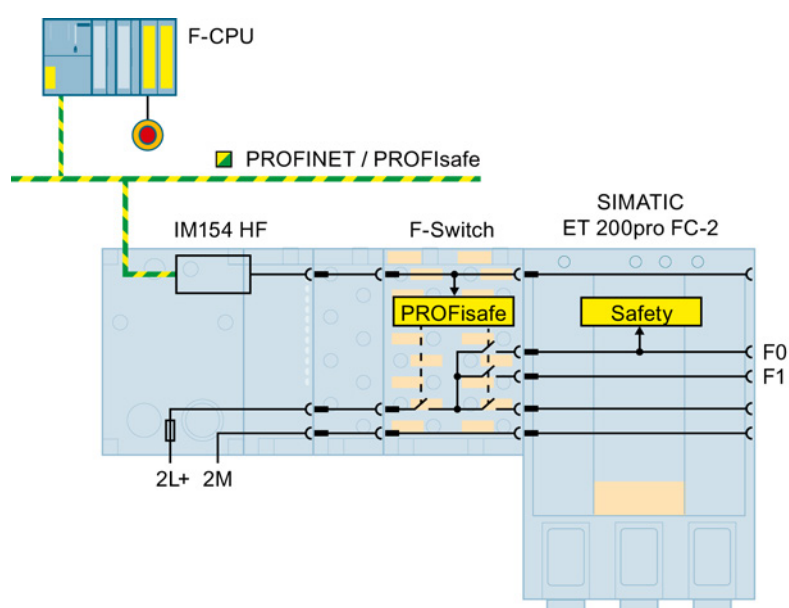
Figure 4-2   F-Switch to connect PROFIsafe of the ET 200pro FC-2 converter, e.g. via PROFINET

Additional information on the ET 200pro system and the F-Switch module is available in the "SIMATIC distributed ET 200pro I/O system" Operating instructions. See also Section: Manuals for your inverter (Page 334).

Additional possibilities of installing the F-Switch module are listed in the Internet: FAQ (http://support.automation.siemens.com/WW/view/en/26694409).

Shared Device

The PROFINET "Shared Device" function allows two controls to access the same PROFINET IO device, e.g. on a SIMATIC ET 200 I/O system or on an inverter. Typical applications for "Shared Device" are systems, in which a standard CPU and a fail-safe CPU are used as separate controllers:

●   The fail-safe controller (F-CPU) is responsible for the safety functions in the inverter or in the SIMATIC ET 200 I/O system.

●   The standard controller transfers all other signals.
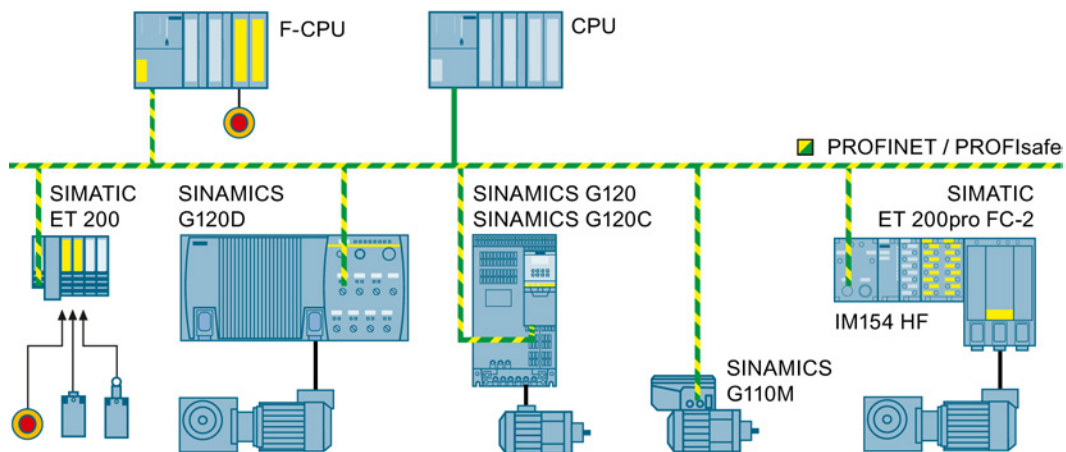
Figure 4-3   Shared device is possible with every inverter

Communication I-slave ↔ slave

It is only possible to use an F-CPU as I slave via PROFIBUS.

The SIMATIC ET 200pro FC-2 converter permits I-slave-slave communication. On one hand, the F-CPU is slave on PROFIBUS – and on the other hand, controls the safety functions of the inverter via PROFIsafe.

PROFIsafe communications between SINAMICS inverters and an I-slave is not possible.
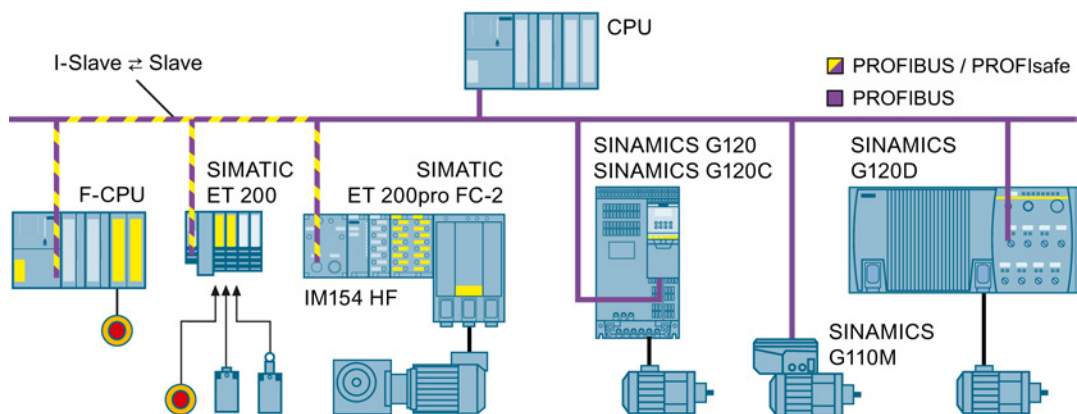
Figure 4-4   The I-slave-slave communication is only possible with ET 200pro FC-2

PROFIsafe communication within the SIMATIC ET 200pro

The SIMATIC-ET-200pro system allows safety-related communication, restricted to the system:

- The ET-200pro system is node on the PROFIBUS or PROFINET.

- Within the ET-200pro system, the interface module with integrated fail-safe control (IM F-CPU) controls the safety functions of the inverter via PROFIsafe.
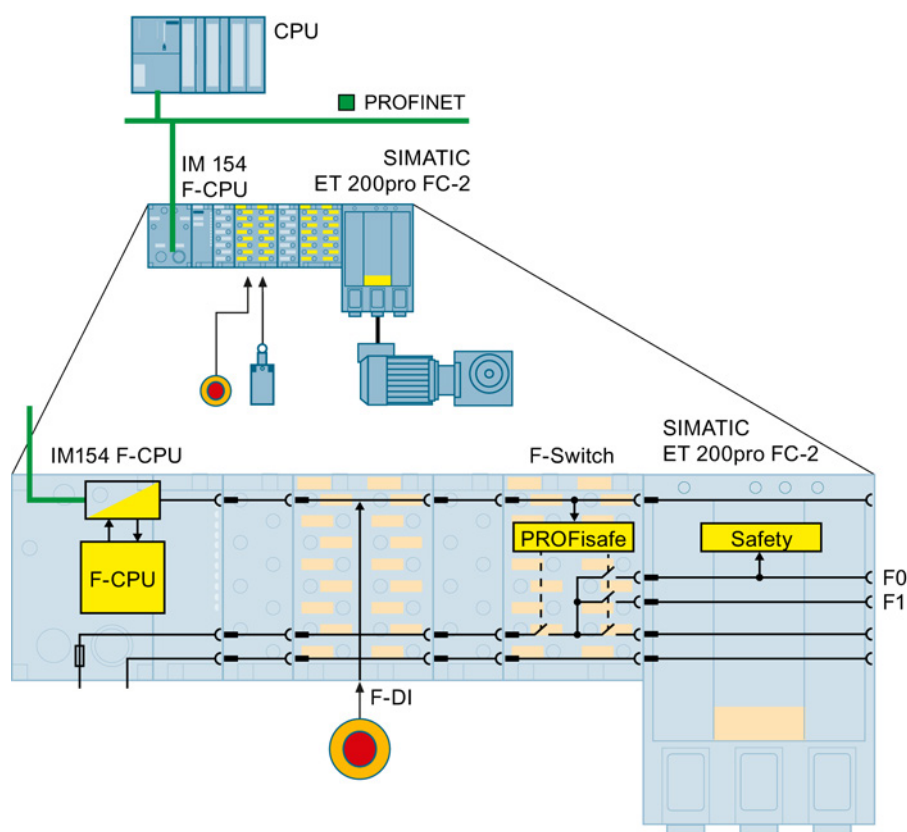
Figure 4-5   Safety-related communication between an IM F-CPU and inverter within an ET 200pro, e.g. on PROFINET

4.2.2 PROFIsafe telegrams

Two telegrams are available for the data exchange via PROFIsafe between the inverter and the higher-level controller:

Table 4- 1   PROFIsafe telegrams

Overview using PROFINET / PROFIsafe as example	Telegram	Process data (PZD)	
		PZD1	PZD2
	Telegram 30 PZD 1/1	S_STW1	---
		S_ZSW1	---
	Telegram 900 PZD 2/2	S_STW1	S_STW5
		S_ZSW1	S_ZSW5
	The higher-level control selects the safety functions in the inverter via the control word S_STW1. The inverter uses the status word S_ZSW1 to report the status of the safety functions to the controller. Telegram 900 of the PROFIsafe profile also contains control and status word 5. The inverter uses status word S_ZSW5 to transfer the state of the safety digital inputs to the control.		

S_STW: Safety control word; S_ZSW: Safety status word

4.2.3   Control word 1 and status word 1 (basic functions)

Table 4- 2   Control word 1 (bit 0 ... 15)

Byte	Bit	Function	Comment	
0	0	STO	0	Select STO
			1	Deselect STO
	1	SS1	0	Select SS1
			1	Deselect SS1
	2 ... 6	*Not relevant*		
	7	Internal Event ack	0	Do not acknowledge faults
			1 → 0	Acknowledge "Internal event" for a 1 → 0 signal change
1	*8 ... 15*	*Not relevant*		

Table 4- 3   Status word 1 (bit 0 ... 15)

Byte	Bit	Function	Comment	
0	0	Power removed	0	STO is not active
			1	STO is active
	1	SS1 active	0	SS1 is not active
			1	SS1 is active
	2 ... 6	*Not relevant*		
	7	Internal Event	0	Fault-free operation
			1	The inverter signals an "internal event"
1	*8 ... 15*	*Not relevant*		

4.2.4 Control word 1 and status word 1 (extended functions)

Table 4- 4   Control word 1 (bit 0 ... 15)

Byte	Bit	Function	Comment				
0	0	STO	0	Select STO			
			1	Deselect STO			
	1	SS1	0	Select SS1			
			1	Deselect SS1			
	2, 3	*Not relevant*					
	4	SLS	0	Select SLS			
			1	Deselect SLS			
	5, 6	*Not relevant*					
	7	Internal event ack	0	Do not acknowledge faults			
			1 → 0	Acknowledge "Internal event" for a 1 → 0 signal change			
1	*0*	*Not relevant*					
	1	SLS level bit 0	Select SLS level			Bit 10	Bit 9
				Level 1		0	0
	2	SLS level bit 1		Level 2		0	1
				Level 3		1	0
				Level 4		1	1
	3	*Not relevant*					
	4	SDI positive	0	Select SDI with positive direction of rotation			
			1	Deselect SDI with positive direction of rotation			
	5	SDI negative	0	Select SDI with negative direction of rotation			
			1	Deselect SDI with negative direction of rotation			
	6, 7	*Not relevant*					

Table 4- 5   Status word 1 (bit 0 ... 15)

Byte	Bit	Function	Comment				
0	0	Power removed	0	STO is not active			
			1	STO is active			
	1	SS1 active	0	SS1 is not active			
			1	SS1 is active			
	2, 3	*Not relevant*					
	4	SLS active	0	SLS is not active			
			1	SLS is active			
	5, 6	*Not relevant*					
	7	Internal Event	0	Fault-free operation			
			1	The inverter signals an "internal event"			
1	*0*	*Not relevant*					
	1	SLS level bit 0	SLS level is active			Bit 10	Bit 9
	2	SLS level bit 1		Level 1		0	0
				Level 2		0	1
				Level 3		1	0
				Level 4		1	1
	3	*Not relevant*					
	4	SDI positive active	0	SDI positive direction of rotation is not active			
			1	SDI positive direction of rotation is active			
	5	SDI negative active	0	SDI negative direction of rotation is not active			
			1	SDI negative direction of rotation is active			
	6	*Not relevant*					
	7	Status SSM	0	Absolute value of the speed is greater than the SSM limit value			
			1	Absolute value of the speed is less than the SSM limit value			

4.2.5 Control word 5 and status word 5

Table 4- 6   Control word 5 (bit 0 ... 15)

Byte	Bit	Function	Comment
0 … 1	0 … 15	*Reserved*	Assign the value 0 to the reserved bits.

Table 4- 7   Status word 5 (bit 0 ... 15)

Byte	Bit	Function	Comment		SINAMICS G120	SINAMICS G120D
0	0 … 7	*Reserved*	-			
1	8	**Status of safety inputs**	0	LOW signal (0 V)	At terminals 5 and 6	At pins X7.2 and X7.4
			1	HIGH signal (24 V)		
	9		0	LOW signal (0 V)	At terminals 7 and 8	At pins X8.2 and X8.4
			1	HIGH signal (24 V)		
	10		0	LOW signal (0 V)	At terminals 16 and 17	At pins X9.2 and X9.4
			1	HIGH signal (24 V)		
	11 … 15	*Reserved*	-			

An overview of the safety inputs can be found in section Safety inputs (Page 51).

If one of the two following conditions is satisfied, the inverter sets the particular bit 8 … 10 in the status word 5 to zero, independent of the voltage levels that are present:

● The corresponding safety input is not used.

● The inverter has deactivated the relevant safety input due to a discrepancy.

4.3 Activation via F-DI

4.3.1 Safety inputs

In the factory setting of the inverter, the safety inputs are not assigned to the integrated safety functions. Only when commissioning do you define whether you use, for example, digital inputs DI 4 and DI 5 for standard functions, or by combining them, you create a safety input.

The SIMATIC ET 200pro FC-2 converter does not have directly accessible safety inputs. If you wish to control the safety functions of this inverter via an input within the ET-200pro station, then you will need the F-RSM or F-Switch module.

Wiring examples are provided in the following section, also see Wiring examples (Page 54).

Assignment of safety inputs

Table 4- 8   Inverters (chassis units, IP20) with only one safety input

SINAMICS G120C	SINAMICS G120 with CU240E-2 CU240E-2 DP CU240E-2 PN Control Units	Terminal strip	Digital input	Safety input
		16	DI 4	F-DI 0
		17	DI 5	

Table 4- 9   Inverters (chassis units IP20) with several safety inputs

SINAMICS G120 with CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F CU250S-2 CU250S-2 CAN CU250S-2 DP CU250S-2 PN Control Units	Terminal strip	Digital input	Safety inputs	
			Basic functions	Extended functions
	5	DI 0	-	F-DI 0
	6	DI 1		
	7	DI 2		F-DI 1
	8	DI 3		
	16	DI 4	F-DI 0	F-DI 2
	17	DI 5		

Table 4- 10   Inverters for cabinet-free installation (IP65) with only one safety input

	Connector.pin	Digital input	Safety input
SINAMICS G120D with CU240D-2 DP CU240D-2 PN Control Units	X9.4	DI 4	F-DI 0
	X9.2	DI 5	
SINAMICS G110M	X8.4	DI 2	F-DI 0
	X8.2	DI 3	

Table 4- 11   Inverters for cabinet-free installation (IP65) with several safety inputs

SINAMICS G120D with CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU240D-2 PN-F FO CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP CU250D-2 PN-F FO Control Units	Connector.pin	Digital input	Safety inputs	
			Basic functions	Extended functions
	X7.4	DI 0	-	F-DI 0
	X7.2	DI 1		
	X8.4	DI 2		F-DI 1
	X8.2	DI 3		
	X9.4	DI 4	F-DI 0	F-DI 2
	X9.2	DI 5		

Safety-related signals, e.g. the switching state of a sensor, must be wired using two channels with one safety input. The inverter evaluates the signal on two separate signal paths.

What devices can be connected?

The safety-related input is designed for the following devices:

- Connection of safety sensors, e.g. emergency stop command devices or light curtains.
- Connection of pre-processing devices, e.g. fail-safe control systems and safety relays.

Signal states

The inverter expects signals with the same state at its safety-related input:

- High signal: The safety function is deselected.
- Low signal: The safety function is selected.

Fault detection

The inverter evaluates deviations in the two signals of the safety-related input. The inverter thus detects, for example the following faults:

- Cable break
- Defective sensor

The inverter cannot detect the following faults:

- Cross-circuit of the two cables
- Short-circuit between signal cable and 24 V power supply

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Special measures when establishing connections

When routing cables over longer distances, e.g. between remote control cabinets, you have the following options to reduce the risk of damaged cables when your plant or machine is operating:

- Use shielded cables with grounded shield.
- Lay signal cables in steel pipes.

4.3.2 Wiring examples

On the following pages, you will find examples of interconnecting safety digital inputs in accordance with PL d to EN 13849-1 and SIL 2 to IEC 61508.

4.3.2.1 Connecting sensors

Electromechanical sensor

If there is a risk of cross-circuits or short-circuits, the cables between the sensor and the inverter must be protected, for example, by routing them in a steel tube.

The inverter provides the supply voltage
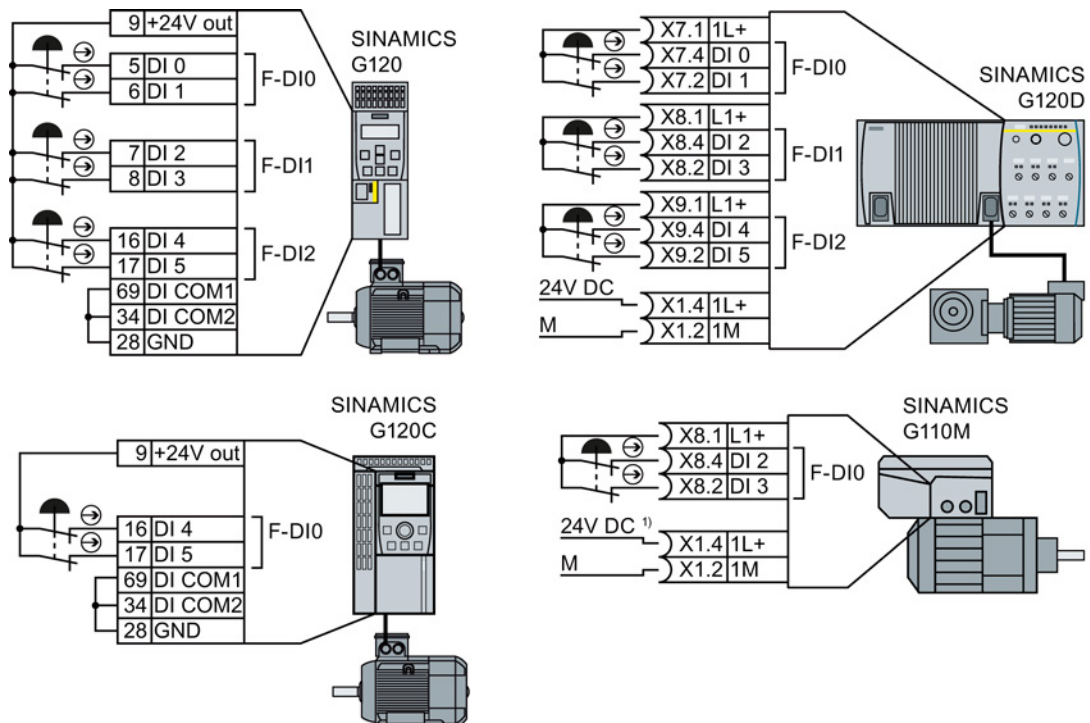
[1] The 24 V supply is not required when using the G110M "24 V Power Module" option

Figure 4-6   Connecting an electromechanical sensor to the inverter power supply

External power supply
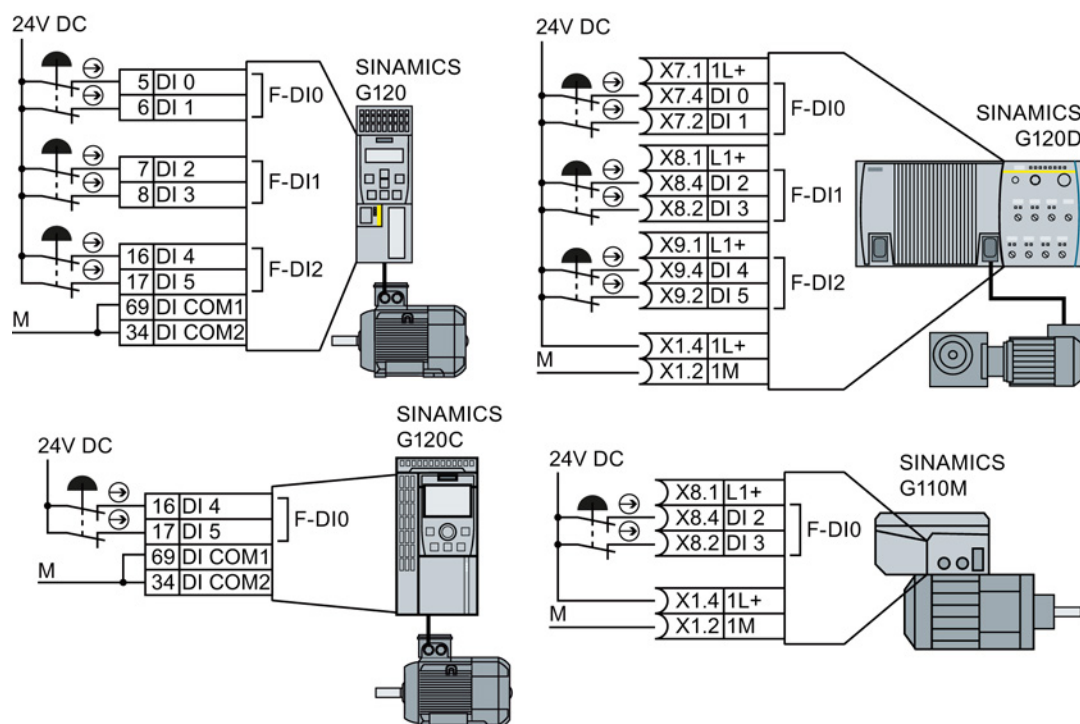
Figure 4-7   Connecting an electromechanical sensor to an external power supply

SIMATIC ET 200pro

The SIMATIC ET 200pro FC converter does not have its own inputs. If you wish to directly control the safety functions of the ET 200pro FC-2 via a sensor, then you will require the F-RSM or the F-Switch module.

The F-RSM module evaluates the sensor, and switches the "F0 rail" in the backplane bus of the ET-200pro system. The inverter evaluates the F0 rail using an internal, safety input.
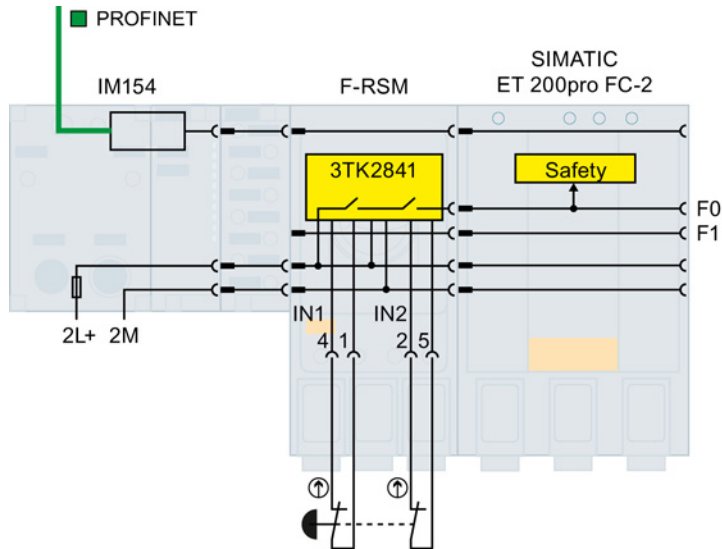
Figure 4-8   Directly controlling the safety functions in the ET 200pro FC-2 converter via the F-RSM module

The F-Switch module evaluates the sensor, and also switches the "F0 rail" in the backplane bus of the ET-200pro system. The inverter evaluates the F0 rail using an internal, safety input.
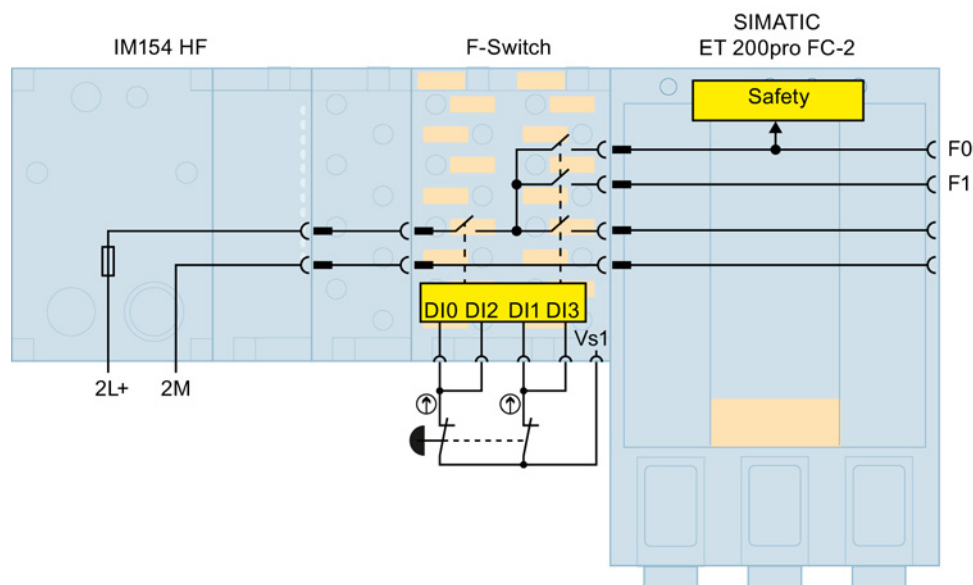
Figure 4-9   Directly controlling the safety functions in the ET 200pro FC-2 converter via the F-Switch module

Additional installation options for the F-Switch and F-RSM modules are listed in the following FAQ: FAQ (http://support.automation.siemens.com/WW/view/en/26694409).

Series-connected electromechanical sensors

You may connect Emergency Stop control devices in series if it can be ruled out that the Emergency Stop command devices are simultaneously actuated. The simultaneous failure of Emergency Stop control devices connected in series can generally be ruled out.

According to IEC 62061 (SIL) and EN ISO 13849-1 (PL), position switches of protective doors may also connected in series.
Exception: If several protective doors are regularly opened at the same time, it is not possible for faults to be detected, which means that the position switches must not be connected in series.

If there is a risk of cross-circuits or short-circuits, the cables between the sensor and the inverter must be protected, for example, by routing them in a steel tube.

The inverter provides the supply voltage

Connect the 24 V supply of the inverter to the sensors and connect the reference potentials of the inputs used to GND.
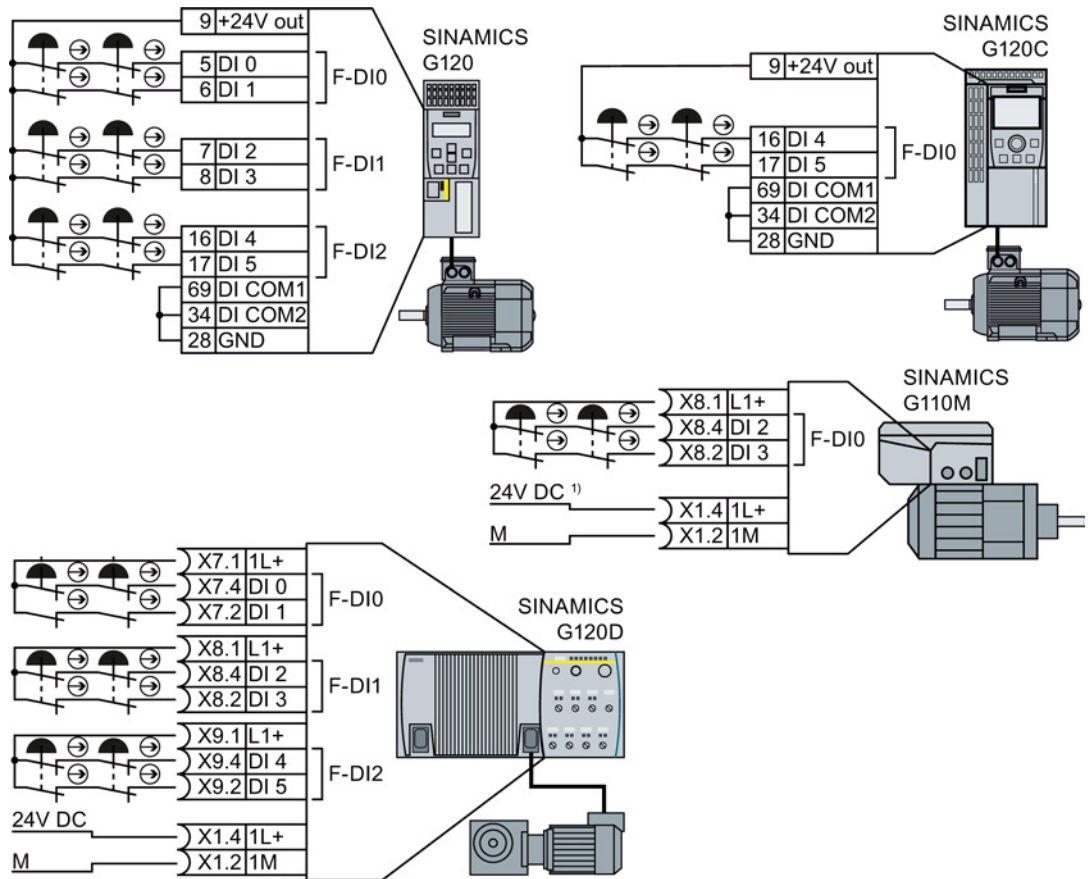
[1] The 24 V supply is not required when using the G110M "24 V Power Module" option

Figure 4-10   Connecting electromechanical sensors to the inverter power supply in series

External power supply

Connect the external power supply to the sensors and connect the reference potentials of the inputs used to the reference potential of the external power supply.
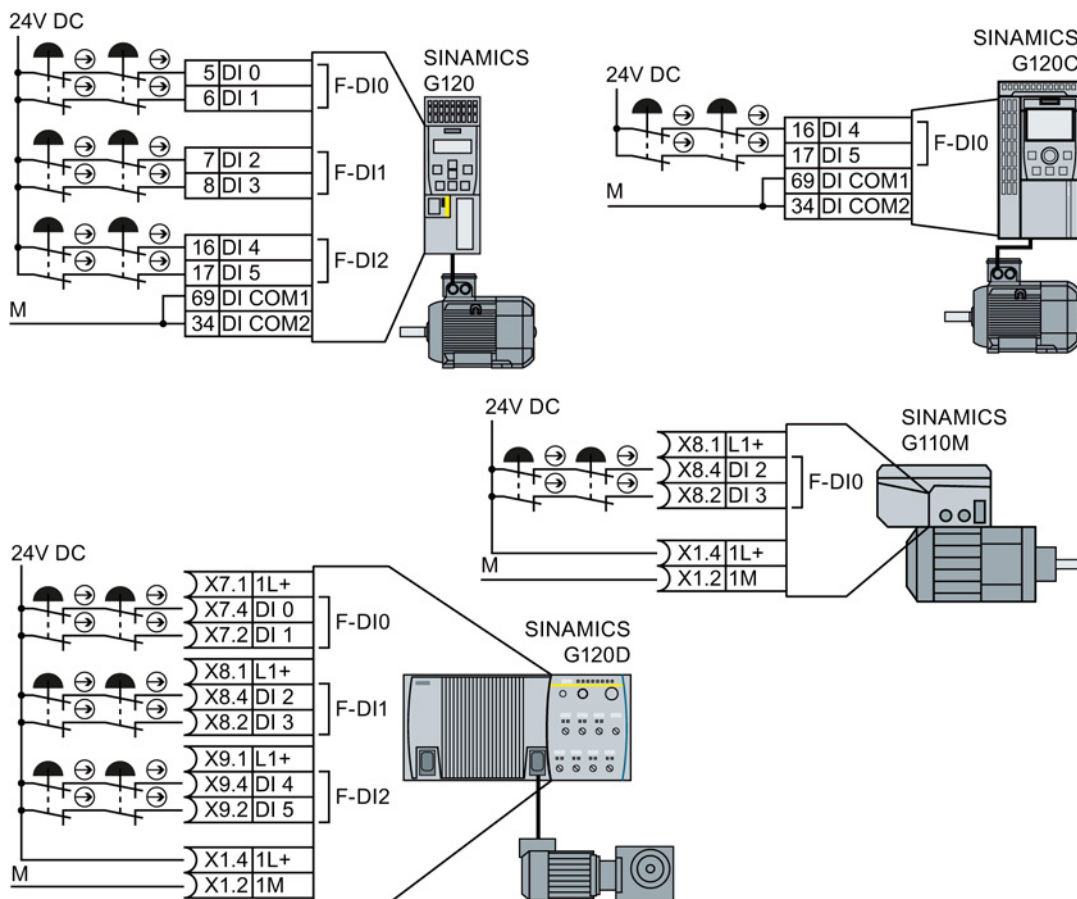
Figure 4-11   Connecting electromechanical sensors to an external power supply in series

Activating several inverters simultaneously

You may activate the safety functions of several converters simultaneously with one or several series-connected safety sensors.

If there is a risk of cross-circuits or short-circuits, the cables between the sensor and the converter must be protected, for example, by routing them in a steel tube.

The converter provides the supply voltage

Connect the 24 V supply of the converter to the sensors and connect the reference potentials of the inputs used to GND.
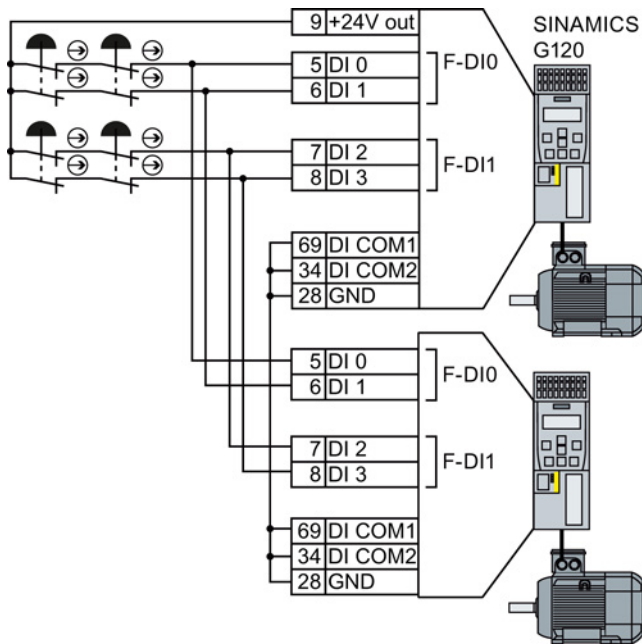
Figure 4-12   Simultaneous activation of several converters with converter power supply

External power supply

Connect the external power supply to the sensors and connect the reference potentials of the inputs used to the reference potential of the external power supply.
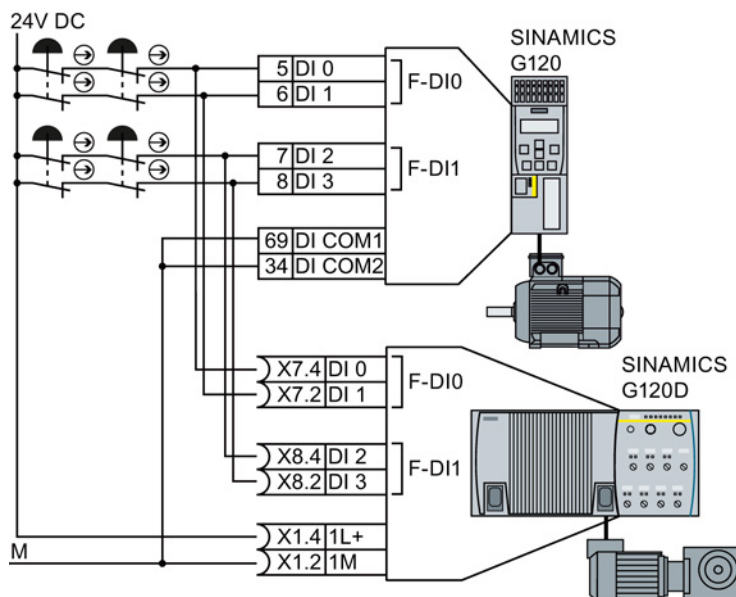
Figure 4-13   Simultaneous activation of several converters with external power supply

4.3.2.2 Connecting pre-processing devices

If you use safety relays with electronic enabling circuits, the relays must feature outputs that switch to P potential. The safety relay switches the 24 V supply line to the converter but not the ground return line.

Safety relays with relay enabling circuits are only permitted if, as a minimum, they have an internal two-channel configuration.

The following pages describe a number of typical circuits for various types of safety relay. Exactly how these are interconnected depends on whether the safety relay and the converter are housed in the same or separate control cabinets.

3TK28 safety relay

The typical circuits described on the following pages are based on safety relays with relay enabling circuits. Safety relays with semiconductor enabling circuits can also be used.

The diagrams only show how the safety relay and inverter are interconnected. Information providing full details of how the safety relay is wired can be found in the product-specific documentation: SIRIUS 3TK28 safety relays (http://support.automation.siemens.com/WW/view/en/26414637/133300).

Components in the same control cabinet

A control cabinet that has been designed and wired correctly does not contain any damaged wiring or cross circuits.

Under the assumption that the preprocessing devices switch the output used twice (involves two contacts in series), within a control cabinet you can interconnect the safety relay and inverter through a single channel cable connection. The two terminals of the safety input must be connected to each other at the inverter.

Figure 4-14   Interconnecting the inverter and safety relay within the same control cabinet

Components in separate control cabinets

If the components are located in separate control cabinets, the wiring between the safety relay and safety inputs in the inverter must be installed such that it is protected against cross and short-circuits.

Transfer the two signals for activating a safety function via wires in separate lines. In the example, the signals for terminal 5 and 7 are transferred via the first wire. The signals for terminal 6 and 8 are then transferred via the second wire.

Figure 4-15   Interconnecting the inverter and safety relay in separate control cabinets

3RK3 Modular Safety System

You can use both the safety outputs in the MSS Basic central unit of the 3RK3 modular safety system as well as the outputs in the EM 2/4F-DI 2F-DO expansion module to activate the F-DIs of the inverter.

The safety relay outputs of the EM 2/4F-DI 1/2F-RO expansion module must not be used because these only have a single-channel configuration.

The diagrams only show how the 3RK3 Modular Safety System and inverter are interconnected. Information providing full details of how the 3RK3 Modular Safety System are wired can be found in the product-specific documentation: SIRIUS 3RK3 Modular Safety System (http://support.automation.siemens.com/WW/view/en/26412499/133300).

Components in the same control cabinet

A control cabinet that has been designed and wired correctly does not contain any damaged wiring or cross circuits.

Under the assumption that the preprocessing devices switch the output used twice (involves two contacts in series), within a control cabinet you can interconnect the safety relay and inverter through a single channel cable connection. The two terminals of the safety input must be connected to each other at the inverter.
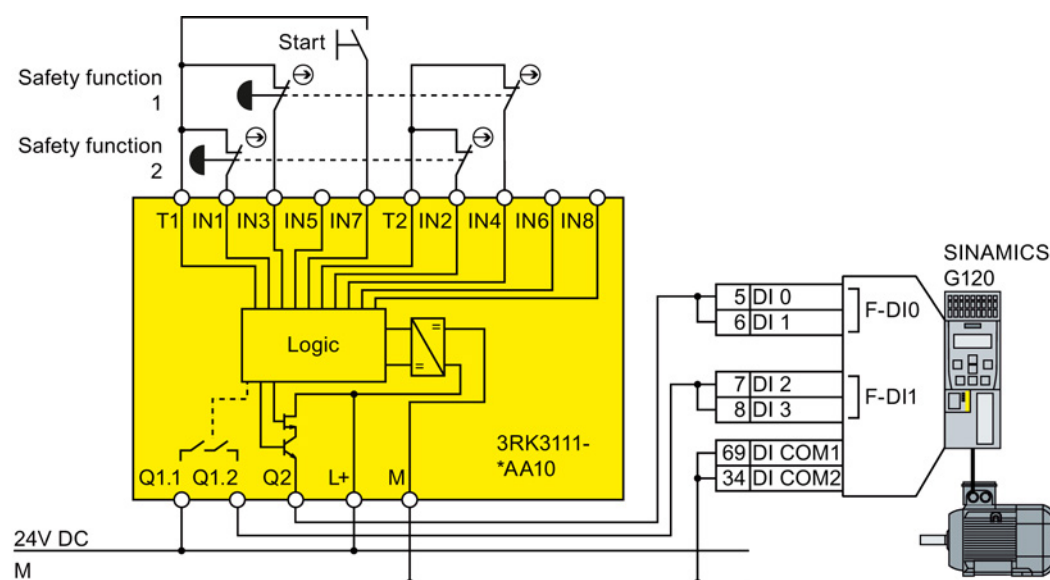
Figure 4-16   Interconnecting the inverter and Modular Safety System within the same control cabinet

Components in separate control cabinets

If the components are located in separate control cabinets, the wiring between the Modular Safety System and the F-DIs on the inverter must be installed such that it is protected against cross and short-circuits.

Transfer the two signals for activating a safety function via wires in separate lines. In the example, the signals for terminal 5 and 7 are transferred via the first wire. The signals for terminal 6 and 8 are then transferred via the second wire.

If you want to use the safety outputs of the 3RK3 central unit for transferring signals via two channels, inverter discrepancy monitoring must be adapted to the different switching times of the electronic output and relay contact.
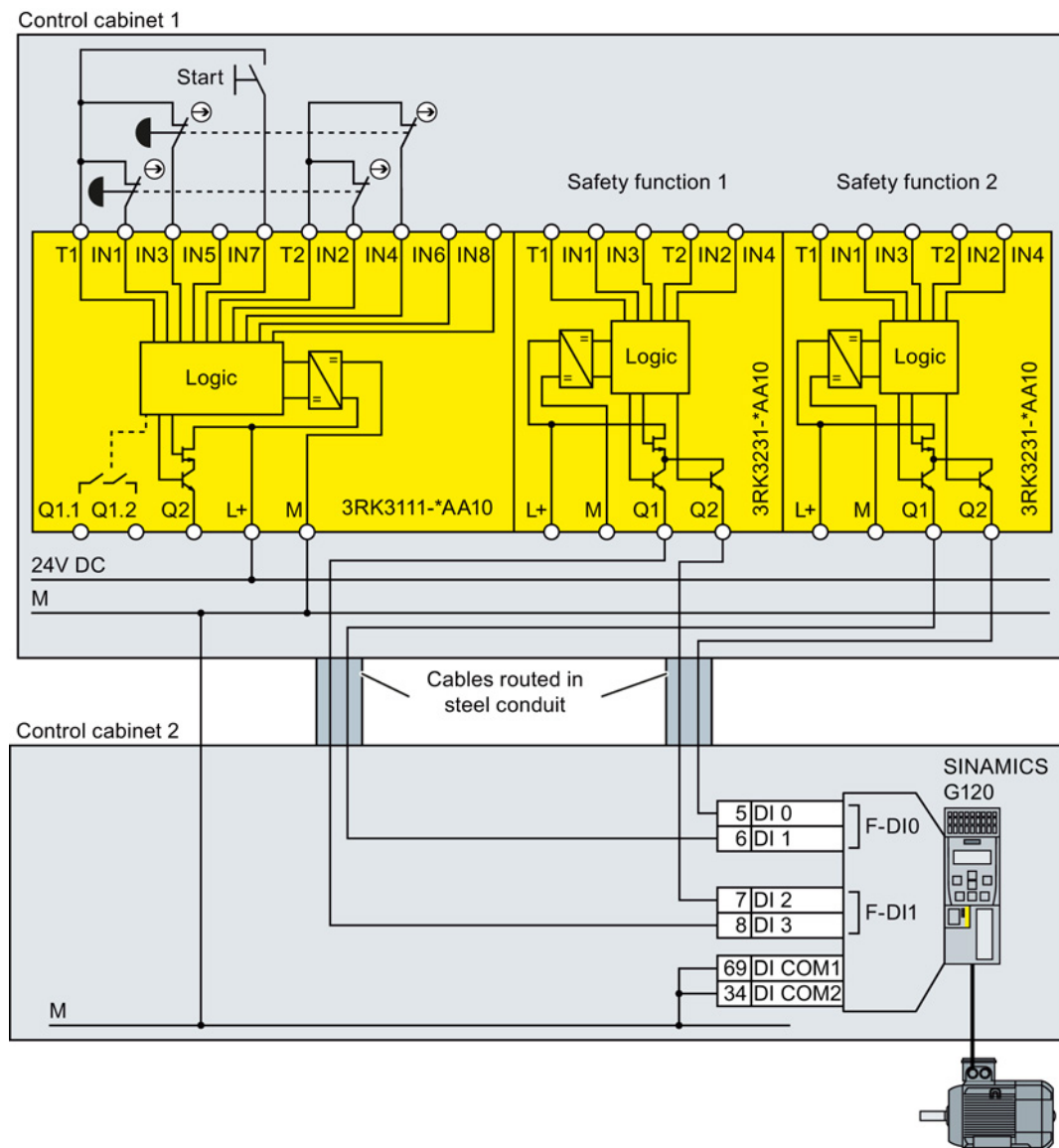
Figure 4-17   Interconnecting the inverter and Modular Safety System in separate control cabinets

S7-300 I/O modules

Safety outputs that switch to P potential are required for activating the safety digital inputs of the SINAMICS G120. From the S7-300 range, the SM326 DO 10 x 24 V / 2 A PP I/O module fulfills this requirement.

The diagrams only show how the I/O module and inverter are interconnected. Information providing full details of how the I/O module is wired can be found in the product-specific documentation: S7-300 (http://support.automation.siemens.com/WW/view/en/10805159/133300).

Components in the same control cabinet

A control cabinet that has been designed and wired correctly does not contain any damaged wiring or cross circuits.

Under the assumption that the preprocessing devices switch the output used twice (involves two contacts in series), within a control cabinet you can interconnect the I/O module SM326 and inverter through a single channel cable connection. The two terminals of the safety input must be connected to each other at the inverter.
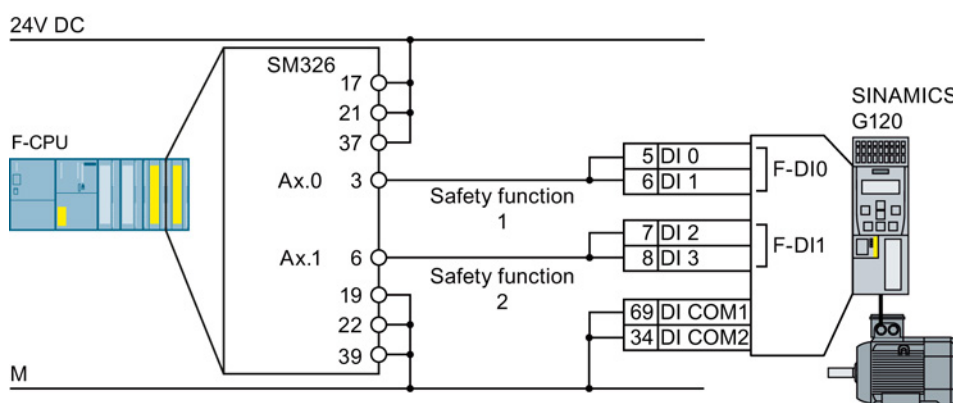
Figure 4-18   Interconnecting the inverter and SM326 I/O module within the same control cabinet

Components in separate control cabinets

If the components are located in separate control cabinets, the wiring between the SM326 I/O module and the F-DIs on the inverter must be installed such that it is protected against cross and short-circuits.

Transfer the two signals for activating a safety function via wires in separate lines. In the example, the signals for terminal 5 and 7 are transferred via the first wire. The signals for terminal 6 and 8 are then transferred via the second wire.
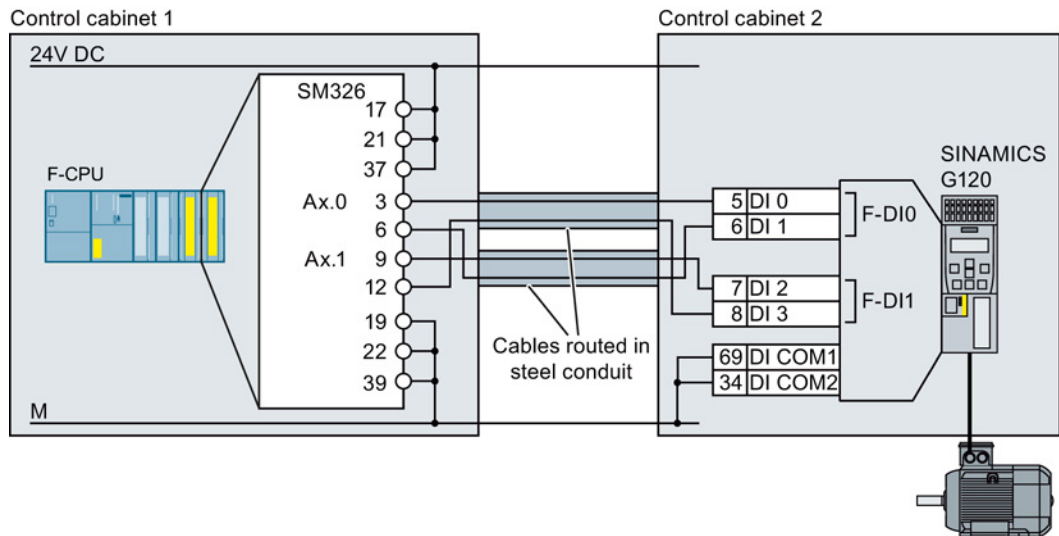
Figure 4-19   Interconnecting the inverter and SM326 I/O module in separate control cabinets

ET 200 I/O modules

Safety outputs that switch to P potential are required for activating the safety digital inputs of the SINAMICS G120. From the ET 200 system range, only the fail-safe relay module EM 1 F-RO DC 24 V / AC 24…230 V / 5 A of the ET 200S system fulfills this requirement.

The relay module is controlled via a fail-safe ET 200S output module.

The diagrams only show how the I/O modules and inverter are interconnected. Information providing full details of how the I/O modules is wired can be found in the product-specific documentation: ET 200S (http://support.automation.siemens.com/WW/view/en/10805258/133300).

Components in the same control cabinet

A control cabinet that has been designed and wired correctly does not contain any damaged wiring or cross circuits.

For this reason, you may interconnect the I/O modules and inverter in a control cabinet by means of a single-channel wiring arrangement. The two terminals of the safety input must be connected to each other at the inverter.
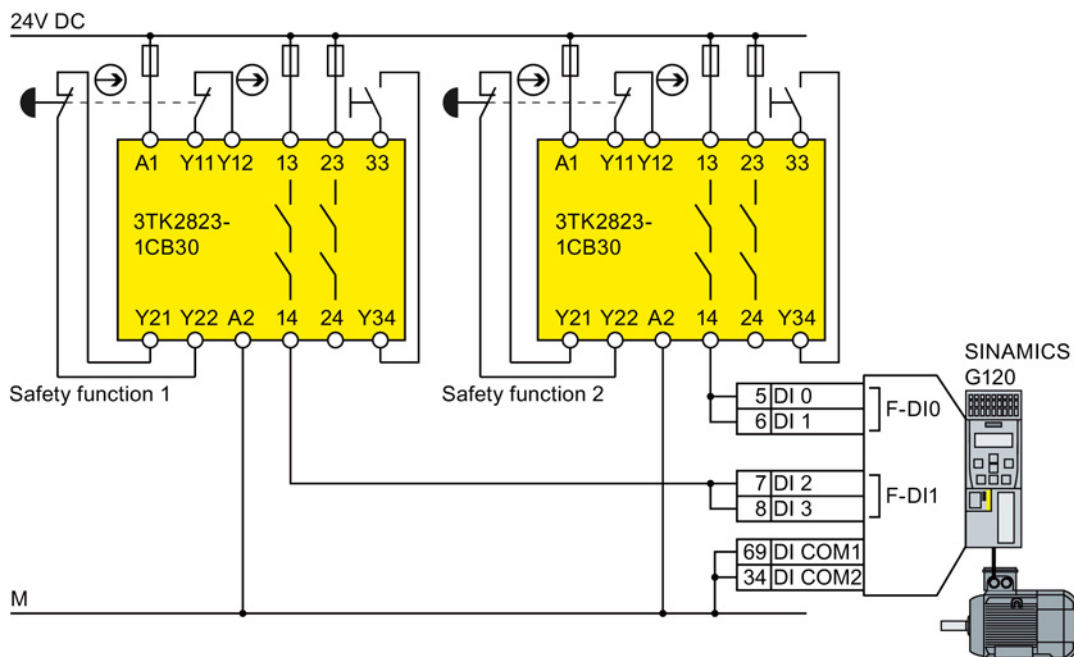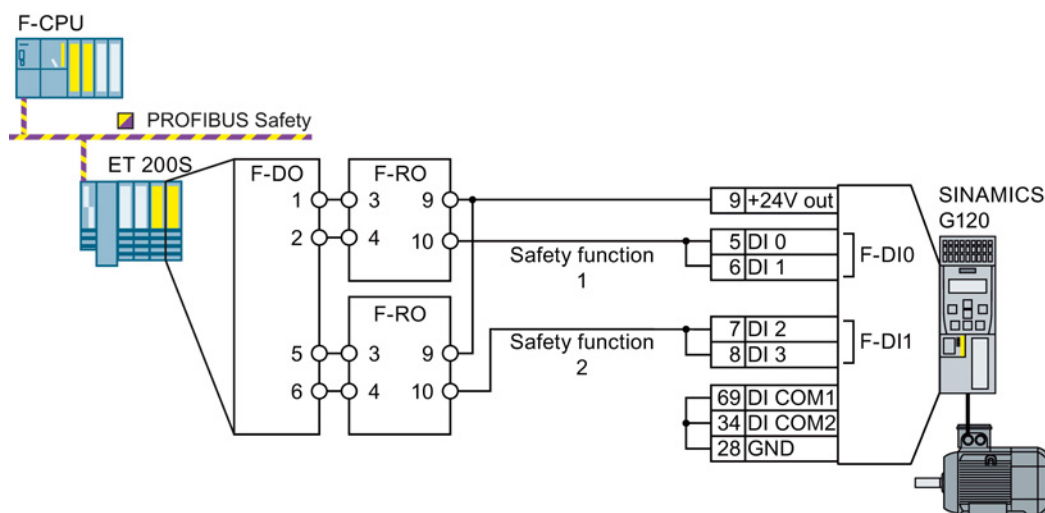

Figure 4-20   Interconnecting the inverter and I/O modules within the same control cabinet

Components in separate control cabinets

If the components are located in separate control cabinets, the wiring between the I/O modules and the F-DIs on the inverter must be installed such that it is protected against cross and short-circuits.

Transfer the two signals for activating a safety function via wires in separate lines. In the example, the signals for terminal 5 and 7 are transferred via the first wire. The signals for terminal 6 and 8 are then transferred via the second wire.
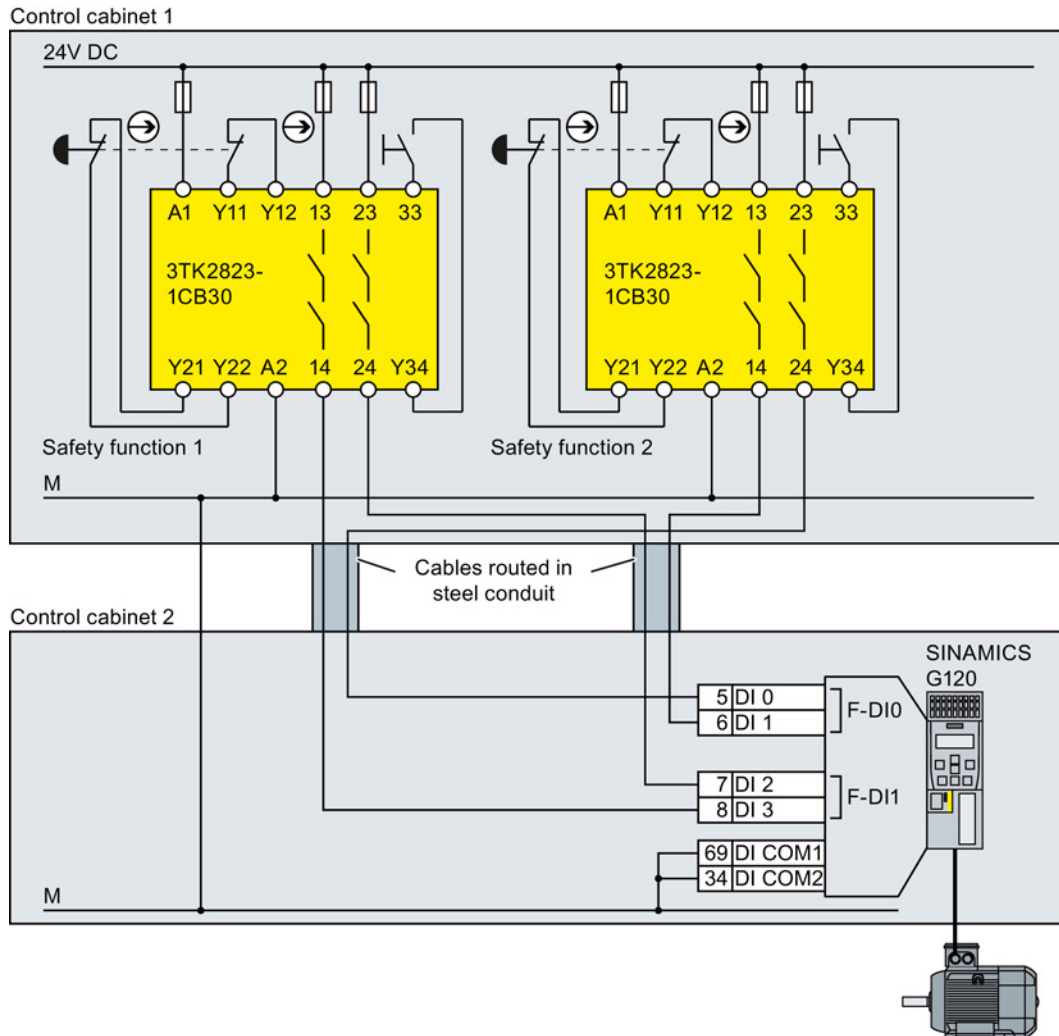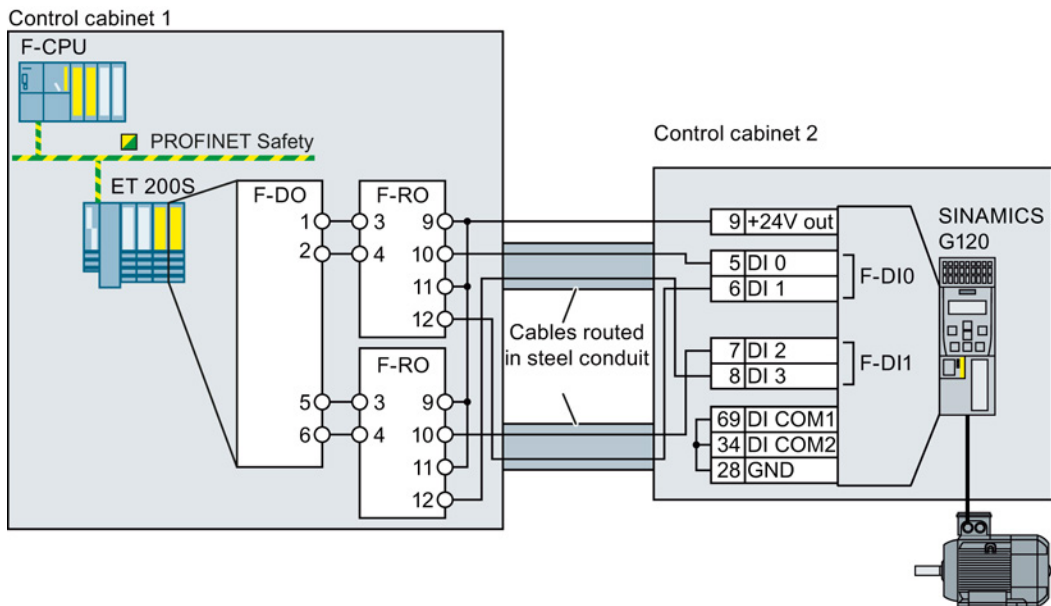
Figure 4-21   Interconnecting the inverter and I/O modules in separate control cabinets

4.4 Evaluating via F-DO

4.4.1 Safety output

In the factory setting of the inverter, the safety output is assigned to none of the integrated safety functions. Only when commissioning do you define whether you use, for example, the two digital outputs for standard functions, or you combine them to create a safety output.

Table 4- 12   inverters for cabinet-free installation (IP65)

SINAMICS G120D with Control Unit		Connector. Pin	Digital output	Safety output	Read back input	
	CU240D-2 DP-F	X5.4	DO 0	F-DO 0	X9.2	DI 5
	CU240D-2 PN-F	X5.2	DO 1			
	CU240D-2 PN-F PP	X5.3	2M			
	CU250D-2 DP-F					
	CU250D-2 PN-F					
	CU250D-2 PN-F PP					

Table 4- 13   Inverter for installation in a control cabinet (IP20)

SINAMICS G120 with Control Unit		Terminal strip	Digital output	Safety output	Read back input	
	CU250S-2	18: NC	DO 0	F-DO 0	67	DI 6
	CU250S-2 DP	19: NO				
	CU250S-2 PN	20: COM				
	CU250S-2 CAN	23: NC	DO 2			
		24: NO				
		25: COM				
Most applications require NO contacts for a safety output.						
If your application requires it, instead of NO contacts, you can also use the two NC contacts of the inverter. The safe state of the output is always the quiescent state of the two relays.						

What devices can be connected?

The safety output is designed for the following devices:

- Direct connection of a safety input.
- Connection of two relays.

The two signals of the safety output each have the same state:

- High signal or NO contact closed: Safety output is active.
- Low signal or NO contact open: Safety output is not active.

4.4.2　　Connecting the safety output for SINAMICS G120D

Connecting a relay
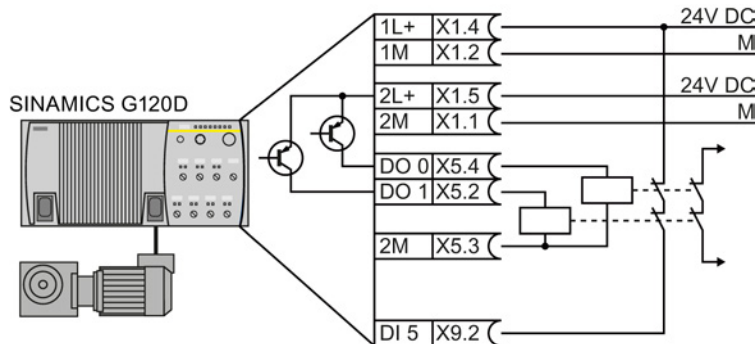
Figure 4-22　Connecting a relay at the F-DO

Connecting an actuator with feedback signal
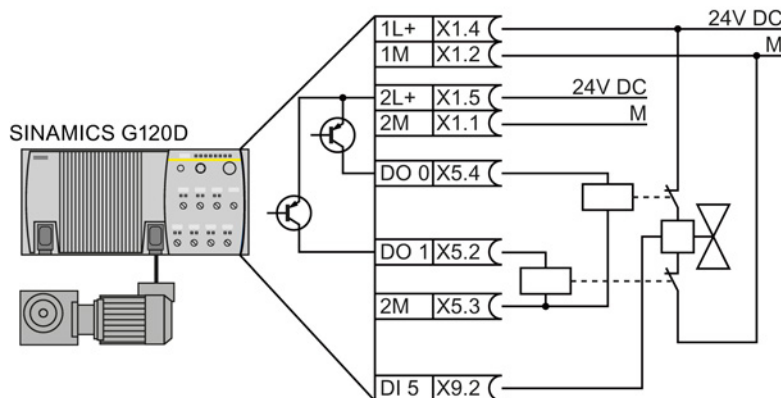
Figure 4-23　Connecting an F-DO to an actuator

Connecting a safety input
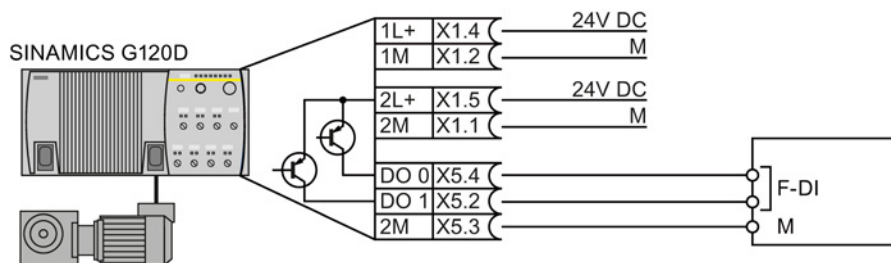
Figure 4-24　Connecting an F-DO with an F-DI

4.4.3   Connecting the safety output for SINAMICS G120

Connecting a relay
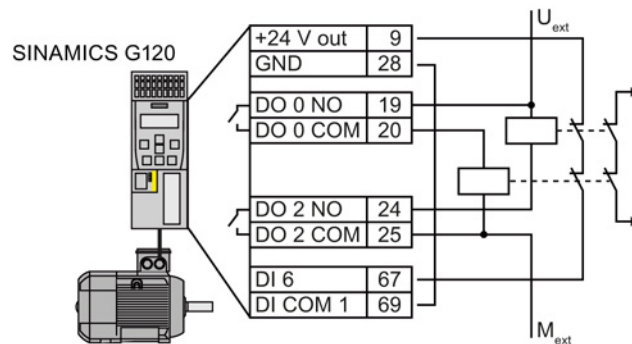
Figure 4-25   Connecting a relay at the F-DO

Connecting an actuator with feedback signal
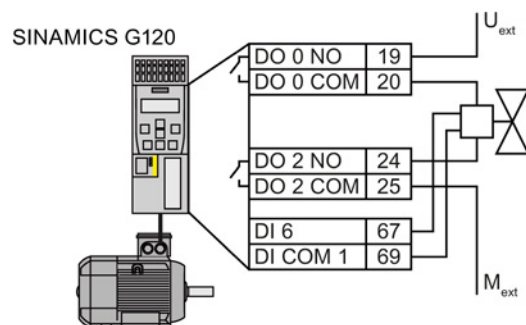
Figure 4-26   Connecting an F-DO to an actuator

Connecting a safety input
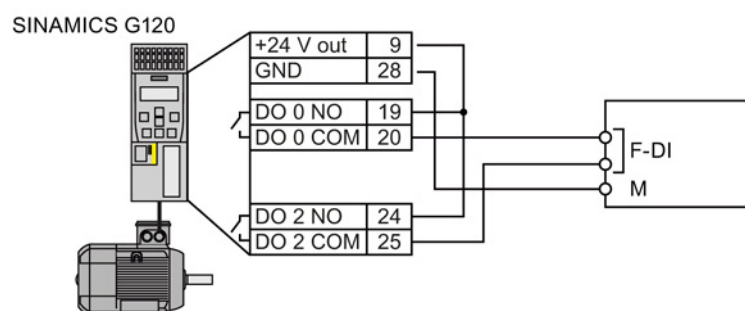
Figure 4-27   Connecting an F-DO with an F-DI

The safety input F-DI must monitor both signals of the safety output for consistency.

4.5 Connecting a motor holding brake to a Safe Brake Relay

Connecting a Safe Brake Relay and a motor holding brake

The Safe Brake Relay serves as an interface between the Power Module and the motor's brake coil.

The following options are available for installing the Safe Brake Relay:

- On a mounting plate
- On the control cabinet wall
- On the inverter's shield connection kit

For additional information, please refer to the associated installation instructions: Installation instructions for the Brake Relay (http://support.automation.siemens.com/WW/view/en/23623179).
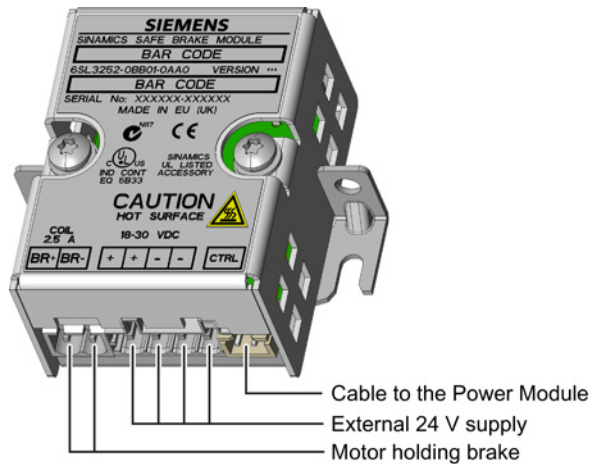
Safe Brake Relay connections

Procedure

To interconnect the inverter with the motor holding brake via the Safe Brake Relay, proceed as follows:

1. Connect the Safe Brake Relay to the Power Module using the cable harness provided.

Power Modules FSA … FSC:
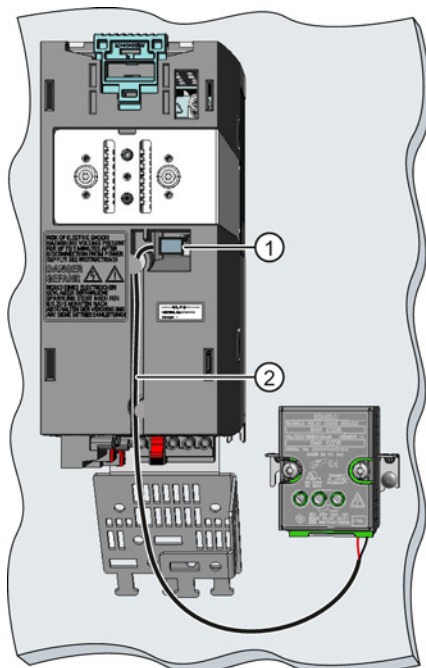
Power Modules FSD … FSF
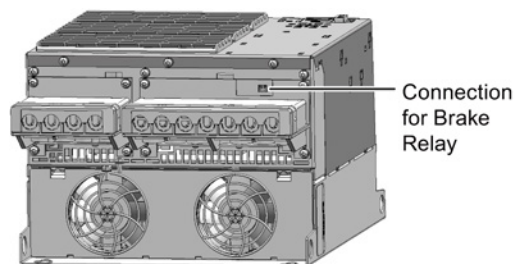
- Connect the Safe Brake Relay at the connector on the lower side of the Power Module.

- Connect the Safe Brake Relay at the connector on the front of the Power Module.
- Route the control cable in the guide on the Power Module.

2. Connect the motor holding brake to the terminals of the Safe Brake Relay:
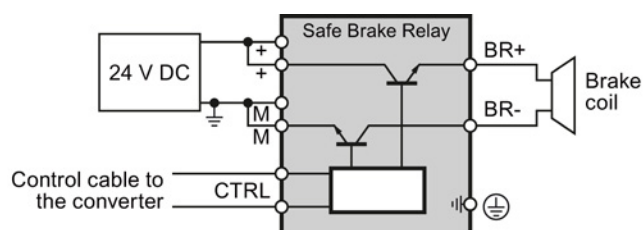
You have connected the motor holding brake to the inverter via the Safe Brake Relay.

Safety Integrated - SINAMICS G110M, G120, G120C, G120D and SIMATIC ET 200pro FC-2
Function Manual, 04/2014, FW V4.7, A5E34261271B AA

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Commissioning

<div style="text-align: right; font-size: 2em;">5</div>

5.1 Commissioning guidelines

The overview below shows the procedure for commissioning an inverter with integrated safety functions.

The steps for commissioning the safety functions form part of the activities for commissioning the entire drive.

- The commissioning steps marked in gray are described → in this manual.
- For the other steps, you are supported by → additional manuals.

Procedure

To commission an inverter with integrated safety functions, proceed as follows:

1. Connect the fieldbus to the inverter, and configure the communication in the higher-level control.

   → manual of your control system

   → operating instructions of your inverter

2. Configure the PROFIsafe communication in the higher-level control system.

   → in this manual: Configure PROFIsafe in the higher-level control system (Page 78).

3. Carry out the basic commissioning of the drive.

   → operating instructions of your inverter

4. Set the inverter safety functions.

   → subsequent pages in this manual

5. Commission all of the other inverter functions required, e.g. motor control or the protective functions.

   → operating instructions of your inverter

6. Perform an acceptance test for the safety functions.

   → in this manual: Acceptance tests for the safety functions (Page 156)
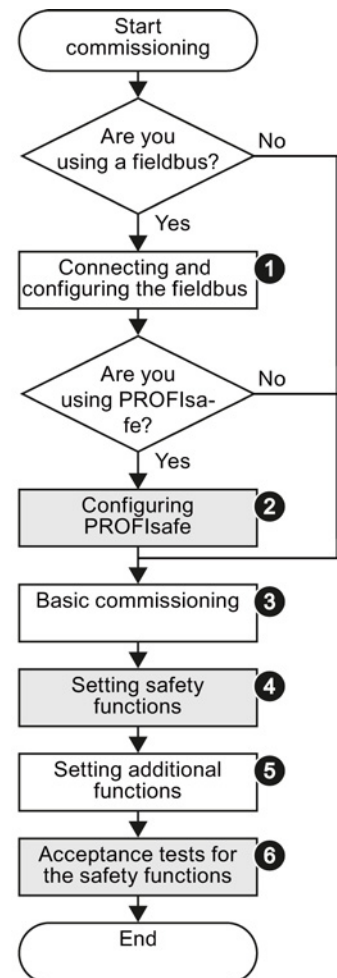
You have commissioned the inverter with integrated safety functions.

5.2 Configure PROFIsafe in the higher-level control system

You will find the following examples in this chapter:

- Configuring PROFIsafe communication between a higher-level control and an inverter with a GSD.

- Defining the interface to a SIMATIC control program.

- Configuring shared device communication

You can find additional information as application description or FAQ in the Internet, e.g.

- Configuring a PROFIsafe telegram with Drive ES Basic
  (http://support.automation.siemens.com/WW/view/en/64326460)

- Controlling SINAMICS G120 via PROFIsafe, displaying inverter messages on an HMI
  (http://support.automation.siemens.com/WW/view/en/61450312)

5.2.1 Configuring PROFIBUS communication with telegram 30 via GSD

Procedure

To configure PROFIsafe communication via PROFIBUS in the higher-level control, proceed as follows:

1. Configure your SIMATIC CPU (for example, a CPU315F-2 PN/DP) with a PROFIBUS network.

2. Integrate the inverter via its GSD into the PROFIBUS network.

3. Assign the first inverter slot to the PROFIsafe telegram.

4. Assign standard telegram 1, for example, to the other slots of the inverter.
   The operating instructions contain further information on the telegrams and slot sequence.
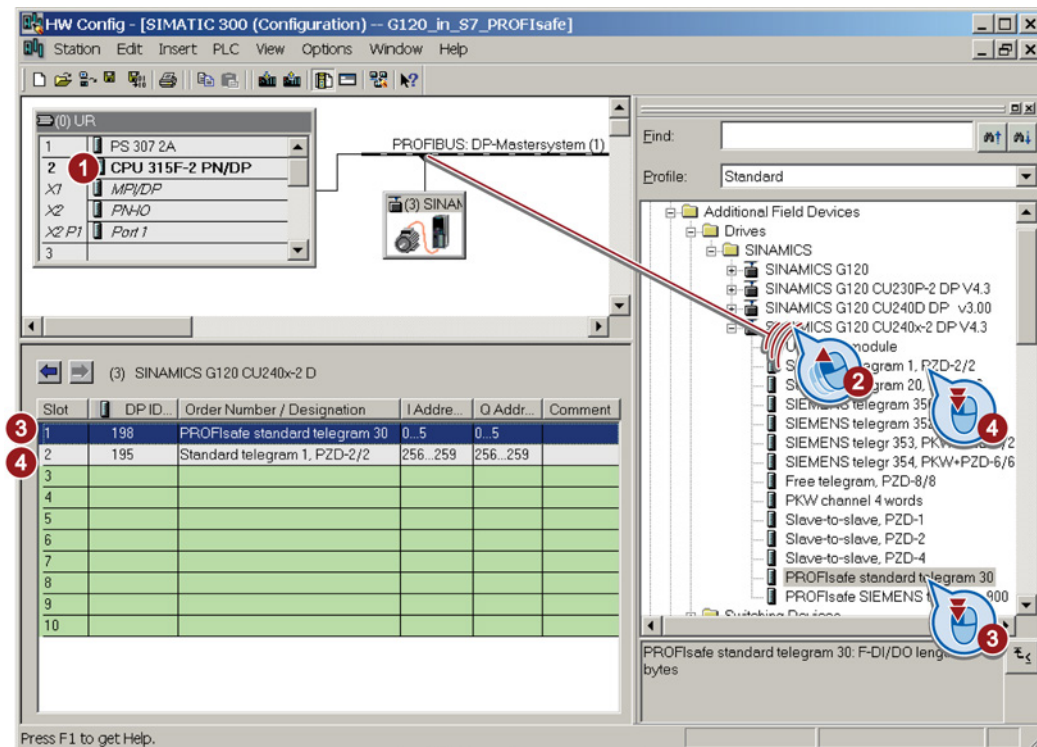
5. Open the properties dialog by double-clicking on the PROFIsafe telegram.

6. Set the input and output range, e.g. to address 14:
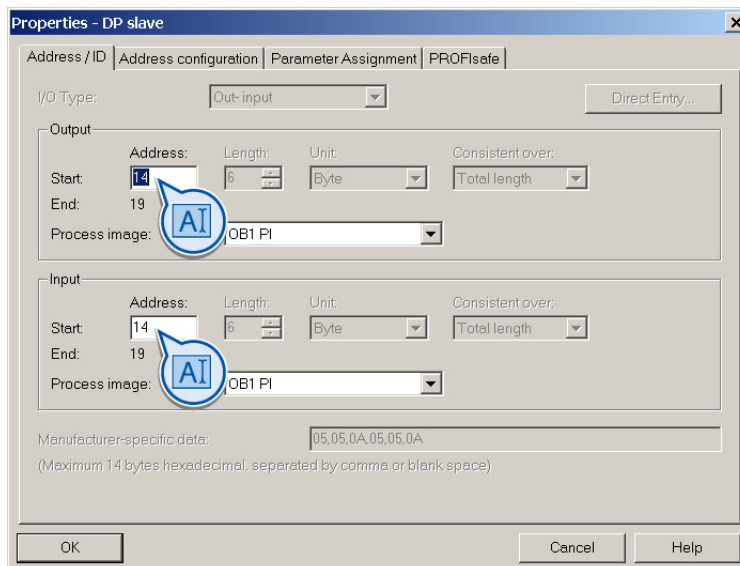
7. In this dialog, select the "PROFIsafe" tab.

   – ① F_Dest_Add

     Note the value of this address. You require this value when commissioning the safety functions.

   – ② F_WD_Time

     Set a value which is greater than the cycle time of your safety program.

     If your safety program is called every 150 ms, for example, in OB35, set the value of F_WD_Time to 200.
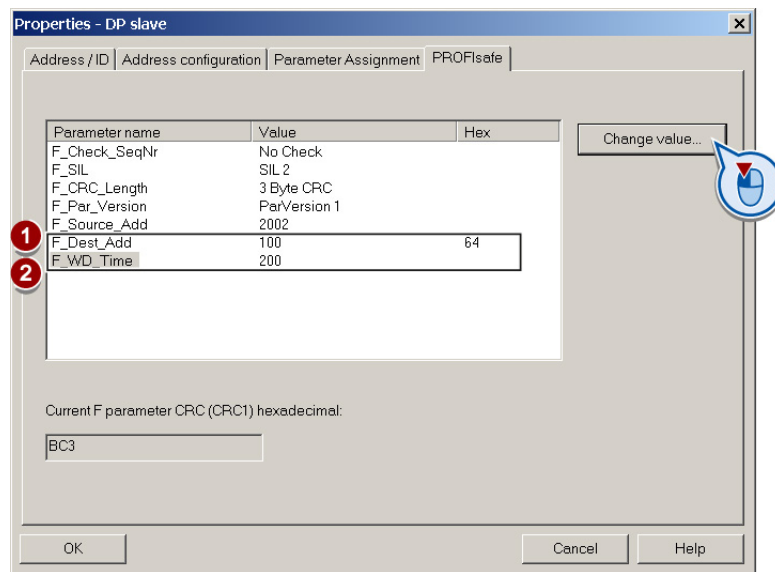
8. Save and compile your project and download the data to your SIMATIC CPU.

9. Close HW Config.

You have configured the PROFIsafe communication in the higher-level control system.

5.2.2 Example: Interface to the S7 safety program

When you configure the hardware in STEP 7, you assign the control word and status word in the PROFIsafe profile of the inverter to specific output and input addresses of the SIMATIC controller. In section Configuring PROFIBUS communication with telegram 30 via GSD (Page 78), start address 14, for example, was assigned. This results in the following assignments between the I/O addresses and inverter signals for this example:

Table 5- 1   Control word 1

I/O address	Meaning		Comment
A14.0	Select STO	0	Select STO
		1	Deselect STO
A14.1	Select SS1	0	Select SS1
		1	Deselect SS1
A14.4	Select SLS	0	Select SLS
		1	Deselect SLS
A14.7	Internal event ACK	-	Acknowledge with signal change 1 → 0
A15.1	Select SLS level bit 0	-	Selection of the SLS level
A15.2	Select SLS level, bit 1	-	
A15.4	Select SDI positive	0	Select SDI positive
		1	Deselect SDI positive
A15.5	Select SDI negative	0	Select SDI negative
		1	Deselect SDI negative

Table 5- 2   Status word 1

I/O address	Meaning		Comment
E14.0	Power removed	0	The motor torque has not yet been switched off safely.
		1	The motor torque has been switched off safely.
E14.1	SS1 active	0	SS1 is not active
		1	SS1 is active
E14.4	SLS active	0	SLS is not active
		1	SLS is active
E14.7	Internal event	0	Fault-free operation
		1	The inverter has detected an internal fault and responded accordingly, e.g. with a STOP A.
E15.1	Active SLS level, bit 0	-	Active SLS level
E15.2	Active SLS level, bit 1	-	
E15.4	SDI positive active	0	SDI positive direction of rotation is not active
		1	SDI positive direction of rotation is active
E15.5	SDI negative active	0	SDI negative direction of rotation is not active
		1	SDI negative direction of rotation is active
E15.7	Status SSM	0	Absolute value of the speed is greater than the SSM limit value
		1	Absolute value of the speed is less than the SSM limit value

You will find additional information on the PROFIsafe interface in Section Control word 1 and status word 1 (extended functions) (Page 48).

5.2.3 Configuring PROFIBUS communication via telegram 900 with the GSDML

If you want to evaluate the status of the safety inputs in the higher-level control directly, choose PROFIsafe telegram 900. The inverter writes the signals of its safety inputs to status word 5.

Hardware configuration

The basic procedure is described in the section Configuring PROFIBUS communication with telegram 30 via GSD (Page 78). Instead of telegram 30, select telegram 900:
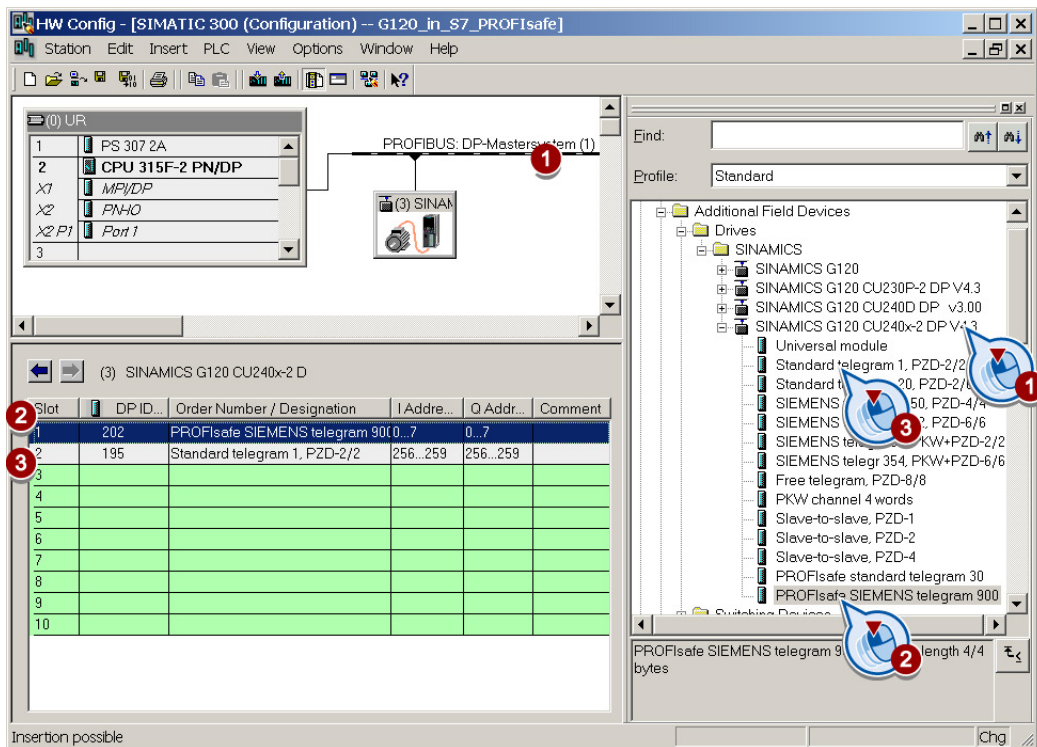
5.2.4 Configuring shared device communication via PROFINET

In the following example, the standard CPU and the F-CPU are combined in a single project. The communication via the Shared Device is also possible, even if both controls are configured in different projects.

Firmware required: see also Support of the IO controller (http://support.automation.siemens.com/WW/view/en/44383955).

Procedure

To configure communication via "Shared Device" in the higher-level control, proceed as follows:

1. Configuring your system with the standard control.

2. In HW Config, in addition to the protocol for the standard functions (for example: telegram 1), insert your communications protocol for the fail-safe functions (e.g. PROFIsafe telegram 30).

3. Deactivate the access to the PROFIsafe telegram via the context menu of the right mouse button:
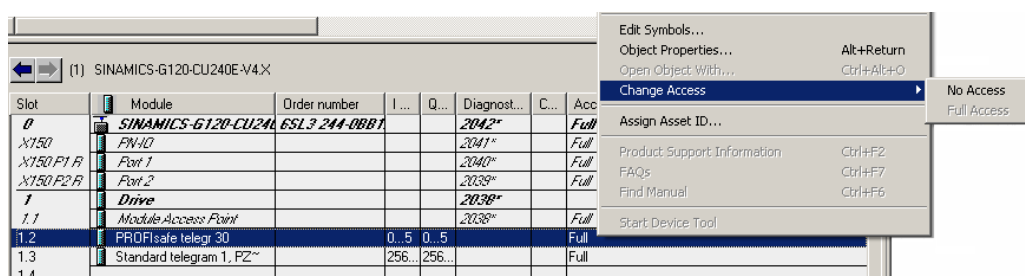
4. You can configure your F-CPU in HW Config, without inserting an inverter.

5. Copy the inverter into the standard control

6. Insert the inverter as "Shared" in the F-CPU.
   This results in the access rights being "reversed".
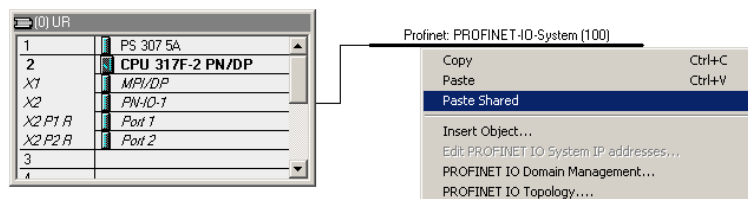
7. Select the F-CPU in HW Config

8. Open the "Object Properties" dialog window.

9. In this window, select the "Protection" tab.

10. Activate the access protection for F-CPU and assign a password.

11. Check the box for "CPU contains safety program" and exit the screen with OK.

12. Save and compile your ⌸ project.

13. Load your project via 🏭 into the fail-safe control.

You have configured the communication via "Shared Device" in the higher-level control system.

5.3 Commissioning tools

We strongly recommend that you commission the safety functions using a PC tool.

If you use a PC tool for commissioning, then you set the functions using the graphic screen forms and you do not have to work with parameters. In this case, you can ignore the parameter tables in the following sections.

Table 5- 3   PC-based commissioning tools

Tool	Can be downloaded at no charge	Order number
STARTER	STARTER (http://support.automation.siemens.com/WW/view/en/26233208)	6SL3072-0AA00-0AG0
Startdrive	Startdrive (http://support.automation.siemens.com/WW/view/en/68034568)	6SL3072-4CA02-1XG0

Commissioning the safety functions with STARTER is subsequently described.

A tutorial is available for Startdrive: Startdrive tutorial (http://support.automation.siemens.com/WW/view/en/73598459).

Commissioning: Online or offline

With STARTER, you can work offline (without a connection to the converter) as well as online. We recommend that you commission the safety functions online.

This manual provides a detailed description of the online commissioning procedure. The section Offline commissioning (Page 153) describes the important points to remember when commissioning the safety functions offline.

Additional information about STARTER is provided in the operating instructions of your converter.

5.4 Resetting the safety function parameters to the factory setting

Procedure

To reset the safety function settings to the factory setting without changing the standard settings, proceed as follows:

1. Go online with STARTER

2. Open the screen form for the safety functions ①.
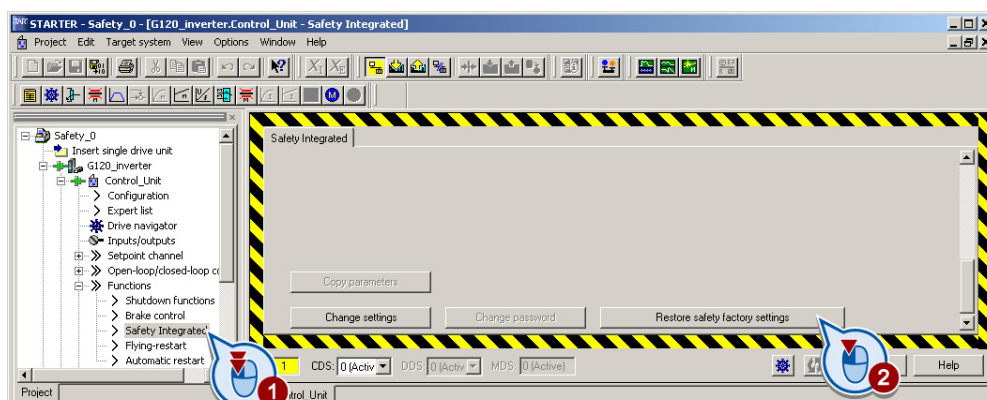
3. Press the button to restore the factory settings ②.

4. Enter the password,for the safety functions.

5. Confirm saving parameters (RAM to ROM).

6. Go offline with STARTER .

7. Switch off the inverter supply voltage.

8. Wait until all LED on the inverter go dark. Now switch on the inverter supply voltage again (power on reset).

You have restored the safety functions in the inverter to the factory settings.

Parameters	Description	
p0010	**Drive, commissioning parameter filter**	
	0	Ready
	30	Parameter reset
p9761	**Enter a password** (factory setting: 0000 hex) Permissible passwords lie in the range 1 … FFFF FFFF.	
p9762	**New password**	
p9763	**Password confirmation** Confirming the new Safety Integrated password.	
p0970	**Reset drive parameters**	
	5	Starts a safety parameter reset. After the reset, the inverter sets p0970 = 0.

5.5 Changing settings

Procedure

To start commissioning the safety functions, proceed as follows:

1. Go online with STARTER

2. In STARTER, select the fail-safe functions.

3. Select "Change settings".
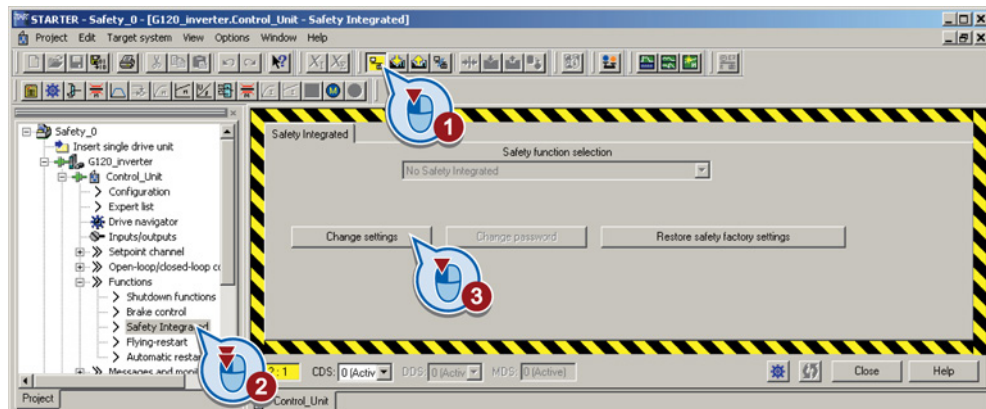
Parameter	Description
p0010 = 95	**Drive commissioning parameter filter** Safety Integrated commissioning
p9761	**Enter a password** (factory setting: 0000 hex) Permissible passwords lie in the range 1 … FFFF FFFF.
p9762	**New password**
p9763	**Confirm password**

4. Define what the results of your commissioning should look like:

- If you are only using STO as safety function of the inverter, select the basic functions ① with the interface that matches your particular application.
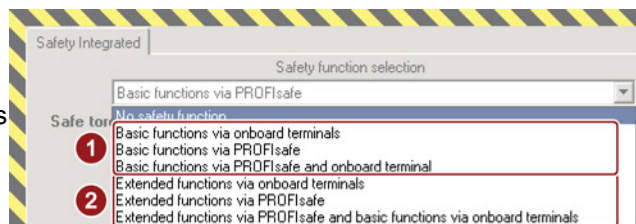
- If, in addition to STO you use other safety functions, then select the extended functions ② with the interface that matches your particular application.

Additional information on the basic and extended functions are provided on the following pages of this section.

You have completed the following commissioning steps:

- You have started to commission the safety functions.

- You have decided to use either the basic functions or the extended functions.

Parameter	Description	
p9601	**Enable functions integrated in the drive** (factory setting: 0000 bin)	
	0 hex	Safety functions integrated in the drive inhibited
	1 hex	Basic function STO via onboard terminals is enabled
	4 hex	Extended Functions via onboard terminals are enabled
	8 hex	Basic function STO is enabled via PROFIsafe
	9 hex	Basic function STO is enabled via PROFIsafe and onboard terminals
	C hex	Extended functions are enabled via PROFIsafe
	D hex	Extended functions are enabled via PROFIsafe and basic function STO via onboard terminal

Safety Integrated - SINAMICS G110M, G120, G120C, G120D and SIMATIC ET 200pro FC-2
Function Manual, 04/2014, FW V4.7, A5E34261271B AA

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Overview of the safety functions

When starting to commission the system, you already define the following:

● Which safety functions are available?

● Which interfaces are used to control the safety functions?
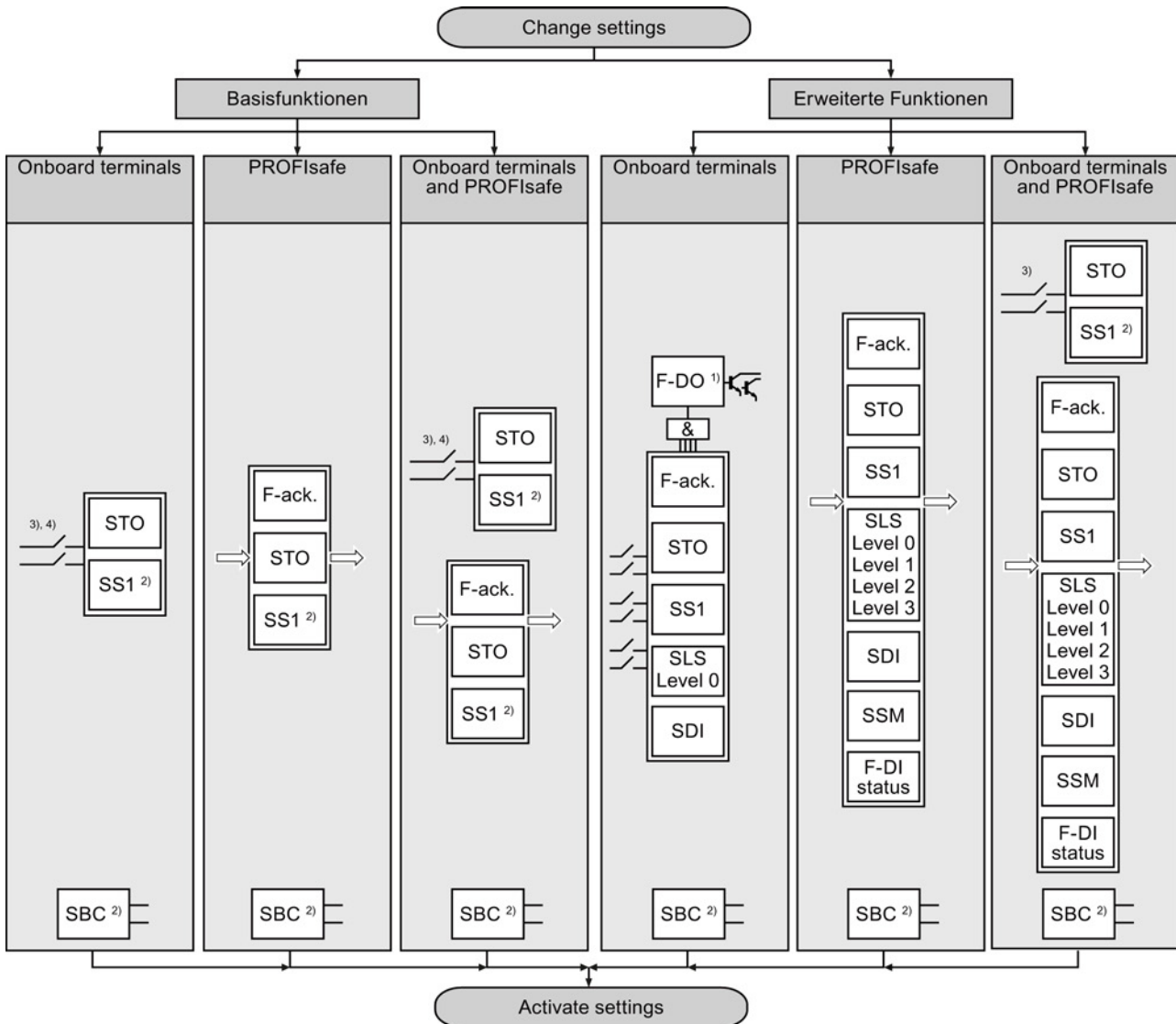
[1] Not all of the Control Units have a safety output, also refer to Section: Overview of the safety-related inverter interfaces (Page 21).

[2] The basic SS1 functions and the SBC function are only available with the CU250S-2 Control Unit, also see Section:Overview of the safety functions (Page 19)

[3] Controlling the basic functions for SINAMICS G inverters via F-DI 0, also see Section: Safety inputs (Page 51).

[4] Controlling the basic functions for SIMATIC ET 200pro FC-2 via the F0 rail.

Your selection	Outcome of commissioning	See section ...
Basic functions via onboard terminals	• Select STO via F-DI. • Acknowledge safety function faults after selecting and deselecting STO. Additionally, with CU250S-2: • Select SS1 via F-DI. • Control the motor holding brake via SBC.	Setting basic functions (Page 90).
Basic functions via PROFIsafe	• Select STO via PROFIsafe. • Evaluate state of STO via PROFIsafe. • Acknowledge safety function faults via PROFIsafe. Additionally, with CU250S-2: • Select SS1 via PROFIsafe. • Control the motor holding brake via SBC.	

Basic functions via PROFIsafe and onboard terminals	• Select STO via F-DI as well as also via PROFIsafe.
	• Evaluate state of STO via PROFIsafe.
	• Acknowledge safety function faults:
	  – via PROFIsafe
	  – after selecting and deselecting STO
	Additionally, with CU250S-2:
	• Select SS1 via F-DI or PROFIsafe.
	• Control the motor holding brake via SBC.	

Extended functions via onboard terminals	• Select safety functions via F-DI.
	• Only one monitoring limit of SLS can be used (SLS level 0).
	• Acknowledge safety function faults:
	  – via F-DI
	  – after selecting and deselecting STO
		Setting extended functions (Page 103).

Extended functions via PROFIsafe	• Select safety functions via PROFIsafe. • Evaluate the state of the safety functions via PROFIsafe. • All four monitoring limits of SLS can be used (SLS levels 0 … 3) • Acknowledge safety function faults via PROFIsafe. • Evaluate the state of the safety inputs via PROFIsafe.	

Extended functions via PROFIsafe and basic functions via onboard terminals	• Select safety functions via PROFIsafe.
	• Additionally select STO via F-DI.
	• Evaluate the state of the safety functions via PROFIsafe.
	• All four monitoring limits of SLS can be used (SLS levels 0 … 3)
	• Acknowledge safety function faults:
	  – via F-DI
	  – after selecting and deselecting STO
	• Evaluate the state of the safety inputs via PROFIsafe.
	Additionally, with CU250S-2:
	• Additionally select SS1 via F-DI.
	• Control the motor holding brake via SBC.	

5.6   Setting basic functions

STARTER screen form for the basic functions

Depending on the interface that has been selected, one of the following versions is displayed on the STARTER screen form of the basic functions:

- ① The onboard terminals for SINAMICS inverters or the F0 rail for SIMATIC ET 200pro FC.

- ② The PROFIsafe interface

- ① + ② Onboard terminals as well as the PROFIsafe interface

- ③ + ④ if you have an inverter equipped with the CU250S-2 Control Unit, the delay time for SS1 and the enable for SBC are visible.
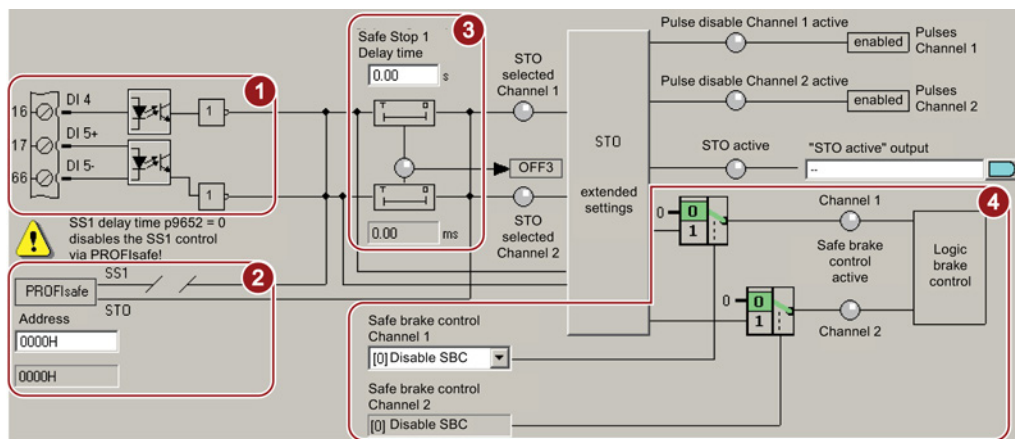
5.6.1 Interconnecting the "STO active" signal

If you require the feedback signal "STO active" of the inverter in your higher-level control system, then you must appropriately interconnect the signal.

Procedure

To interconnect the "STO active" checkback signal, proceed as follows:

1. Select the button for the feedback signal.
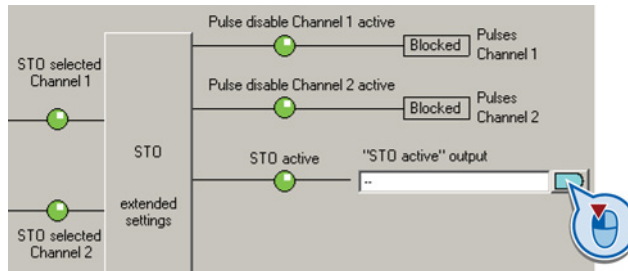
2. In the following selection menu, select the appropriate setting for your particular application.

You have interconnected the "STO active" checkback signal. The inverter signals "STO active" to the higher-level control after STO has been selected.

Parameter	Description
r9773.01	**1 signal**: STO is active in the drive

5.6.2 Configuring PROFIsafe

Setting the address

Procedure

To set the PROFIsafe address, proceed as follows:

1. In STARTER select the input field for the PROFIsafe address
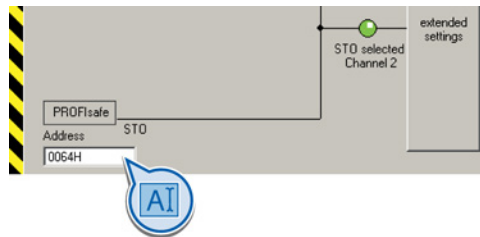
2. Enter the same address as hexadecimal value, which you defined in the hardware configuration (F_Dest_Add).

   See also Section: Configuring PROFIBUS communication with telegram 30 via GSD (Page 78).

You have configured the communication between the inverter and the higher-level control (F-CPU) using PROFIsafe telegram 30.

Parameter	Description
p9610	**PROFIsafe address** (factory setting: 0000 hex)

Enabling Shared Device

If you control the inverter safety functions via PROFINET and "Shared Device", you must enable this function in the inverter.

See also Section: Configuring shared device communication via PROFINET (Page 82).

Procedure

To configure communication via "Shared Device" in the inverter, proceed as follows:

1. In STARTER change to the expert list.

2. In STARTER, set p8929 = 2.

You have configured the communication via "Shared Device" in the inverter.

Starting communication via PROFIsafe

When you connect the converter to the higher-level control system (F-CPU) via the fieldbus for the first time, the central control system sends the PROFIsafe configuration to the converter. After the configuration data have been received in the converter, PROFIsafecommunication starts.

The converter only monitors the communication to the F-CPU after the configuration data have been received from the central control system.

5.6.3 Setting the filter for safety inputs

You must set the input filter and the simultaneity monitoring of the safety input for all SINAMICS inverters where the safety F-DI input evaluates two redundant signals.

For SIMATIC ET 200pro FC, the input signal for STO is received from the F0 rail of the backplane bus of the ET-200pro system. As a consequence, the simultaneity monitoring is not applicable for this converter.

Procedure

To set the input filter and simultaneity monitoring of the safety-related input, proceed as follows:

1. Select the advanced settings for STO.
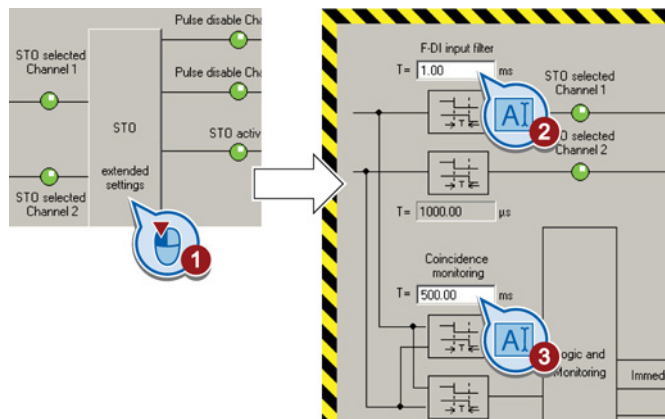
2. Set the debounce time for the F-DI input filter.

3. Set the discrepancy for the simultaneity monitoring.

4. Close the screen form.

You have set the input filter and the simultaneity monitoring of the safety-related input.

Description of the signal filter

The following are available for the signal processing of the safety-related inputs:

- A tolerance for the simultaneous monitoring.
- A filter to suppress short signals, e.g. test pulses.

A tolerance for the simultaneous monitoring

The inverter checks whether the signals at both inputs always have the same signal status (high or low).

With electromechanical sensors (e.g. emergency stop buttons or door switches), the two sensor contacts never switch at exactly the same time and are therefore temporarily inconsistent (discrepancy). A long-term discrepancy indicates a fault in the wiring of a safety-related input, e.g. a wire break.

When appropriately set, the inverter tolerates brief discrepancies.

The tolerance time does not extend the inverter response time. The inverter selects its safety function as soon as one of the two F-DI signals changes its state from high to low.

Figure 5-1   Tolerance regarding discrepancy

Filter to suppress short signals

The inverter normally responds immediately to signal changes at its safety-related inputs. This is not required in the following cases:

- When you interconnect a safety-related input of the inverter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the inverter responds.

- Several control modules test their safety-related outputs using bit pattern tests (light/darkness tests) to identify faults due to either short-circuiting or cross circuiting. When you interconnect a safety-related input of the inverter with a safety-related output of a control module, the inverter responds to these test signals.
  A signal change during a bit pattern test usually lasts:

  – On test: 1 ms

  – Off test: 4 ms

If the safety-related input signals too many signal changes within a certain time, then the inverter responds with a fault.

Figure 5-2   Inverter response to a bit pattern test

An adjustable signal filter in the inverter suppresses temporary signal changes using bit pattern test or contact bounce.

The filter increases the inverter response time. The inverter only selects its safety function after the debounce time has elapsed.
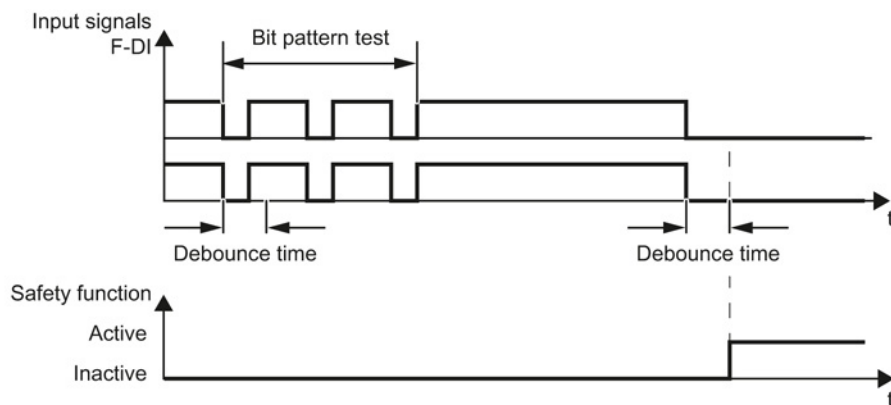
Figure 5-3   Filter for suppressing temporary signal changes

Parameter	Description
p9650 [1]	**F-DI switchover discrepancy time** (factory setting: 500 ms) Tolerance time to switch over the safety input for the basic functions.
p9651	**STO debounce time** (factory setting: 1 ms) Debounce time of the safety input for the basic functions.

[1] For SIMATIC ET 200pro FC, the tolerance time is always 0 ms.

Debounce times for standard and safety functions

The debounce time p0724 for "standard" digital inputs does not influence the safety input signals. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

If you use an input as a standard input, set the debounce time using parameter p0724.

If you use an input as a safety input, set the debounce time as described above.

5.6.4 Setting the forced checking procedure (test stop)

Procedure

To set the forced checking procedure (test stop) of the basic functions, proceed as follows:

1. Select the advanced settings for STO.
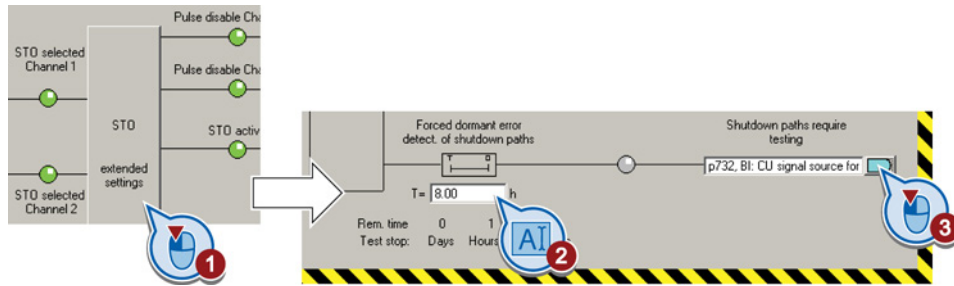
2. Set the monitoring time to a value to match your application.

3. Using this signal, the inverter signals that a forced checking procedure (test stop) is required.

   Interconnect this signal with an inverter signal of your choice.

You have set the forced checking procedure (test stop) for the basic functions.

Description

The forced checking procedure (test stop) of the basic functions is an inverter self test. The inverter checks its circuits to switch off the torque. If you are using the Safe Brake Relay, for a forced checking procedure, the inverter also checks the circuits of this component.

You start the forced checking procedure each time that the STO function is selected.

Using a timer block, the inverter monitors as to whether the forced checking procedure is regularly performed.
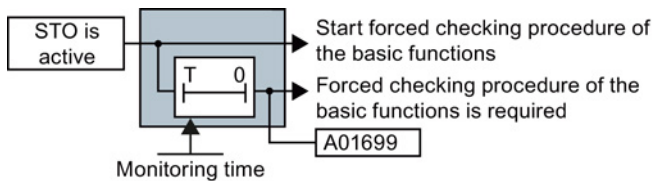
Figure 5-4   Starting and monitoring the forced checking procedure (test stop)

Parameter	Description
p9659	**Forced dormant error detection timer** (Factory setting: 8 h) Monitoring time for the forced dormant error detection.
r9660	**Forced dormant error detection remaining time** Displays the remaining time until the forced dormant error detection and testing the safety switch-off signal paths.
r9773.31	**1 signal: Forced dormant error detection is required** Signals for the higher-level control system.

5.6.5 Setting the delay time for SS1

Procedure

Set the delay time for SS1. The delay time must be longer than the OFF3 ramp-down time.

You have set the SS1 function.

Parameter	Description
p9652	**Safe Stop 1 delay time** Sets the delay time of the pulse suppression for the "Safe Stop 1" (SS1) function to brake with the OFF3 ramp-down time.
p1135	OFF3 ramp-down time

Description: the SS1 function without monitoring the speed
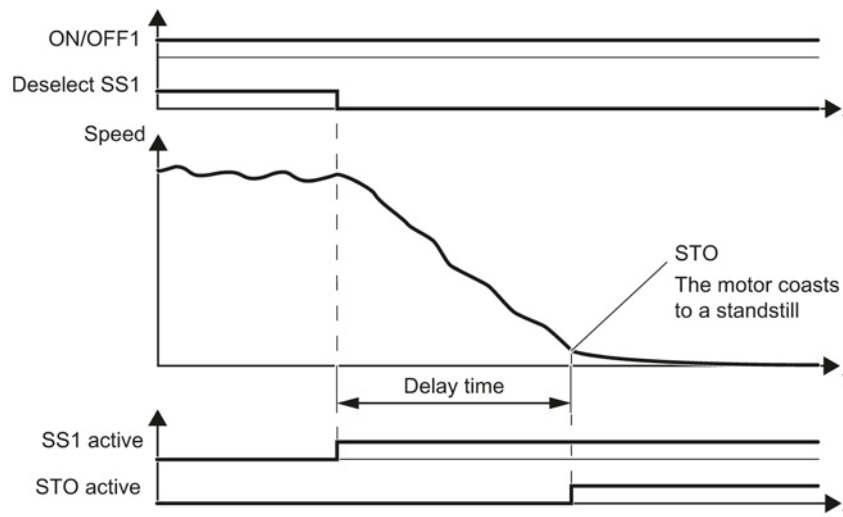
Figure 5-5   SS1 without monitoring the speed

When SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time.

After the delay time, independent of the actual speed, the inverter switches off the motor torque using the STO function.

5.6.6 Enabling SBC

Procedure

Enable the SBC function.
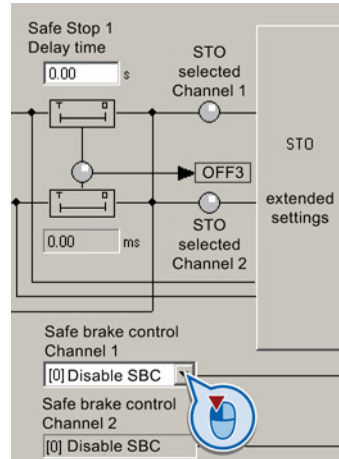
You have enabled the SBC function.

Parameter	Description
p9602	**Enable safe brake control** 0: SBC is locked 1: SBC is enabled

5.6.7 Final steps

Activate settings

Procedure

To activate the settings for the safety functions, proceed as follows:

1. Press the "Copy parameters" button, to create a redundant image of your inverter settings.

2. Press the "Activate settings" button.

3. If the password is the factory default, you are prompted to change the password.
   If you try to set a password that is not permissible, the old password will not be changed.

4. Confirm the prompt for saving your settings (copy RAM to ROM).

5. Switch off the inverter supply voltage.

6. Wait until all LEDs on the inverter go dark (no voltage condition).

7. Switch on the inverter supply voltage again.

Your settings are now active.

Parameter	Description
p9700 = D0 hex	**SI copy function** (factory setting: 0) Starting the SI parameter copy function.
p9701 = DC hex	**Confirm data change** (factory setting: 0) Confirm SI basic parameter change.
p0010 = 0	**Drive commissioning parameter filter** 0: Ready
p0971 = 1	**Save parameter** 1: Save the drive object (copy from RAM to ROM) After the inverter has saved the parameters in a non-volatile fashion, then p0971 = 0.

Checking the connection of digital inputs

The simultaneous connection of digital inputs with a safety function and a "standard" function may lead to the drive behaving in unexpected ways.

If you control the safety functions in the inverter using digital inputs, you must check whether these digital inputs are connected to a "standard" function.

Figure 5-6   Example: Assignment of digital inputs DI 4 and DI 5 with STO

Procedure

In order to prevent the safety-related inputs of the safety functions unintentionally controlling "standard" functions in the inverter, proceed as follows:

1. Select the inputs/outputs in STARTER in the project navigator.

2. Select the screen for the digital inputs.

3. Remove all digital input interconnections that you use as safety-related input F-DI:

4. If you use the CDS dataset switchover, you must delete the digital input connections for all CDS.
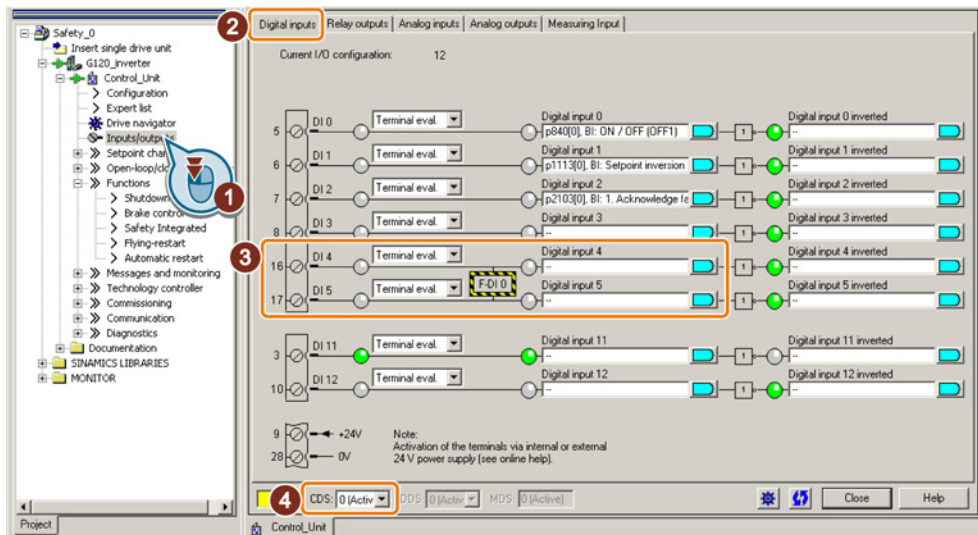
Figure 5-7   Removing the DI 4 and DI 5 digital-input connections

You have now prevented safety-related inputs in the safety functions controlling "standard" functions in the inverter.

5.7 Setting extended functions

STARTER screen form for setting the extended functions

The following STARTER screen form is the starting point for all subsequent settings:

Overview of the procedure

To set all extended functions, proceed as follows:

1. Define the basic settings for all of the safety functions. See Section:
   Basic settings (Page 104).

2. If necessary, interconnect the safety inputs and outputs. See sections:
   - Setting safety inputs (Page 111)
   - Setting a safety output (Page 120).

3. If necessary, configure the communication via PROFIsafe. See section: Configuring
   PROFIsafe in the converter (Page 127).

4. Adapt the safety functions that you are using to suit your application. See Sections:
   - Setting SS1 (Page 130)
   - Setting SLS (Page 137)
   - Setting SSM (Page 142)
   - Setting SDI (Page 146)

5. Complete commissioning. See also Section:
   Final steps (Page 150).

You have set the extended functions.

5.7.1 Basic settings

5.7.1.1 Enabling safety functions

Enabling safety functions

Procedure
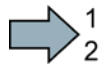
To enable the safety functions, proceed as follows:

1. Select the STARTER screen form for the extended functions.
2. Enable the safety functions.
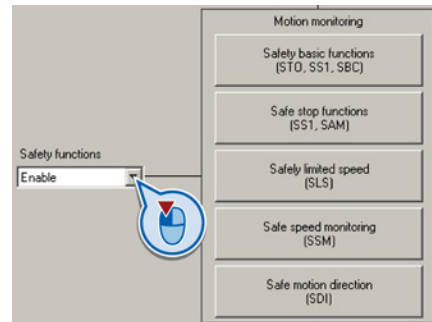
You have enabled the safety functions in the inverter.

5.7.1.2 Setting the forced dormant error detection (test stop)

Procedure

To set the forced dormant error protection (test stop) of the extended functions, proceed as follows:

1. Press the "Configuration" button.

2. Set the following:
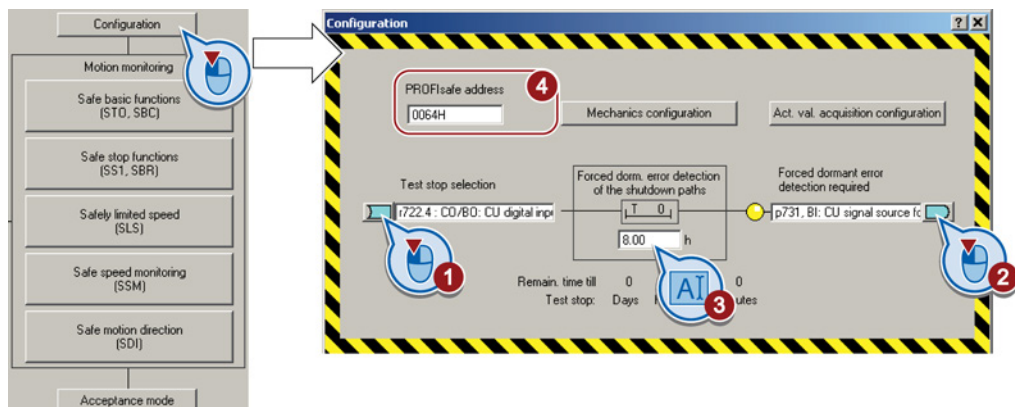
- – ① This signal starts the forced dormant error detection and sets the remaining monitoring time to the value ③. Interconnect this signal, for example, with a digital input or a bit in the fieldbus control word.

- – ② You must conduct a forced dormant error detection (test stop) for this signal. Interconnect this signal, for example with a digital output of your choice or a status bit in the fieldbus.

- – ③ Time until the next test stop

- – ④ This input field is only visible if you have selected PROFIsafe as interface. Initially, you can ignore the setting. See also section: Configuring PROFIsafe in the converter (Page 127).

3. Close the screen form.

4. Press the button for the "STO" function:
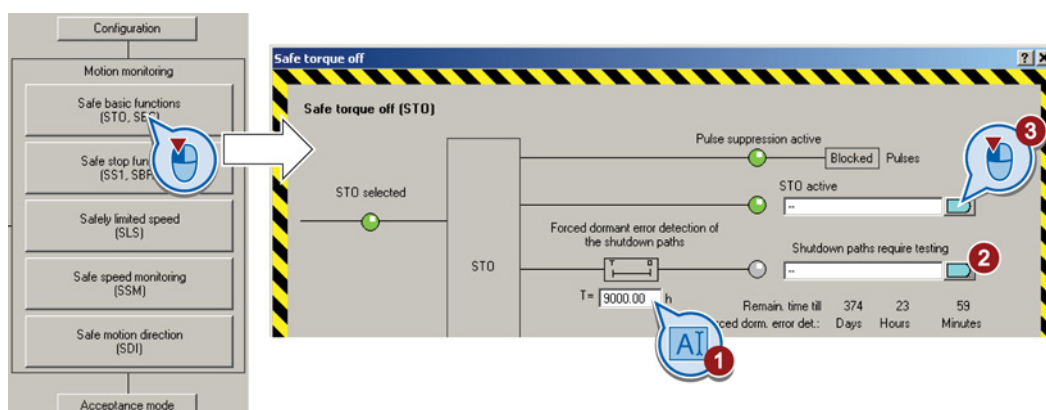
5. Set the following:

- – ① monitoring time = maximum value (9000 hours). This means that the forced dormant error detection monitoring for the basic functions is deactivated.

  This monitoring is not required when using the extended functions, as the forced dormant error detection of the extended functions also includes the forced dormant error detection of the basic functions.

- – ② No setting is required.

- – ③ If necessary, interconnect the status of the STO function with a digital output of your choice, for example.

6. Close the screen form.

You have set the forced dormant error detection (test stop) of the extended functions.

Description

The forced dormant error detection (test stop) of the extended functions is an inverter self test. The inverter checks its circuits to monitor the speed and to switch off the torque.

Using a timer block, the inverter monitors as to whether the forced dormant error detection is regularly performed.

You must start the forced dormant error detection with a signal of your choice.
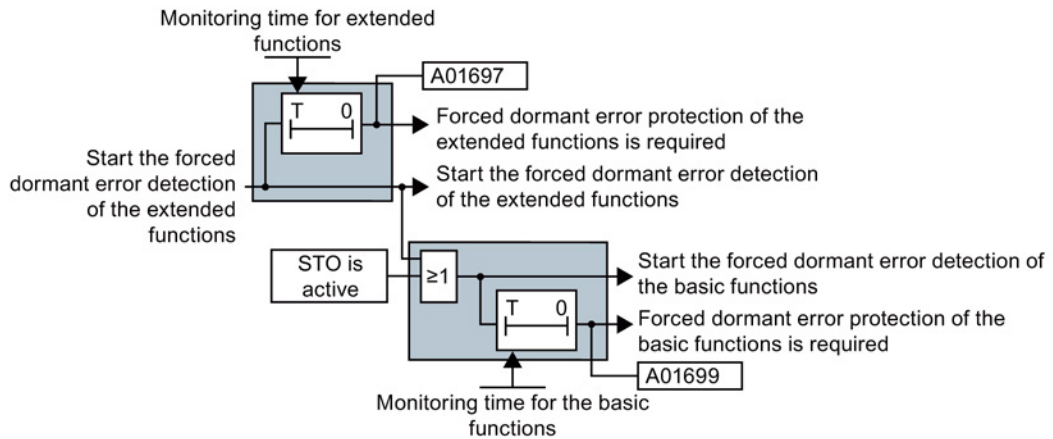
Figure 5-8   Starting and monitoring the forced dormant error detection (test stop)

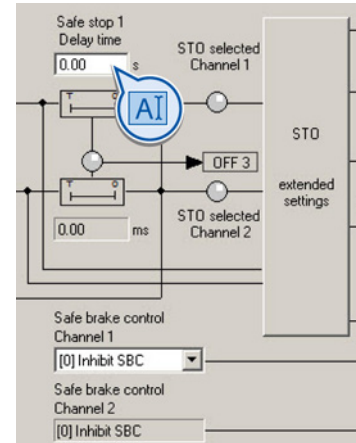| Parameter	Description
p9559	**Forced dormant error detection timer** (Factory setting: 8 h) Monitoring time for the forced dormant error detection of the extended functions.
p9659	**Forced dormant error detection timer** (Factory setting: 8 h) Monitoring time for the forced dormant error detection of the basic functions.
r9660	**Forced dormant error detection remaining time** Displays the remaining time up to performing the forced dormant error detection of the basic functions.
p9705	**Forced dormant error detection signal source** (Factory setting: 0) Signal source for the forced dormant error detection of the basic functions and the extended functions.
r9723.0	**1 signal: Forced dormant error detection of the extended functions is necessary** Signal for the higher-level control.
r9765	**Forced dormant error detection remaining time** Displays the remaining time up to performing the forced dormant error detection of the extended functions.
r9773.31	**1 signal: Forced dormant error detection of the basic functions is required**

5.7.1.3 Setting the gear ratio and actual value tolerance

Procedure

To set the gear ratio and the actual value tolerance, proceed as follows:

1. Press the "Configuration" button.

2. Press the "Mechanical configuration" button.

3. Set the following:

   – ① **Actual value tolerance**:
   In most cases, you do not have to change this value. If, in operation, the inverter issues message C01711 or C30711 (fault value 3 or 44 … 57), increase this value step-by-step until the message to longer occurs.
   Note: If you increase this value, the speed monitoring of the inverter becomes less sensitive to limit violations.

   – ②, ③ **Gear ratio**:
   Read off the pole pair number ④ of the motor, and set the data of your motor according to the following table.

	Number of load revolutions	Number of motor revolutions
Without gear	Value ② = 1	Value ③ = pole pair number ④
Gearbox with speed ratio Load/motor = L/M	Value ② = L	Value ③ = M × pole pair number ④

Example: The drive has a gearbox with a load/motor speed ratio = 23/50 ⇒

⇒ value ② = 23, value ③ = 50 × pole pair number ④
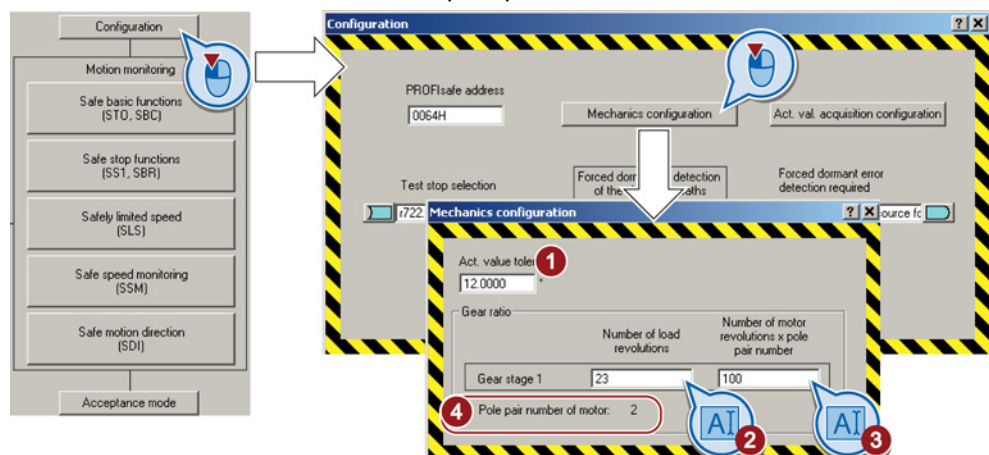
4. Close the screen forms.

You have set the gearbox ratio and actual value tolerance.

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Parameter	Description
p9521	**Number of load revolutions** (factory setting: 1) Denominator for the gear ratio between the motor and load.
p9522	**Number of motor revolutions** (factory setting: 2000 rpm) Numerator for the gear ratio between the motor and load.
p9542	**Actual value tolerance** (Factory setting: 12 °) Tolerance for the crosswise comparison of the actual position between processor 1 and 2.

5.7.1.4 Setting encoderless actual value sensing

Procedure

To set the encoderless actual value sensing, proceed as follows:

1. Press the "Configuration" button.

2. Press the "Configuration actual value sensing" button.

3. Set the following:

   – ① **Delay time actual value sensing**:
   In most cases, you do not have to change this value. If you switch on the motor with the safety functions active (SLS, SDI or SSM) and the inverter responds when switching on with a safety fault, increase this value in the range 50 % … 100 % of the motor excitation build-up time (p0346).

   – ② **Minimum current actual value sensing**:
   In most cases, you do not have to change this setting. When the motor draws a low current, and the inverter responds with a fault, then reduce this value in steps of 1 % until the fault no longer occurs.

   – ③ **Voltage tolerance acceleration**:
   In most cases, you do not have to change this parameter. During acceleration with very short ramp-up and ramp-down times, if the inverter responds with a safety function fault, increase this value step-by-step by approx. 10%.

   – ④ **Fault tolerance**:
   In most cases, you do not have to change this parameter. This parameter can suppress sporadic faults of the safety functions. The parameter defines how often the inverter tolerates its internal plausibility monitoring per second.
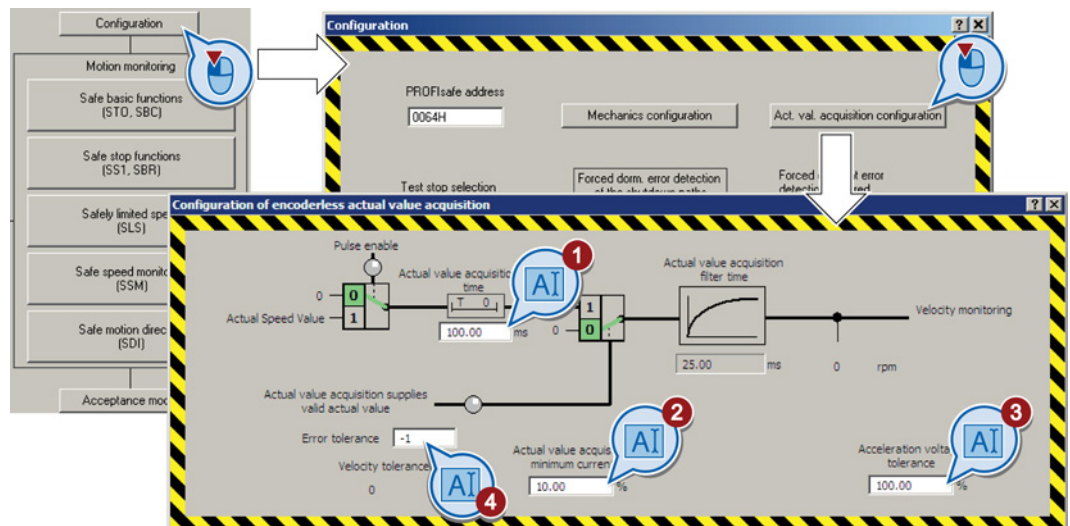
4. Close the screen forms.

You have set the encoderless actual value sensing.

Parameter	Description
p9585	**Fault tolerance** (Factory setting: -1) Plausibility monitoring tolerance for the current and voltage angle.
p9586	**Delay time actual value sensing** (Factory setting: 100 ms) Delay time for evaluating the encoderless actual value sensing after the motor has been switched on.
p9588	**Minimum current actual value sensing** (Factory setting: 10 %) Minimum current for encoderless actual value sensing (1 % ≙ 10 mA).
p9589	**Voltage tolerance acceleration** (Factory setting: 100 %) Acceleration limit to filter discontinuities in the speed/velocity.

5.7.2 Setting safety inputs

Precondition

You have selected the extended functions via onboard terminals.

Procedure

To interconnect the safety inputs with safety functions, proceed as follows:

1. Press the "Safety inputs/outputs" button.

2. Click the "Drive" button.

3. Interconnect the safety inputs with the safety functions:

   – ③ If you are not using a safety function, set the associated "Select F-DI" = "[255] Statically inactive".

   – ④ interconnect the safety inputs with the corresponding safety functions.

   – ⑤ if a safety function should always be active, set the associated "Select F-DI" = "[0] Statically active".
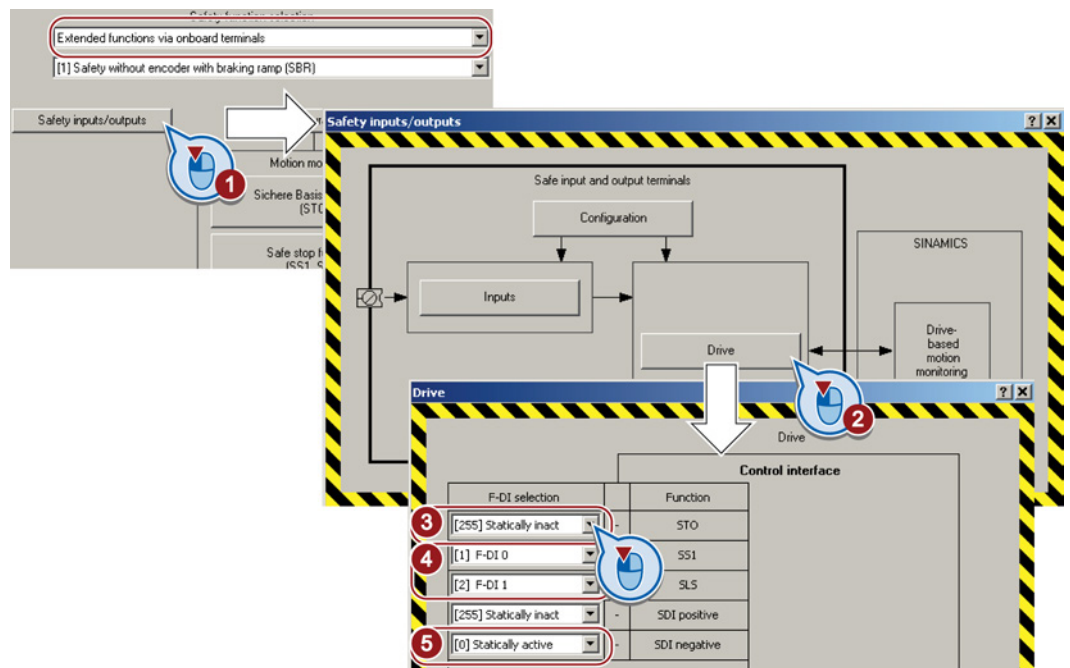
4. Close the screen forms.

You have assigned specific safety functions to the safety inputs.

Parameter	Description
p10022	**STO input terminal** (Factory setting: 0)
p10023	**SS1 input terminal** (Factory setting: 0)
p10026	**SLS input terminal** (Factory setting: 0)
p10030	**SDI positive input terminal** (Factory setting: 0)
p10031	**SDI negative input terminal** (Factory setting: 0)
all	0: Static, active 1: F-DI 0 2: F-DI 1 3: F-DI 2 255: Static, inactive

5.7.2.1 Setting the filter for safety inputs

Control via onboard terminals

Precondition

You have selected the extended functions via onboard terminals.

Procedure

To set the filters for the safety inputs, proceed as follows:

1. Press the "Safety inputs/outputs" button.

2. Press the "Configuration" button.

3. Set the following:

   – ③ Discrepancy time of the safety inputs.

   – ④ Input filter of the safety inputs.
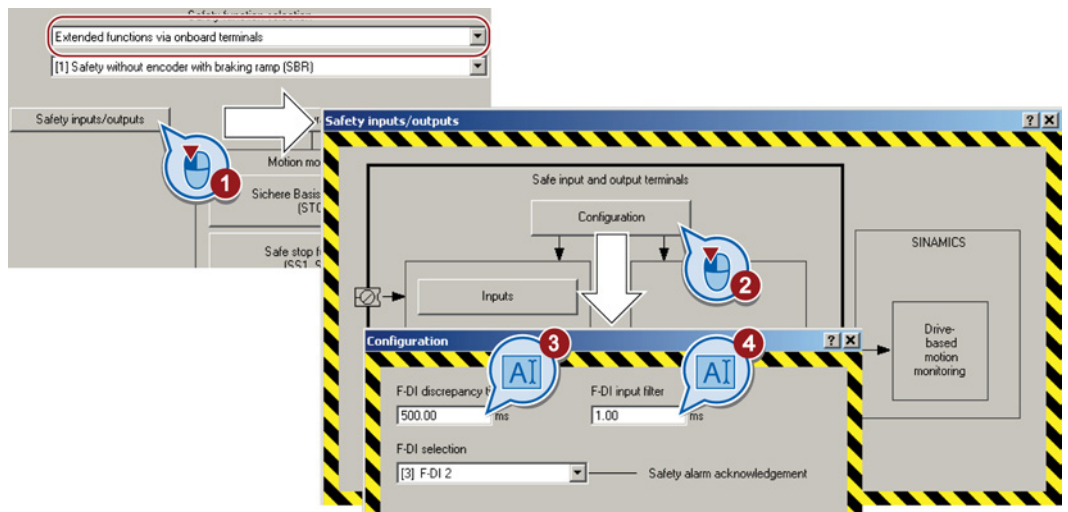
4. Close the screen forms.

You have set the filter for the safety inputs.

Control via PROFIsafe and onboard terminals

Precondition

You have selected the extended functions via PROFIsafe and onboard terminals.

Procedure

To set the filters for the safety inputs, proceed as follows:

1. Press the "Safety basic functions" button.

2. In the following two screen forms, press the "STO" button.

3. Set the following:

   – ③ Discrepancy time (simultaneity monitoring) of the safety input.

   – ④ Input filter of the safety input.
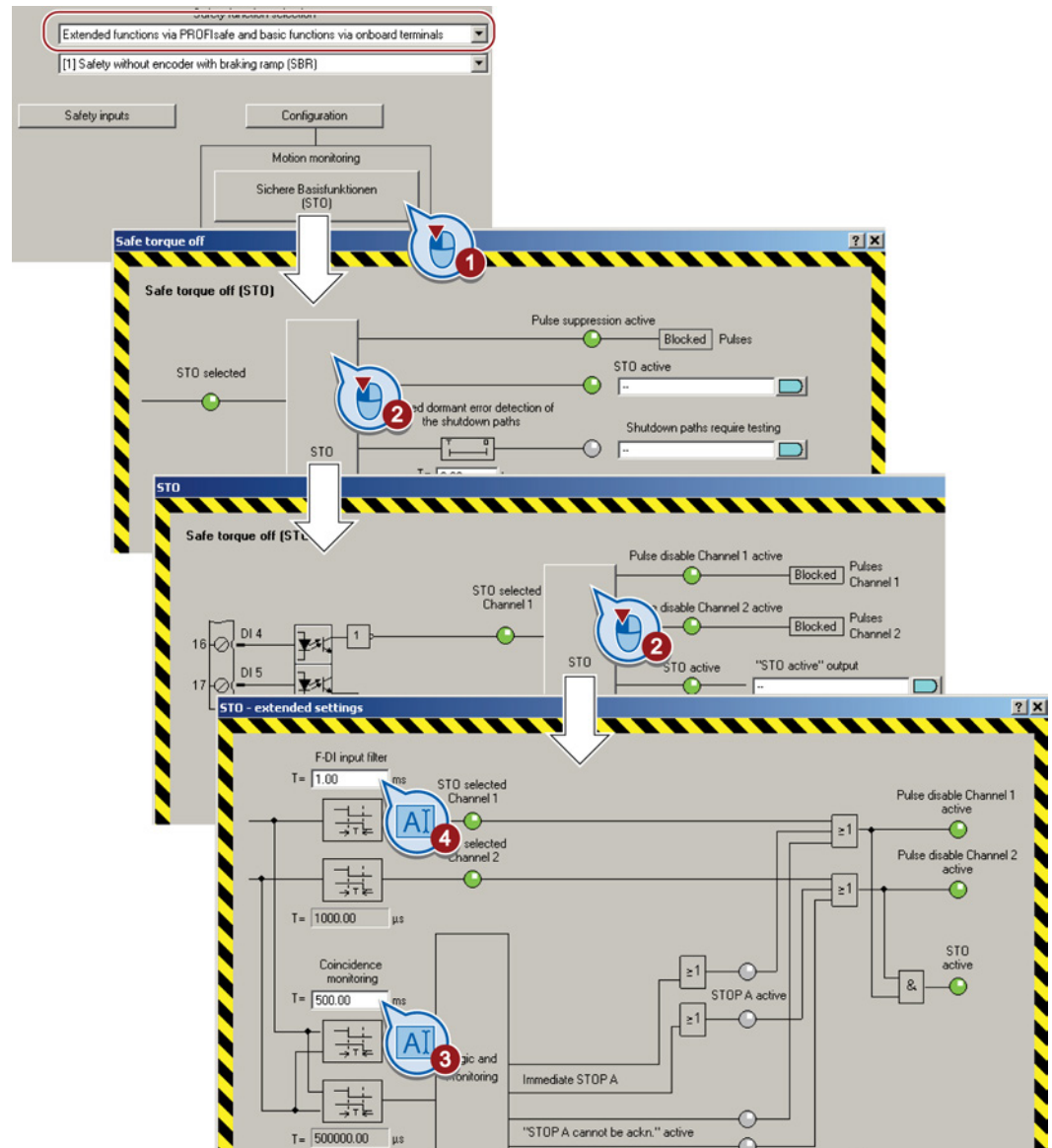
4. Close the screen forms.

You have set the filter for the safety inputs.

Description of the signal filter

The following are available for the signal processing of the safety-related inputs:

- A tolerance for the simultaneous monitoring.

- A filter to suppress short signals, e.g. test pulses.

A tolerance for the simultaneous monitoring

The inverter checks whether the signals at both inputs always have the same signal status (high or low).

With electromechanical sensors (e.g. emergency stop buttons or door switches), the two sensor contacts never switch at exactly the same time and are therefore temporarily inconsistent (discrepancy). A long-term discrepancy indicates a fault in the wiring of a safety-related input, e.g. a wire break.

When appropriately set, the inverter tolerates brief discrepancies.

The tolerance time does not extend the inverter response time. The inverter selects its safety function as soon as one of the two F-DI signals changes its state from high to low.

Figure 5-9   Tolerance regarding discrepancy

Filter to suppress short signals

The inverter normally responds immediately to signal changes at its safety-related inputs. This is not required in the following cases:

- When you interconnect a safety-related input of the inverter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the inverter responds.

- Several control modules test their safety-related outputs using bit pattern tests (light/darkness tests) to identify faults due to either short-circuiting or cross circuiting. When you interconnect a safety-related input of the inverter with a safety-related output of a control module, the inverter responds to these test signals.
  A signal change during a bit pattern test usually lasts:

  – On test: 1 ms

  – Off test: 4 ms

If the safety-related input signals too many signal changes within a certain time, then the inverter responds with a fault.

Figure 5-10   Inverter response to a bit pattern test

An adjustable signal filter in the inverter suppresses temporary signal changes using bit pattern test or contact bounce.

The filter increases the inverter response time. The inverter only selects its safety function after the debounce time has elapsed.
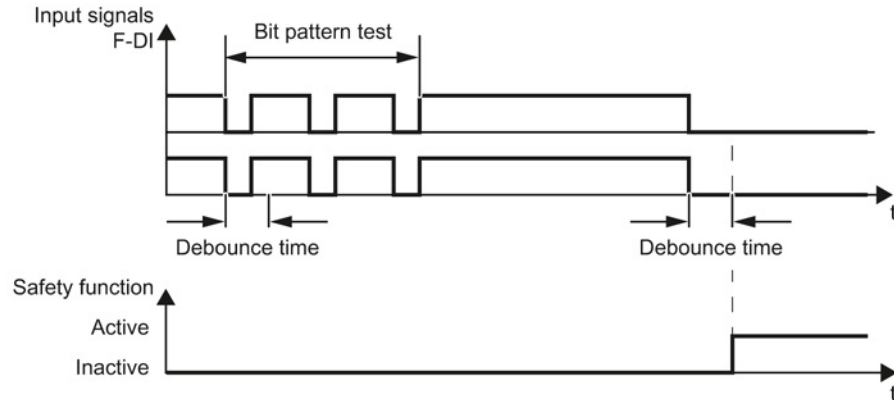
Figure 5-11   Filter for suppressing temporary signal changes

Parameter	Description
p9650	**F-DI switchover discrepancy time** (Factory setting: 500 ms) Tolerance time to switch over the safety input for the basic functions.
p9651	**STO debounce time** (factory setting: 1 ms) Debounce time of the safety input for the basic functions.
p10002	**F-DI switchover discrepancy time** (Factory setting: 500 ms) Tolerance time to switch over the safety inputs for the extended functions.
p10017	**Digital inputs debounce time** (factory setting: 1 ms) Debounce time of the safety inputs for the extended functions.

Debounce times for standard and safety functions

The debounce time p0724 for "standard" digital inputs does not influence the signals of the safety inputs F-DI. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

If you use an input as a standard input, set the debounce time using parameter p0724 .

If you use an input as a safety input, set the debounce time as described above.

5.7.2.2 Interconnecting the signal for fail-safe acknowledgment

Precondition

You have selected the extended functions via onboard terminals.

Procedure

To assign the fail-safe acknowledgement signal to a safety input, proceed as follows:

1. Press the "Safety inputs/outputs" button.

2. Press the "Configuration" button.

3. Select a free safety input for fail-safe acknowledgment.

   If there are no free safety inputs available, you have to acknowledge the safety function faults using a different method.
   Also see section: Acknowledging using a fail-safe signal (Page 232).
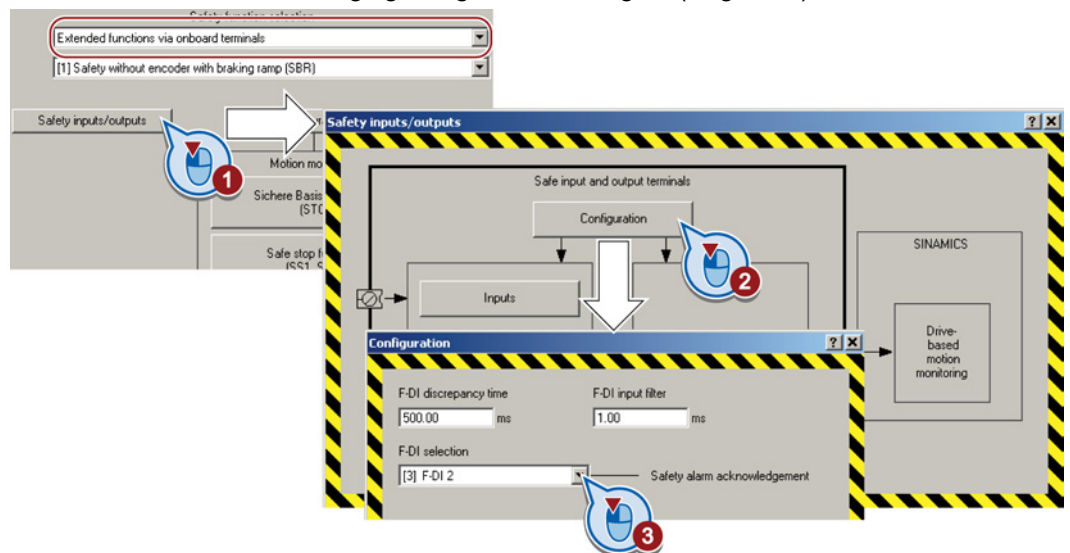
You have interconnected fail-safe acknowledge signal with a safety input.

5.7.3 Setting a safety output

5.7.3.1 Output signal and setting the test mode

Precondition

You have selected the extended functions via onboard terminals.

Procedure

To set the safety output, proceed as follows:

1. Press the "Safety inputs/outputs" button.

2. Press the "Output" button.
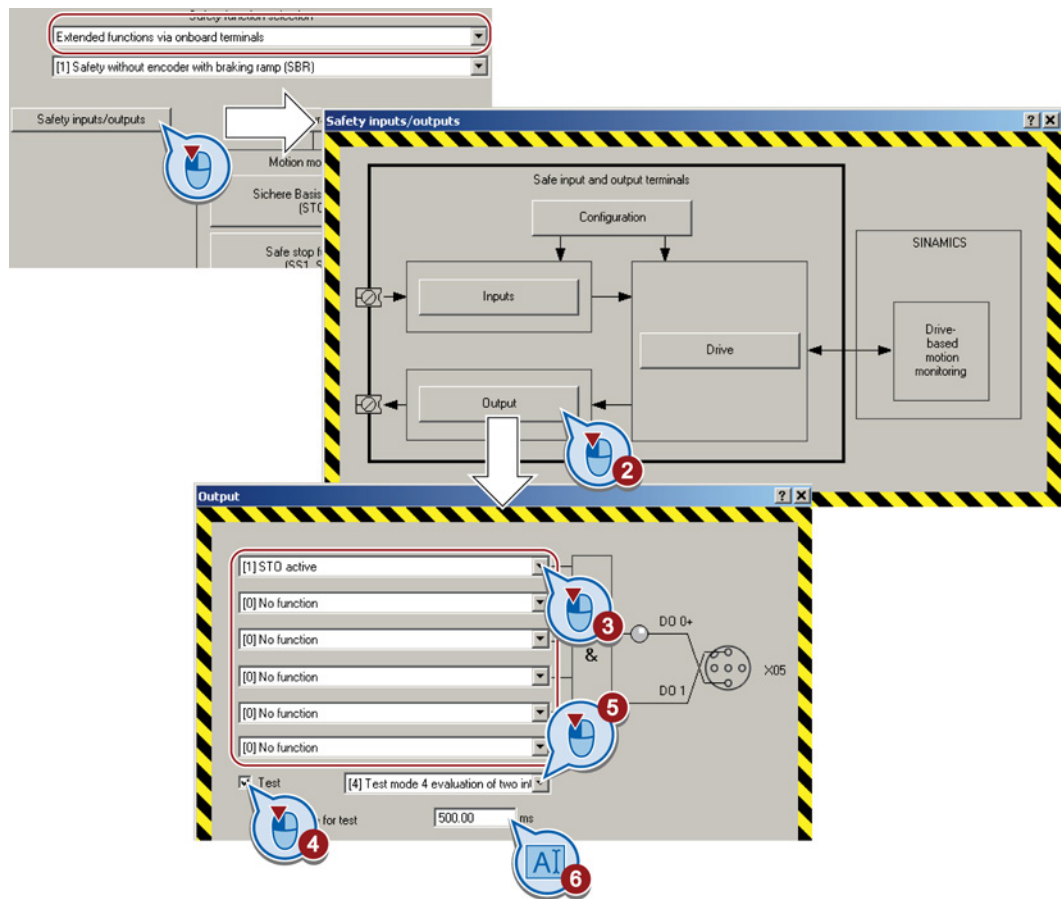
3. Interconnect the status signals of your choice with the fail-safe output.

    The following signals are available:
    – STO active
    – SS1 active
    – SLS active
    – SSM feedback active
    – Internal event
    – SDI positive active
    – SDI negative active
    – Safe state
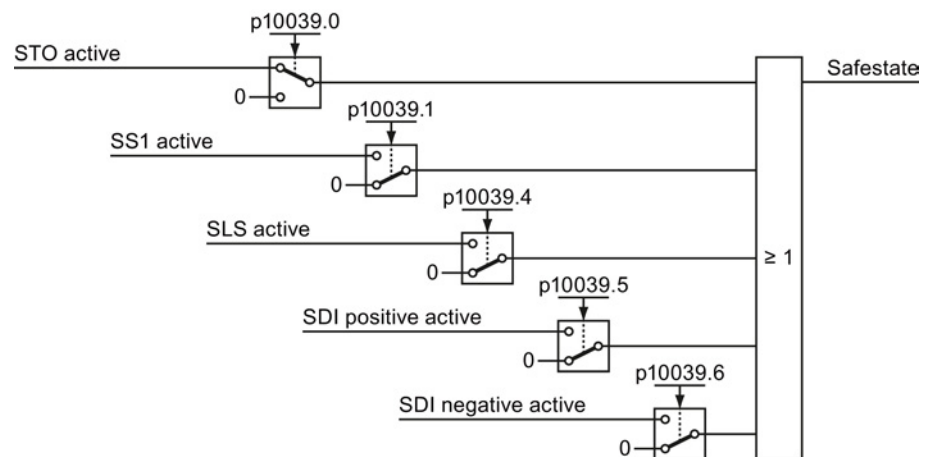
Figure 5-12   The safe state signal in the factory setting

    If you wish to change the "safe state" signal, you must set the parameters in STARTER via the expert list.

    The inverter logically combines the status signals according to the following rules:
    – The inverter ignored inputs without interconnection.
    – If none of the inputs is interconnected, then the output signal = 0.

4. Activate the test for the safety output.

5. Select the test mode that is compatible with your application.

6. Adjust the wait time. The following lower limits apply for the setting:
    – The wait time must be longer than the response time t_R of the connected actuator.
    – The wait time must be longer than or equal to 24 ms.
    – The wait time must be longer than the time for the input filter of the feedback input (p10017).

        See also: Setting the filter for safety inputs (Page 113).

7. Close the screen forms.

You have defined which signal the inverter transfers via its safety output, and how the inverter tests its safety output.

Description: Test mode of the safety output

Using its adjustable test mode, the inverter checks as to whether the safety output can be shut down.

The test mode is aligned according to the interconnection of the safety output. For test modes 2 and 3, you must adapt the appropriate wait time to your particular application.

Test mode 2

For test mode 2, the inverter switches off the two outputs one after the other, and evaluates the feedback via a digital input.
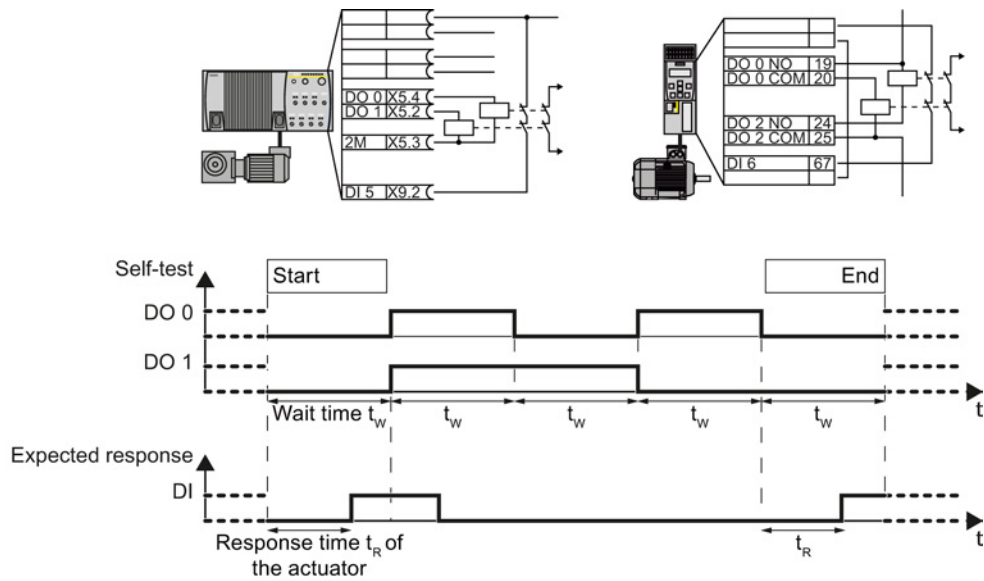
Figure 5-13   Expected response at the digital input for test mode 2

Test mode 3

When testing the safety output, the inverter switches off the two outputs one after the other and evaluates the feedback via a digital input.
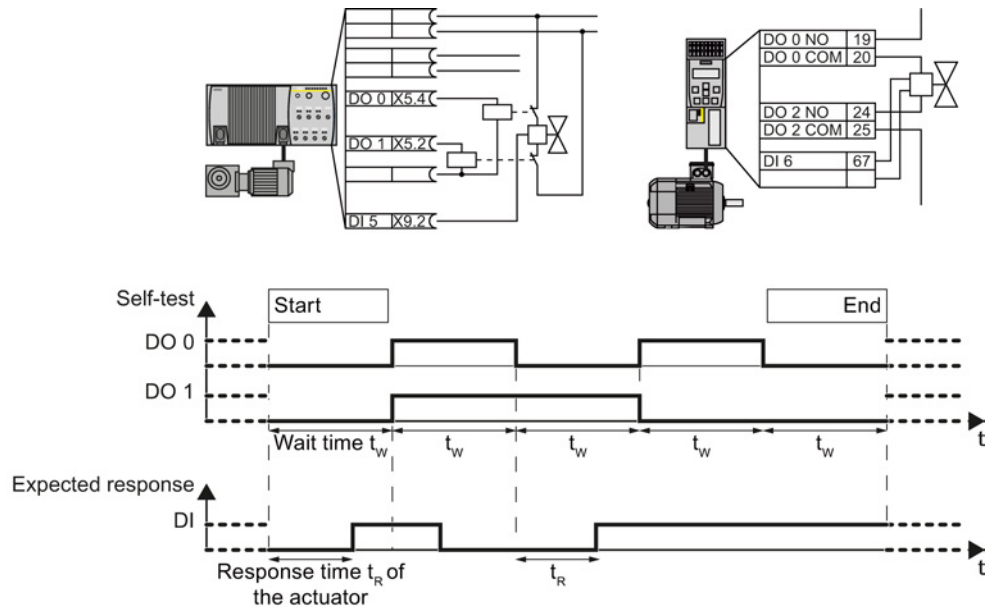
Figure 5-14   Expected response at the digital input for test mode 3

Test mode 4

When testing the safety output, the inverter switches off the two outputs one after the other.

The transistor outputs of the SINAMICS G120D monitor the inverter using internal signals.

The safety input F-DI must monitor the safety output of the inverter.
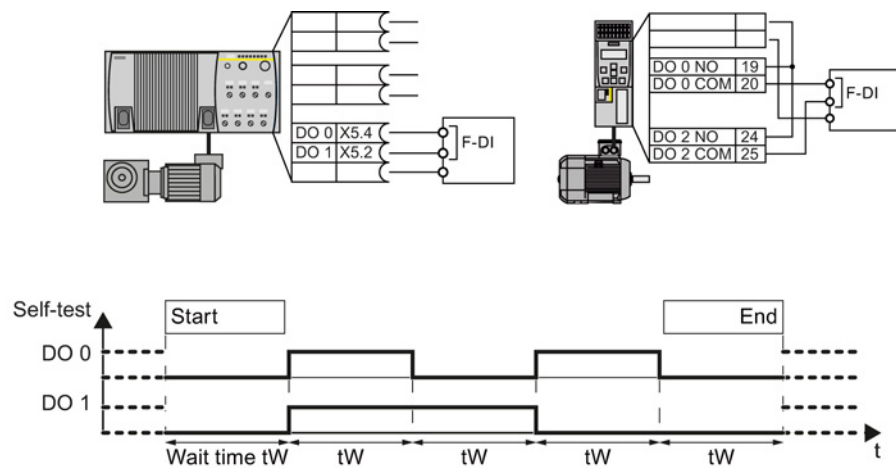
Figure 5-15   Test mode 4

Parameter	Description
p10039	**Safe State signal selection** (factory setting: 0000 0001 bin) Setting the signals for the "Safe State" signal.
p10042[0…5]	**F-DO signal sources** (Factory setting: 0) Setting the 6 signal sources for F-DO.
p10046	**F-DO feedback signal input activation** (Factory setting: 0000 bin) Activation of the feedback input for the safety output.
p10047	**F-DO test mode** (Factory setting: 0100 bin) Setting the test mode for the safety output
p10001	**Wait time for the forced checking procedure at DO** (Factory setting: 500 ms) Within this time, for a forced dormant error detection of the digital output, the signal must have been detected via the corresponding feedback input (p10047). The inverter always waits for a minimum of 24 ms.

5.7.3.2   Setting the forced dormant error detection (test stop)

Precondition

You have selected the extended functions via onboard terminals.

Procedure

To set the forced dormant error detection (test stop) of the safety output, proceed as follows:

1. Press the "Safety inputs/outputs" button.

2. Press the "Configuration" button.
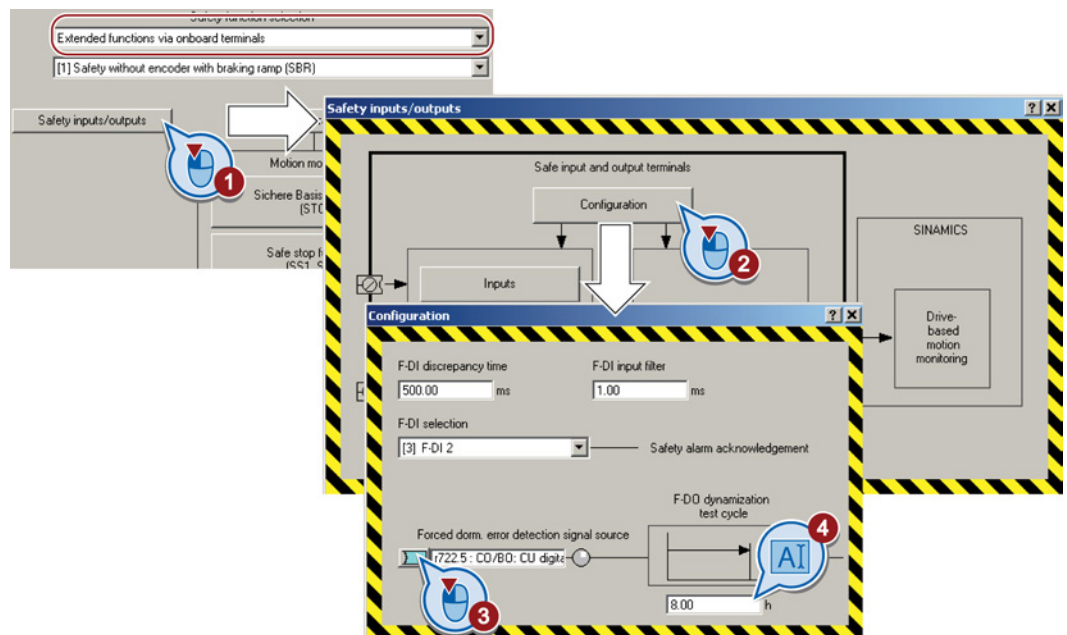
3. Interconnect this signal, for example with a digital input or a control bit in the fieldbus. This signal starts the forced dormant error detection (test stop) of the safety output and resets the remaining monitoring time to the value ④.

   We recommend that the safety output is tested together with the forced dormant error detection of the safety functions. To do this, interconnect the signal source with the same signal as the forced dormant error detection of the safety functions. See also Section: Setting the forced dormant error detection (test stop) (Page 104).

4. Set the monitoring time for the forced dormant error detection.

   The time must be longer than or equal to the time for monitoring the forced dormant error detection of the extended functions. See also Section: Setting the forced dormant error detection (test stop) (Page 104).

5. Close the two screen forms.

You have defined which signal the inverter uses to start the forced dormant error detection (test stop) of its safety output.

Description: Forced dormant error detection of the safety output

The forced dormant error detection of the safety output is the regular self-test of the inverter, in which the inverter checks whether the output can be shut down (deactivated).

The inverter monitors the regular forced dormant error detection of the safety output using a timer element.

You must start the forced dormant error detection with a signal of your choice.
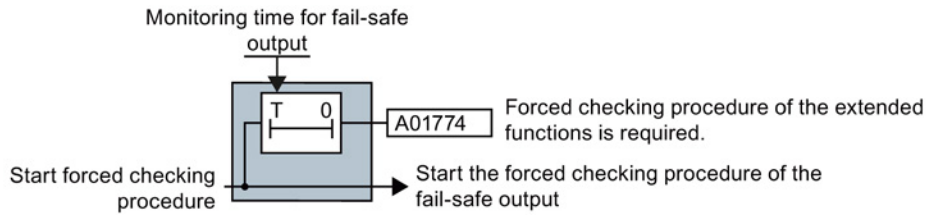
Figure 5-16   Start and monitoring of the forced dormant error detection of the safety output

Parameter	Description
p10003	**Forced dormant error detection timer** (Factory setting: 8 h) Setting the time to perform the forced checking procedure.
p10007	**Forced checking procedure F-DO signal source** (Factory setting: 0) Select an input terminal to start the forced checking procedure.

5.7.4 Configuring PROFIsafe in the converter

Precondition

You have selected PROFIsafe as interface.

Procedure

Proceed as follows to assign the inverter a PROFIsafe address:

1. Press the "Configuration" button.

2. Enter the same PROFIsafe address in the hexadecimal format that you defined in the hardware configuration.
   Also see section: Configuring PROFIBUS communication with telegram 30 via GSD (Page 78).
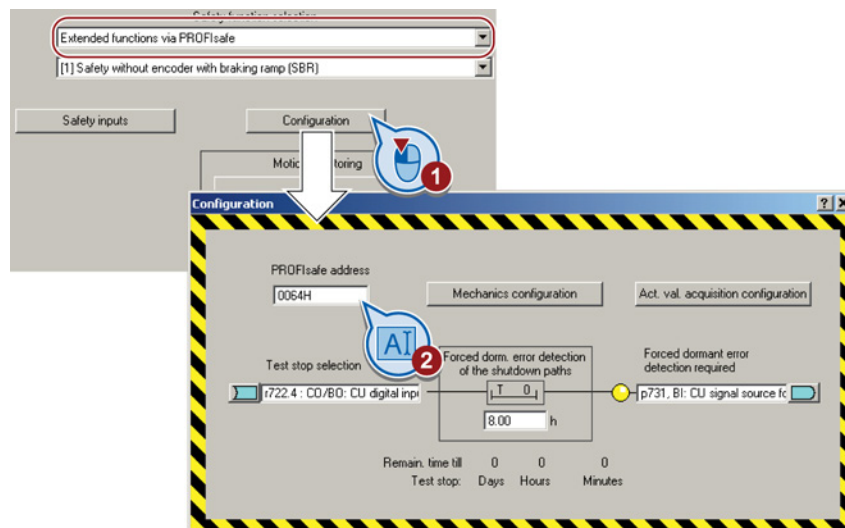
3. Close the screen form.

You have assigned the inverter its PROFIsafe address.

Parameter	Description
p9610	**PROFIsafe address** (Factory setting: 0000 hex)

PROFIsafe telegram 30 Factory setting

Telegram 30 is the factory setting in the inverter. If you enable the safety functions with communication via PROFIsafe, then the inverter expects telegram 30 from the higher-level control system.

Setting PROFIsafe telegram 900

Precondition

You have selected the extended functions "via PROFIsafe" or "via PROFIsafe and onboard terminals"

Procedure

To set the PROFIsafe telegram 900, proceed as follows:

1. Press the "Safety inputs" button.
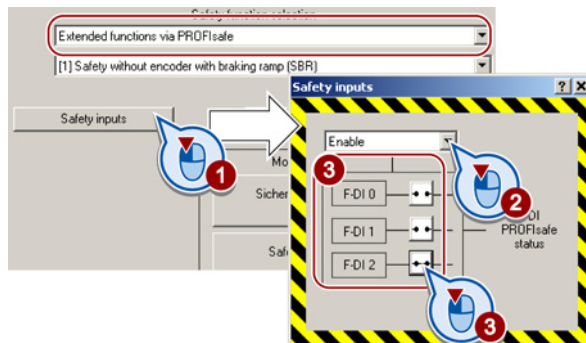
2. Enable telegram 900.

   If you disable this function, the inverter operates with telegram 30.

3. Set which F-DI status of the inverter is transferred via PROFIsafe status word 5 .

   Note

   The status of the safety inputs is transferred irrespective of whether you use one of the safety inputs to control a fail-safe function.

   ---

4. Close the screen form.

You have set PROFIsafe telegram 900 in the inverter.

Parameter	Description		
p9501.30	**Enable F-DI in PROFIsafe telegram**(Factory setting: 0 bin) 0 signal: F-DI is inhibited in the PROFIsafe telegram 1 signal: F-DI is enabled in PROFIsafe telegram		
p10050	**Transfer PROFIsafe F-DI** (Factory setting: 0000 bin)		
	Bit 0	0 signal: No transfer 1 signal: PROFIsafe status word 5 transfers the status of F-DI 0	
	Bit 1	0 signal: No transfer 1 signal: PROFIsafe status word 5 transfers the status of F-DI 1	
	Bit 2	0 signal: No transfer 1 signal: PROFIsafe status word 5 transfers the status of F-DI 2	

Enabling Shared Device

If you control the inverter safety functions via PROFINET and "Shared Device", you must enable this function in the inverter.

See also Section: Configuring shared device communication via PROFINET (Page 82).

Procedure

To configure communication via "Shared Device" in the inverter, proceed as follows:

1. In STARTER change to the expert list.

2. In STARTER, set p8929 = 2.

You have configured the communication via "Shared Device" in the inverter.

Starting communication via PROFIsafe

When you connect the converter to the higher-level control system (F-CPU) via the fieldbus for the first time, the central control system sends the PROFIsafe configuration to the converter. After the configuration data have been received in the converter, PROFIsafecommunication starts.

The converter only monitors the communication to the F-CPU after the configuration data have been received from the central control system.

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5.7.5 Setting SS1

Monitoring modes

You can select between two different monitoring modes of the SS1 function.

Braking ramp monitoring	Acceleration monitoring

• Using the SBR (Safe Brake Ramp) function, the inverter monitors whether the motor speed decreases.
 	
• The gradient of the SBR function can be adjusted. The SBR function only starts after the "Delay time for braking ramp". The SBR function starts with the speed setpoint that was applicable when SS1 was selected.
 	
• When the standstill monitoring threshold is fallen below, the inverter safely switches off the motor torque (STO).
	• The inverter monitors the motor speed using the SAM (Safe Acceleration Monitor) function.
	
	• The inverter prevents the motor from re-accelerating by continuously adjusting the monitoring threshold to the decreasing speed.
	
	• The inverter reduces the monitoring threshold until the "Shutdown speed" has been reached.
	
	• The inverter safely switches off the motor torque (STO) if one of the following conditions is fulfilled:
	  – The inverter detects that the motor is stationary.
	  – The maximum time until the torque is switched off has expired.

5.7.5.1 Setting SS1 with braking ramp monitoring

Procedure

To set the SS1 function with braking ramp monitoring, proceed as follows:

1. Select "[1] Safety without encoder with braking ramp (SBR)".

2. Press the "Safe stop functions" button.
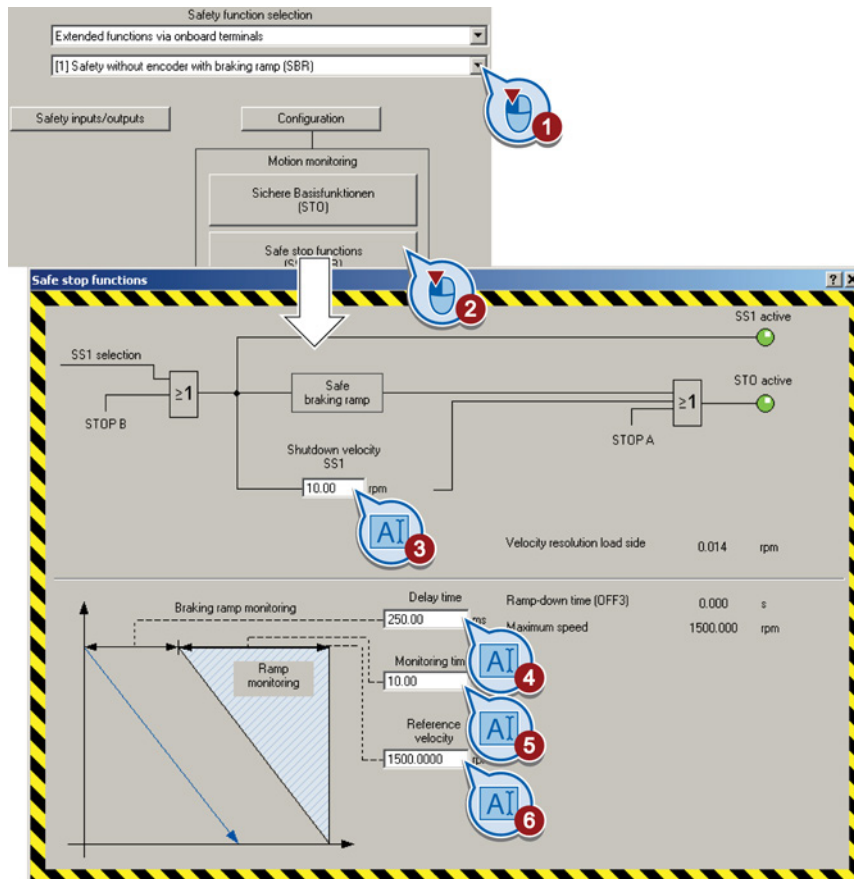
3. Set the following:

   – ③ shutdown speed SS1.

   – ④ Delay time:
   If the ramp-down time (OFF3) in your application is less than 10 seconds, then leave the delay time at its factory setting. If SS1 goes into a fault condition during the function test, increase this value until the motor brakes normally without a fault.
   If the ramp-down time (OFF3) is set to several minutes, you must extend the delay time to several seconds in order to avoid any unwanted faults when selecting SS1.

   – ⑤ Monitoring time
   The monitoring time defines the gradient of the monitoring curve when braking the load.
   If the monitoring curve should be parallel to the down ramp of the load, then you must set the following: **Monitoring time = ramp-down time (OFF3) / gear ratio**.
   Gear ratio = load/motor revolutions.
   Example: Gear ratio = 1 / 3 ⇒ monitoring time = ramp-down time (OFF3) × 3.

A monitoring time shorter than the above calculated value does not make sense, as the inverter can reduce its monitoring curve faster than the load can be braked. The longer you set the monitoring times, the more tolerant the monitoring.

– ⑥ Reference velocity (reference speed):
Set the reference speed to the value of the maximum speed.

4. Close the screen form.

You have set the SS1 function with braking ramp monitoring.

Description: SS1 with braking ramp monitoring
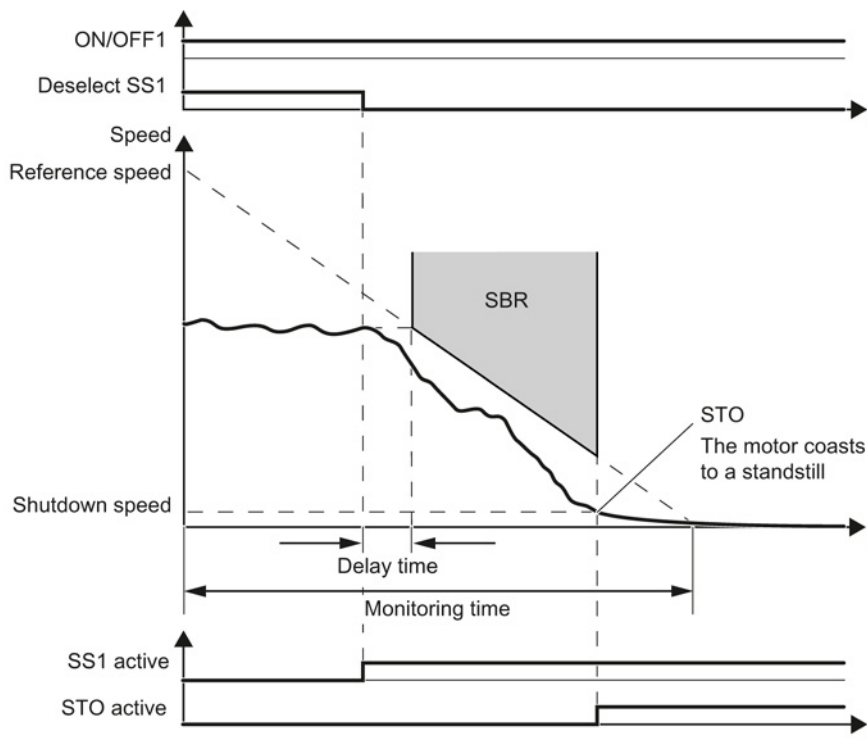
Figure 5-17   SS1 with braking ramp monitoring

Reference speed and monitoring time

The two values define the gradient of the SBR monitoring .

Delay time

The SBR function only starts after an adjustable time. To begin with, the inverter monitors the speed setpoint that applied when SS1 was selected.

Braking

The inverter brakes the motor with the OFF3 ramp-down time.

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Shutdown speed

The inverter safely switches off the motor torque using the STO function if the speed has reached the shutdown speed.

Parameter	Description	
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Disable extended functions.	
p9506	**Function specification:** (Factory setting: 1)	
	1:	With braking ramp monitoring
	3:	With acceleration monitoring
p9546	**SSM speed limit** (factory setting: 20 rpm) Only relevant to the SS1 function if p9560 = 0.	
p9560	**Shutdown speed** (Factory setting: 10 rpm)	
p9581	**Reference speed** (Factory setting: 1500 rpm)	
p9582	**Delay time** (Factory setting: 250 ms)	
p9583	**Monitoring time** (Factory setting: 10 s)	
r9722.1	**1 signal**: SS1 active	
r9723.16	**1 signal**: SAM/SBR active	
p1135	**OFF3 ramp-down time**	
p1226	**Standstill detection, speed threshold** (Factory setting: 20 rpm)	The inverter switches off the motor torque if the speed either fulfills the condition for standstill detection or the shutdown speed p9569 has been reached.
p1227	**Standstill detection monitoring time** (Value depends on the power unit)	

5.7.5.2 Setting SS1 with acceleration monitoring

Procedure

To set the SS1 function with acceleration monitoring, proceed as follows:

1. Select "[3] Safety without encoder with accel_monitoring (SAM)/delay time".

2. Press the "Safe stop functions" button.
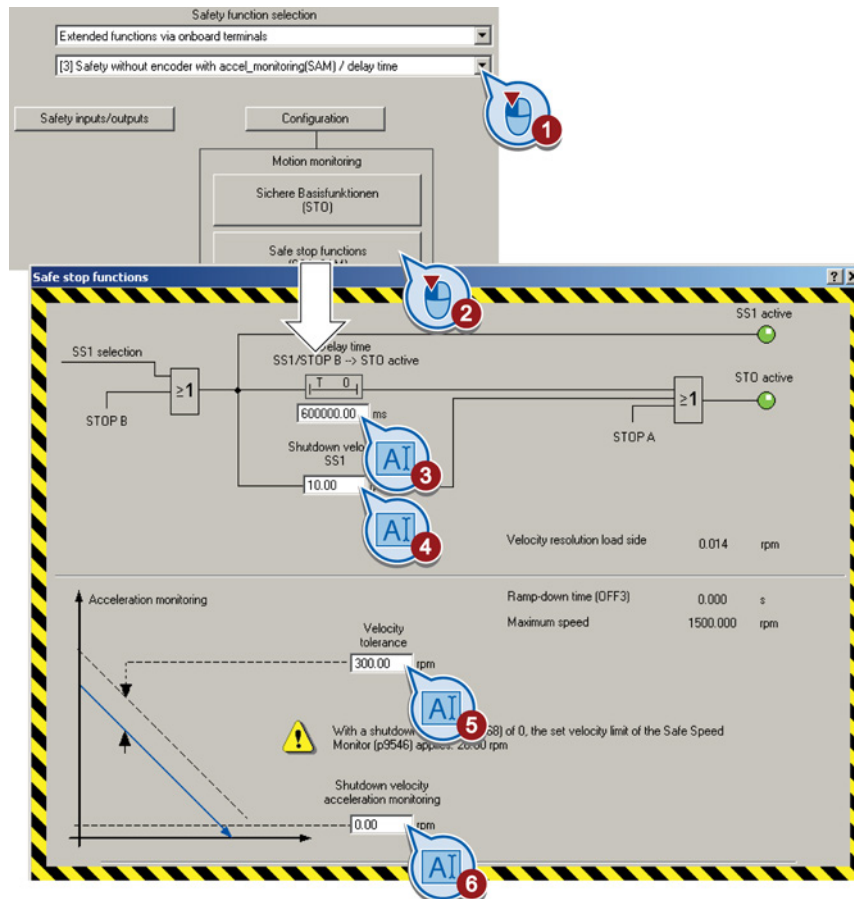
3. Set the following:

    – ③ Delay time
       After this time the inverter safely switches off the motor torque – regardless of the actual speed.

    – ④ shutdown speed SS1

    – ⑤ speed tolerance

    – ⑥ shutdown speed acceleration monitoring

4. Close the screen form.

You have set the SS1 function with acceleration monitoring.

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Description: SS1 with acceleration monitoring
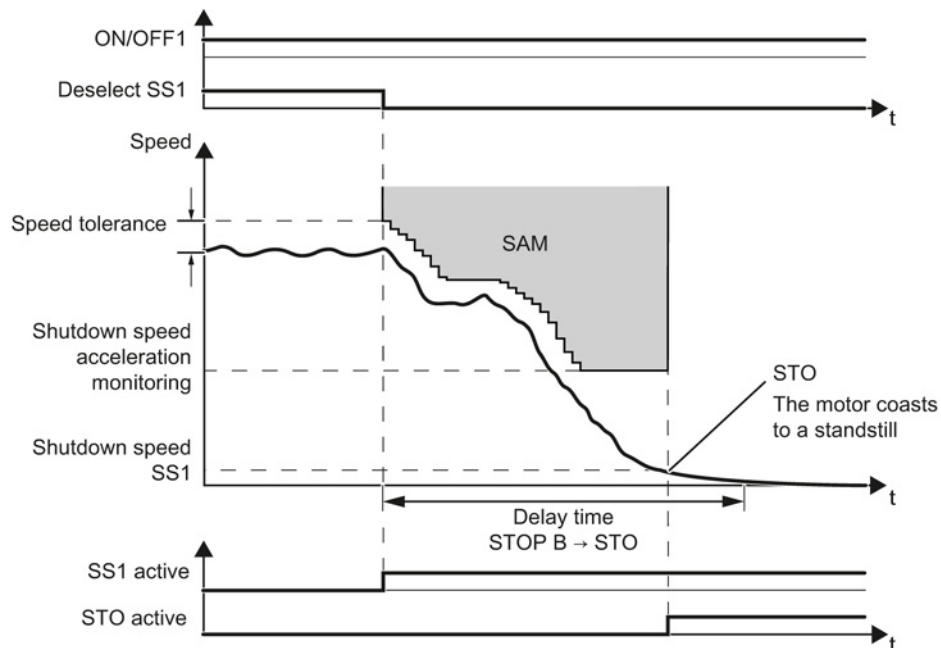
Figure 5-18   SS1 with acceleration monitoring

Speed tolerance

As long as the speed is less, the inverter continuously adds the tolerance to the actual speed so that the monitoring tracks the speed.

Shutdown speed acceleration monitoring

The inverter reduces the monitoring threshold until it reaches the value of the "Shutdown speed acceleration monitoring".

Shutdown speed SS1 and delay time

The inverter safely switches off the motor torque with the STO function if one of the two conditions is fulfilled:

- The actual speed reaches the value of the shutdown speed SS1.
- The delay time has expired.

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Parameter	Description	
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Disable extended functions.	
p9506	**Function specification:** (Factory setting: 1)	
	3: With acceleration monitoring	
p9548	**Speed tolerance** (Factory setting: 300 rpm)	
p9556	**Delay time STOP B → STO** (Factory setting: 600000 ms)	
p9560	**Shutdown speed SS1** (Factory setting: 10 rpm)	
p9568	**Shutdown speed acceleration monitoring** (Factory setting: 0 rpm)	
r9722.1	**1 signal**: SS1 active	
r9723.16	**1 signal**: SAM/SBR active	
p1226	**Standstill detection, speed threshold** (Factory setting: 20 rpm)	The inverter switches off the motor torque if the speed either fulfills the condition for standstill detection or the shutdown speed p9569 has been reached.
p1227	**Standstill detection monitoring time** (Value depends on the power unit)	

5.7.6   Setting SLS

5.7.6.1   Setting the monitoring functions

Procedure

To set the SLS function, proceed as follows:

1. In the main screen form of the extended functions, select one of the two monitoring modes:

   – [1] Safety without encoder with braking ramp (SBR)

   – [3] Safety without encoder with accel_monitoring (SAM)/delay time

2. Select the SLS safety function.

3. Set the following:

   – ③ The delay time only appears if you have selected acceleration monitoring (SAM).
     The delay time must be longer than the time, when SLS is selected, that the motor
     needs to brake with the maximum load from the maximum speed down to the lowest
     SLS level.

   – ④ Setpoint speed limiting as a % of the currently selected SLS level.
     The inverter limits the speed to this value when SLS is active.

   – ⑤ Speed monitoring.
     Set the load speed to be monitored.
     If you have not set PROFIsafe as interface, then you can only set level 1.

   – ⑥ Set the response when the monitoring responds.
     Also see section: Stop responses (Page 227).

4. Close the screen form.

You have set the SLS function.

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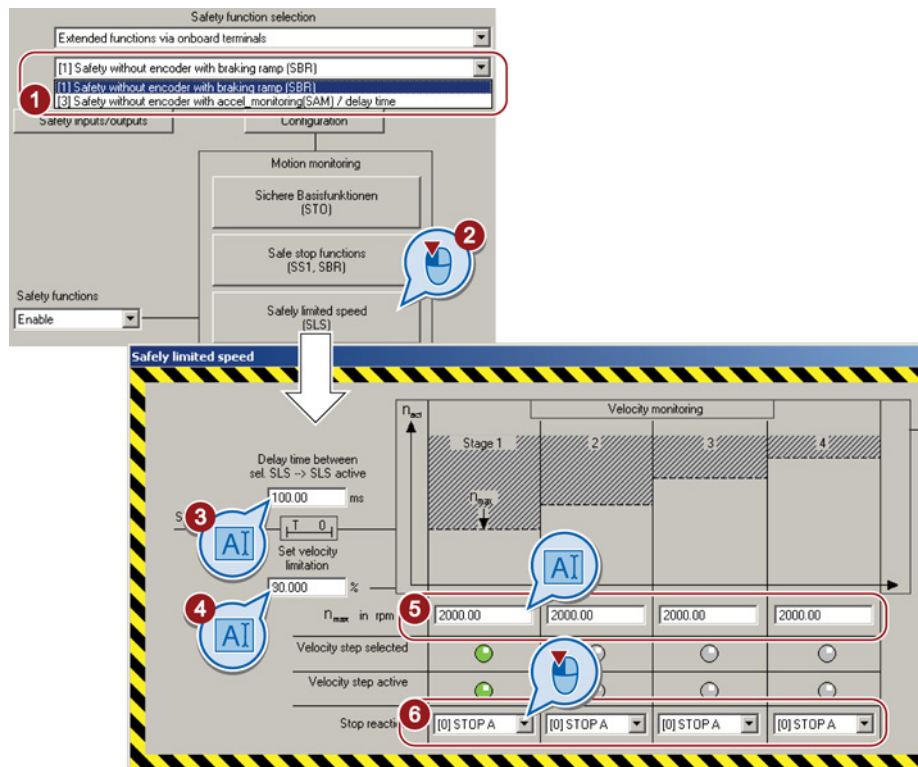
Description of the SLS function
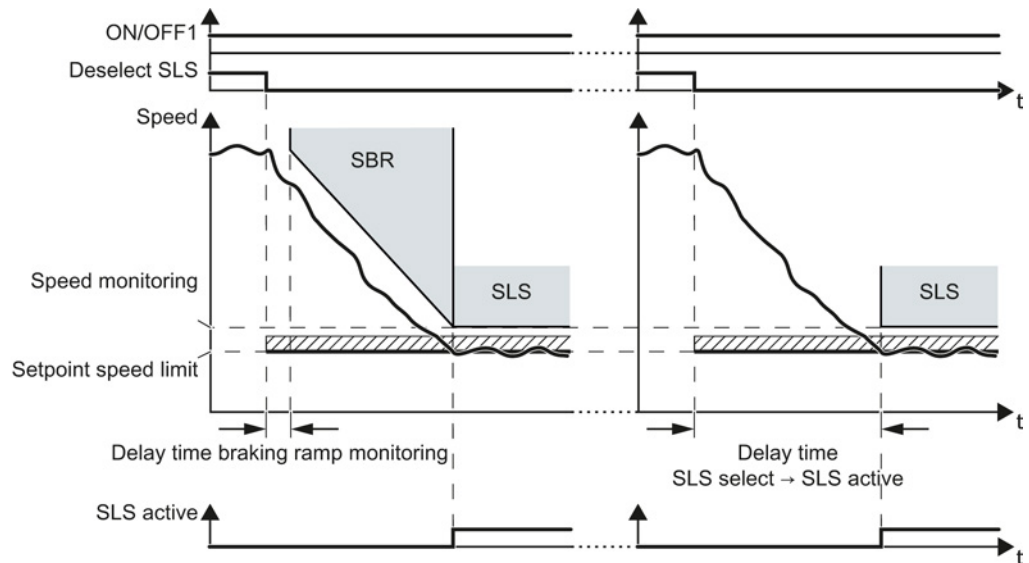
Figure 5-19   Behavior after selecting SLS. Left: with braking ramp monitoring; right: without braking ramp monitoring

After selecting SLS, the inverter brakes the motor according to the OFF3 ramp-down time. Setting the braking ramp monitoring is described in Section. Setting SS1 with braking ramp monitoring (Page 131).

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Parameter	Description
p1135	**OFF3 ramp-down time**
p9501.00	**1 signal:** Enable SLS and extended functions. **0 signal:** Inhibit SLS and extended functions.
p9506	**Function specification:** (Factory setting: 1)
	1: With braking ramp monitoring
	3: Without braking ramp monitoring
p9531[0…3]	**Speed monitoring** (Factory setting for all levels: 2000 rpm)
p9533	**Setpoint speed limiting** (Factory setting: 80 %) The inverter limits the setpoint to the value r9733. r9733[0] = p9531[x] × p9533.
p9551	**Delay time SLS selection → SLS active** (Factory setting: 100 ms) Not active for braking ramp monitoring.
p9563[0…3]	**SLS-specific stop response** (Factory setting: STOP A)
	0: STOP A
	1: STOP B
p9581	**Reference speed** (Factory setting: 1500 rpm)
p9582	**Delay time** (Factory setting: 250 ms)
p9583	**Monitoring time** (Factory setting: 10 s) The gradient of the braking ramp depends on p9581 and p9583.
r9722.04	**1 signal:** SLS active **0 signal:** SLS not active
p1135	**OFF3 ramp-down time**

5.7.6.2 Settings for acceptance test

In order to be able to approach the monitoring limit of the safety function during the acceptance test, you must temporarily deactivate speed limiting in the inverter.

Starter offers you the possibility to temporarily deactivating speed limiting.

Procedure

To prepare for acceptance, proceed as follows:

1. In the main screen form of the extended functions, select the "Acceptance mode" button.

2. Set the time in which the inverter deactivates its internal speed limiting. During the acceptance test, you must reach the monitored limit value within this time.

   After this time expires, the inverter exits the acceptance mode and reactivates its internal speed limiting.

3. Close the screen form.

You have made the preparations for the function to be accepted.

Parameter	
p9558	**Acceptance test mode time limit** (factory setting 40000 ms)
	Maximum time limit: 100 seconds.

5.7.7 Setting SSM

Procedure

To set the SSM function, proceed as follows:

1. In the main screen form of the extended functions, select the SSM safety function.

2. Set the following in this screen form:

   – ① With or without hysteresis.

   – ② The behavior when the motor is switched off.

   – ③ The speed to be monitored.

   – You do not need to set the filter time ④ and hysteresis ⑤ until you have enabled the hysteresis ①.
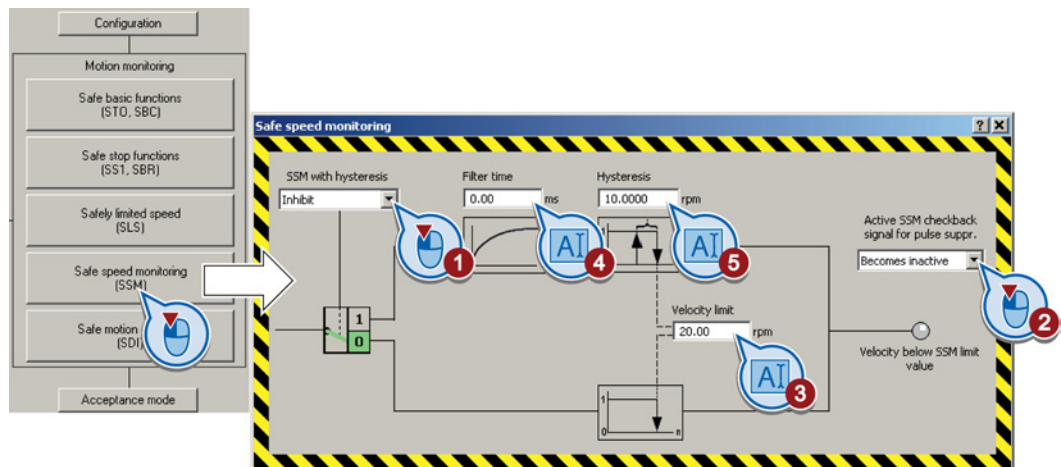
You have set the SSM function.

The SSM function is active immediately after commissioning has been completed.

If you have set the SSM feedback signal for pulse cancellation ② as "remains active", when switching on the motor, you must maintain a specific signal sequence. See also the section Switching on the motor when SSM is active (Page 213).

Description: SSM without hysteresis

Speed monitoring

- When the motor is switched on, the inverter compares the load speed with the speed limit.
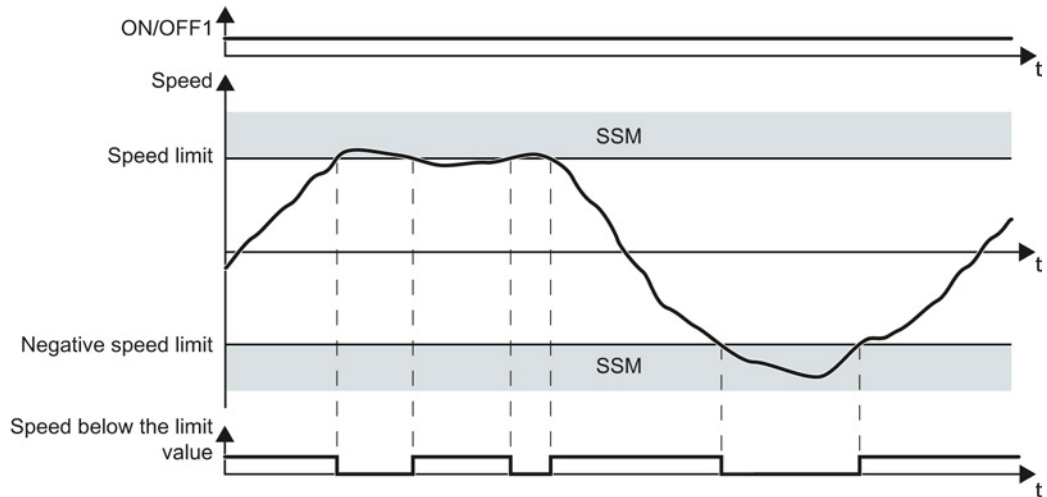
Figure 5-20   Time response of the SSM safety function without hysteresis

Parameter	Description
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Disable extended functions.
p9501.16	**1 signal:** Enable hysteresis and filtering **0 signal:** Disable hysteresis and filtering
p9546	**Speed limit** (Factory setting: 20 rpm)
r9722.15	**1 signal**: Absolute value of the speed is lower than the speed limit

Description: SSM with hysteresis

If you wish to monitor speeds that are very close to the speed limit, you may find it useful to set the hysteresis.

Speed monitoring

- When the motor is switched on, the inverter compares the load speed with the speed limit, taking the hysteresis into account.
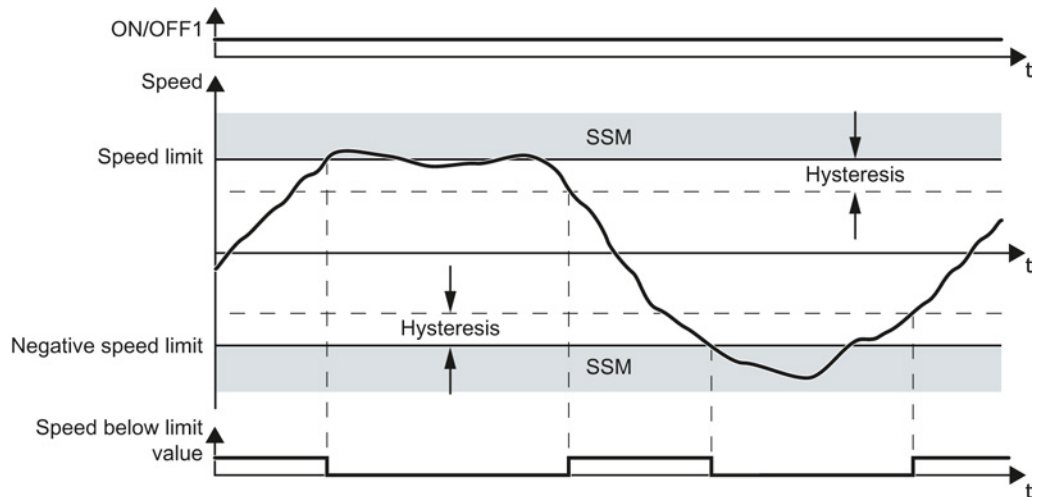
Figure 5-21   Time response of the SSM safety function with hysteresis

Filter

The signal filters smoothes the speed measured by the inverter. Use the filter if you wish to monitor speeds that lie just below the speed limit.
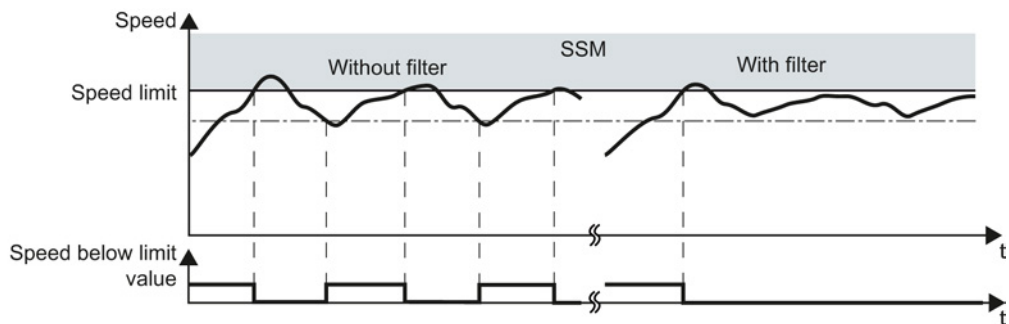
Figure 5-22   Mode of operation of the filter of the SSM function

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Parameter	Description
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Disable extended functions.
p9501.16	**1 signal:** Enable hysteresis and filtering **0 signal:** Disable hysteresis and filtering
p9545	**Filter time** (Factory setting: 0 ms)
p9546	**Speed limit** (Factory setting: 20 rpm)
p9547	**Hysteresis** (Factory setting: 10 rpm)
r9722.15	**1 signal**: Absolute value of the speed is lower than the speed limit

Feedback signal SSM when the motor is switched off

You can select as to whether the SSM function should remain active when the motor is switched off.

The following occurs if SSM remains active:

- With the motor switched off, the inverter freezes the "Speed below limit value" signal.

- When the motor is switched off, STO is active.
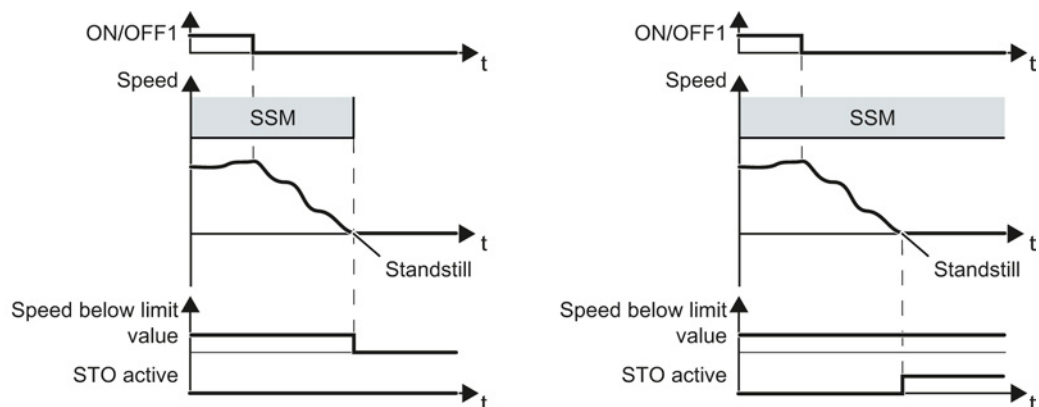
Figure 5-23   Feedback signal SSM when the motor is switched off
Left: SSM becomes inactive. Right: SSM remains active

See also Section: Switching off the motor when SSM is active (Page 208).

Parameter	Description
p9509.00	**1 signal:** SSM becomes inactive when the motor is switched off **0 signal:** SSM remains active when the motor is switched off

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5.7.8 Setting SDI

5.7.8.1 Setting the monitoring functions

Procedure

To set the SDI function, proceed as follows:

1. Select the safety function SDI.

2. Set the following in this screen form:

   – ① Enable the function.

   – ② The delay time up to active monitoring.

   – ③ The tolerance for motion in the monitored direction.

   – ④ The response when the monitoring function responds.

     See also Section: Stop responses (Page 227)

   – ⑤ The behavior when the motor is switched off.

     See also Section: Switching off the motor when SDI is active (Page 217)

   – ⑥ ⑦ If you leave this signal interconnection to the factory setting, when SDI is selected, the inverter limits the speed.
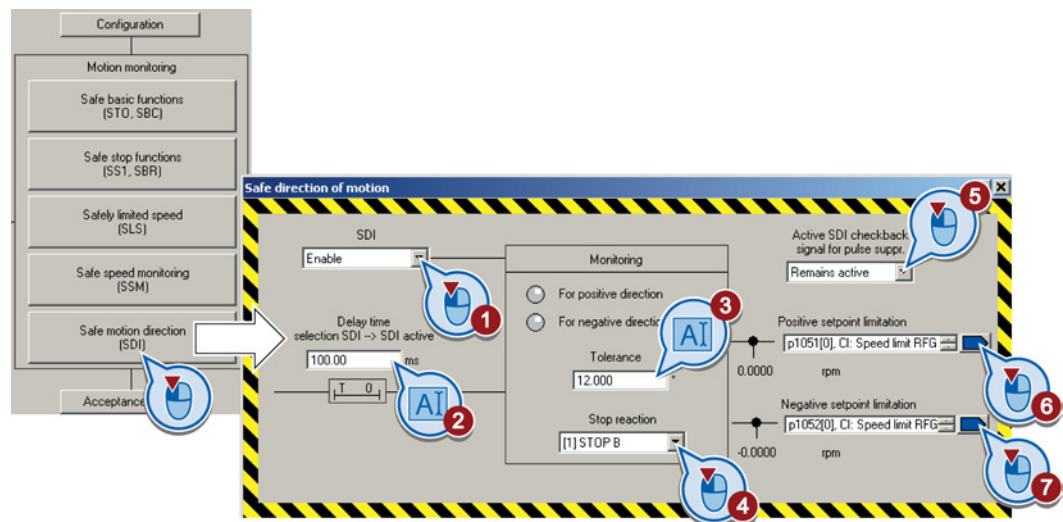
You have set the SDI function.

Description of the SDI function

Time response

If you select SDI, the inverter limits the speed or velocity setpoint to a value of zero in the inhibited direction of rotation.
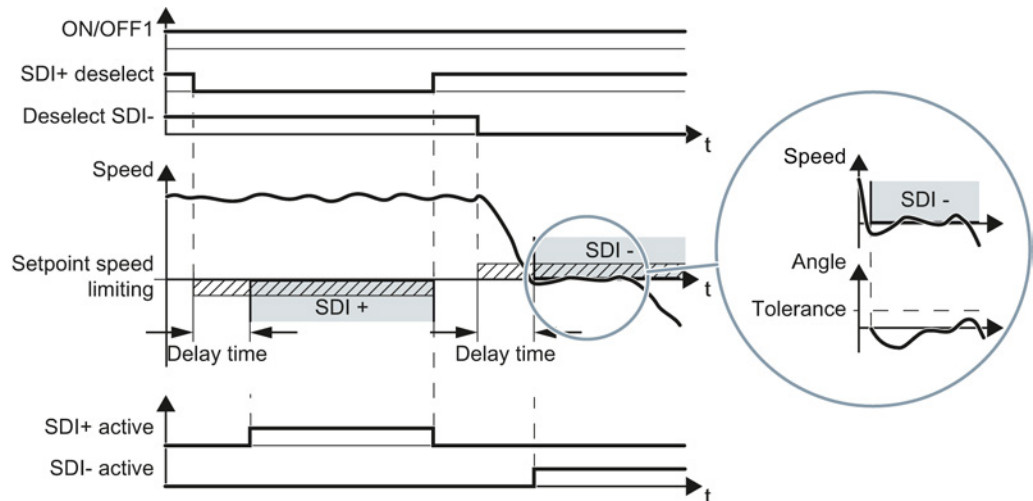
Figure 5-24   Delay time and tolerance

Delay time

The inverter monitors the direction of rotation of the motor after the delay time has expired. When SDI is selected, the delay time must be longer than the time that the motor requires to brake the maximum load from maximum speed down to standstill. The inverter brakes the motor with the OFF3 ramp-down time.

Tolerance

The inverter permits brief motion in the monitored direction, for example for brief speed overshoots after braking down to standstill. To do this, the inverter converts the motor speed into an angle. With the tolerance, you limit the maximum permissible angle in the monitored direction.

Feedback signal SDI when the motor is switched off

You can select as to whether the SDI function should remain active when the motor is switched off.

- With the motor switched off, the inverter freezes the "SDI active" signal.

- When the motor is switched off, STO is active.
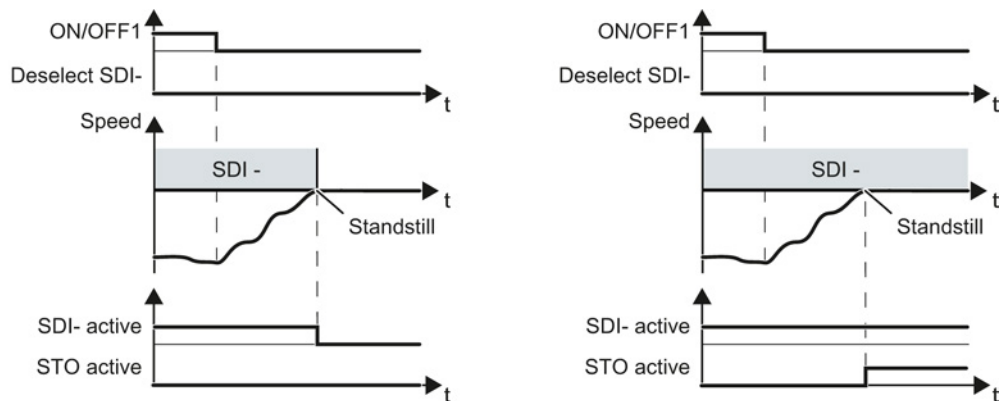
Figure 5-25   Feedback signal SDI when the motor is switched off
              Left: SDI becomes inactive. Right: SDI remains active

Parameter	Description
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Disable extended functions.
p9501.17	**1 signal:** Enable SDI **0 signal:** Inhibit SDI
p9509.08	**1 signal:** SDI becomes inactive when the motor is switched off **0 signal:** SDI remains active when the motor is switched off
p9564	**Tolerance** (Factory setting: 12 degrees)
p9565	**Delay time** (Factory setting: 100 ms)
p9566	**Stop response** (Factory setting: 1)
	0:	STOP A
	1:	STOP B
r9722.12	**1 signal:** SDI positive active
r9722.13	**1 signal:** SDI negative active
p1135	**OFF3 ramp-down time**

5.7.8.2   Settings for acceptance test

In order to be able to approach the monitoring limit of the safety function during the acceptance test, you must temporarily deactivate speed limiting in the inverter.

Starter offers you the possibility to temporarily deactivating speed limiting.

Procedure

To prepare for acceptance, proceed as follows:

1. In the main screen form of the extended functions, select the "Acceptance mode" button.

2. Set the time in which the inverter deactivates its internal speed limiting. During the acceptance test, you must reach the monitored limit value within this time.

    After this time expires, the inverter exits the acceptance mode and reactivates its internal speed limiting.

3. Close the screen form.

You have made the preparations for the function to be accepted.

Parameter	
p9558	**Acceptance test mode time limit** (factory setting 40000 ms)
	Maximum time limit: 100 seconds.

5.7.9 Final steps

Activate settings

Procedure

To activate the settings for the safety functions, proceed as follows:

1. Press the "Copy parameters" button, to create a redundant image of your inverter settings.

2. Press the "Activate settings" button.

3. If the password is the factory default, you are prompted to change the password.
   If you try to set a password that is not permissible, the old password will not be changed.

4. Confirm the prompt for saving your settings (copy RAM to ROM).

5. Switch off the inverter supply voltage.

6. Wait until all LEDs on the inverter go dark (no voltage condition).

7. Switch on the inverter supply voltage again.

Your settings are now active.

Parameter	Description
p9700 = 57 hex	**SI copy function** (factory setting: 0) Starting the SI parameter copy function.
p9701 = AC hex	**Confirm data change** (factory setting: 0) Confirm date change overall.
p0010 = 0	**Drive commissioning parameter filter** 0: Ready
p0971 = 1	**Save parameter** 1: Save the drive object (copy from RAM to ROM) After the inverter has saved the parameters in a non-volatile fashion, then p0971 = 0.

Checking the connection of digital inputs

The simultaneous connection of digital inputs with a safety function and a "standard" function may lead to the drive behaving in unexpected ways.

If you control the safety functions in the inverter using digital inputs, you must check whether these digital inputs are connected to a "standard" function.

Figure 5-26   Example: Assignment of digital inputs DI 4 and DI 5 with STO

Procedure

In order to prevent the safety-related inputs of the safety functions unintentionally controlling "standard" functions in the inverter, proceed as follows:

1. Select the inputs/outputs in STARTER in the project navigator.

2. Select the screen for the digital inputs.

3. Remove all digital input interconnections that you use as safety-related input F-DI:

4. If you use the CDS dataset switchover, you must delete the digital input connections for all CDS.
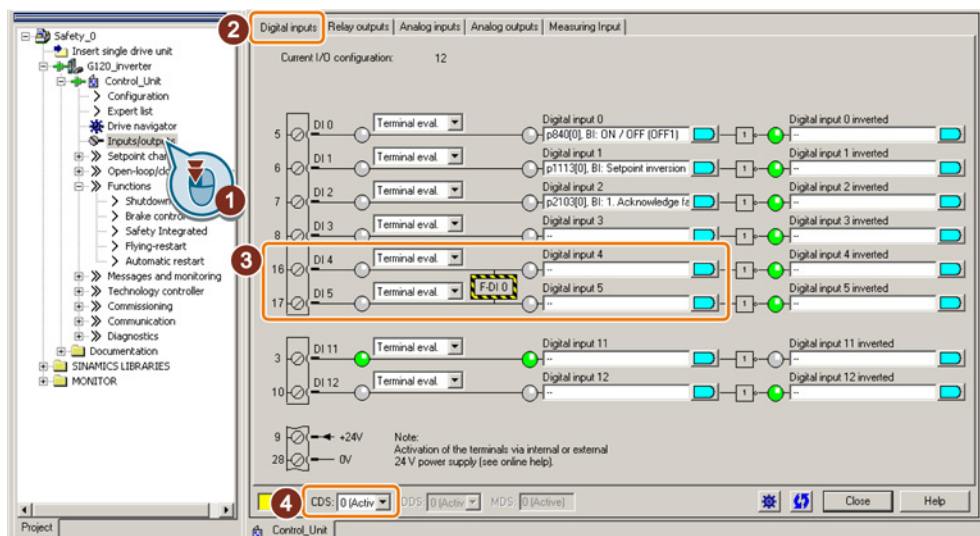
Figure 5-27   Removing the DI 4 and DI 5 digital-input connections

You have now prevented safety-related inputs in the safety functions controlling "standard" functions in the inverter.

Checking the interconnection of the feedback signal input for the safety output

The interconnection of the feedback signal input with a "standard" function may lead to the drive behaving in unexpected ways.

Preconditions

- You use the safety output of the inverter.

- You use one of the test modes 2 or 3, where the inverter evaluates the status of the connected actuator via a digital input.

You must check as to whether this digital input is assigned a "standard" function.

Procedure

In order to prevent that the feedback signal input of the safety output unintentionally controls the "standard" functions in the inverter, proceed as follows:

1. Select the inputs/outputs in the project navigator of STARTER.

2. Select the screen for the digital inputs.

3. Remove the interconnection of the digital input that you use as feedback signal input for the safety output:

   – SINAMICS G120 with CU250S-2 Control Unit: Digital input DI 6 (see diagram).

   – SINAMICS G120D: Digital input DI 5.

4. If you use the CDS data set switchover, remove the interconnection of the feedback signal input for all CDS.
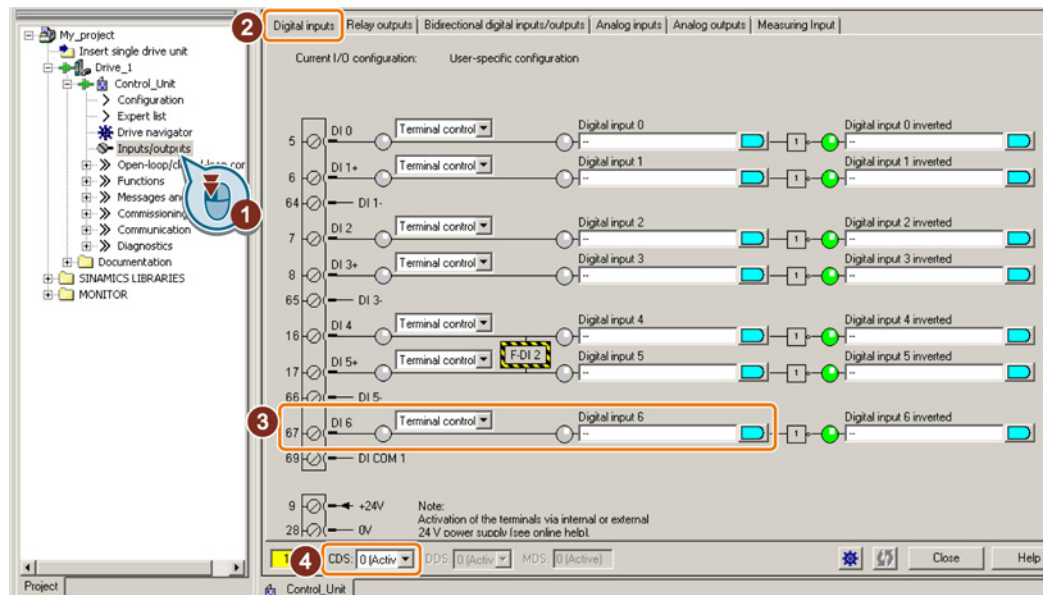
Figure 5-28   Removing the interconnection of the feedback signal input DI 6 for the CU250S-2

You have now prevented that the feedback signal input of the safety output controls "standard" functions in the inverter.

5.8 Offline commissioning

When you set the safety function parameters offline, you have to download them to the inverter. Once you have downloaded them, you have to finish commissioning the safety functions online.

The screens for the safety functions differ from each other slightly depending on whether you work with STARTER online or offline. Follow the descriptions in this manual in order to set all of the necessary parameters in line with the requirements of your application (this also applies when setting the parameters offline).

Setting the safety functions offline

Procedure

To set the safety functions offline, proceed as follows:

1. Select the safety functions in STARTER.

2. Set the check mark "Copy parameters after download":
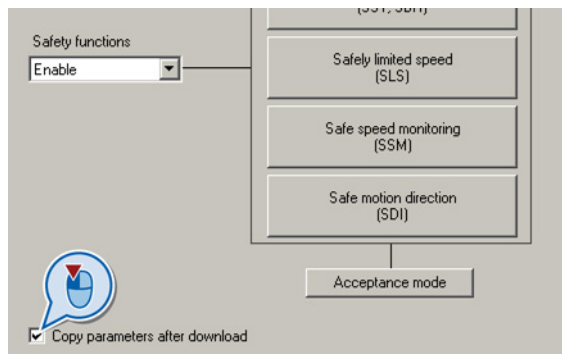
3. Set the safety function parameters offline.
   When doing this, follow the descriptions of the online commissioning, also see Section: Changing settings (Page 86).

4. Once you have finished setting the parameters, save your project by clicking the 💾 button.

You have set the safety functions of the inverter offline, and saved them to your PC or PG.

In the next step, you must transfer the settings from your PC or PG to the inverter.

Loading the settings into an inverter using STARTER

Procedure

To load the settings to the inverter, proceed as follows:

1. Go online with STARTER and start to download to the inverter using the button ![icon]. After the download, the inverter signals faults. Ignore these faults, as they will be automatically acknowledged by the following steps.

2. Select the screen form for the safety functions.

3. Select the button to change the settings.

4. Activate the settings using the associated button.

5. Save your settings (copy RAM to ROM).

6. Switch off the inverter supply voltage.

7. Wait until all of the LED on the inverter go dark.

8. Switch on the inverter supply voltage again.

The inverter has now accepted your settings.

5.9 Series commissioning

Series commissioning is the process where you transfer the settings of one inverter to a second inverter.

Procedure

To transfer settings from one inverter to another, proceed as follows:

1. Using STARTER , save your project to your PC or PG.

2. Loading your backed up settings to a second inverter:

   Follow the procedure described in the section: Offline commissioning (Page 153).

3. If you control your inverter via PROFIsafe , then adapt the PROFIsafe address.

   For further information, refer to the following sections:

   – Basic functions: Configuring PROFIsafe (Page 92)

   – Extended functions: Configuring PROFIsafe in the converter (Page 127)

4. Perform a reduced acceptance for the safety functions.

   The necessary measures are described in the section: Reduced acceptance test after component replacement (Page 266).

You have transferred the settings of the first inverter to a second inverter.

5.10 Acceptance tests for the safety functions

5.10.1 Acceptance test

What is an acceptance?

The machine manufacturer is responsible in ensuring that his plant or machine functions perfectly. As a consequence, after commissioning, the machine manufacturer must check those functions or have them checked by specialist personnel, which represent an increased risk of injury to personnel or material damage. This acceptance or validation is, for example, also specified in the European machinery directive and essentially comprises two parts:

● Checking the safety-relevant functions and machine parts.

    → **Acceptance test**.

● Generate an "Acceptance report" that describes the test results.

    → **Documentation**.

Supply information for the validation, e.g. the harmonized European standards EN ISO 13849-1 and EN ISO 13849-2.

Acceptance test of the machine or plant

The acceptance test checks whether the safety-relevant functions in the plant or machine function correctly. The documentation of the components used in the safety functions can also provide information about the necessary tests.

Testing the safety-related functions includes e.g. the following:

● Are all safety equipment such as protective door monitoring devices, light barriers or emergency-off switches connected and ready for operation?

● Does the higher-level control respond as expected to the safety-relevant feedback signals of the inverter?

● Do the inverter settings match the configured safety-relevant function in the machine?

Acceptance test of the inverter

The acceptance test of the inverter is a part of the acceptance test of the entire machine or plant.

The acceptance test of the inverter checks whether the integrated drive safety functions are set up correctly for the planned safety function of the machine.

You can find examples for the acceptance test of integrated drive safety functions in section: Examples of acceptance tests (Page 277).

Documentation of the inverter

The following must be documented for the inverter:

- The results of the acceptance test.

- The settings of the integrated drive safety functions.

  The commissioning tool STARTER logs the settings of the integrated drive functions, if necessary. See also Section: Documentation for acceptance (Page 309).

The documentation must be signed.

Who may perform the acceptance test of the inverter?

Personnel from the machine manufacturer, who, on account of their technical qualifications and knowledge of the safety functions, are in a position to perform the acceptance test in the correct manner are authorized to perform the acceptance testing of the inverter.

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5.10.2 Reduced acceptance test after expanding the function

A full acceptance test is necessary only after first commissioning. A reduced acceptance test is sufficient when safety functions are expanded.

Table 5- 4   Reduced acceptance test after expanding the function

Measure	Acceptance test	Documentation
Changing a single limit (e.g. SLS level).	Check the modified limit value.	• Supplement function table • Log modified settings • Log the new checksum • Countersignature
Functional expansion of the machine (additional drive).	Check the safety functions of the new drive.	• Supplement machine overview • Supplement order number and firmware version of the drive • Supplement function table • Log the settings of the new drive • Log the new checksum • Countersignature
Functional expansion of a drive (e.g. additional SLS level or new safety function following a firmware update).	Check the additional functions.	• Supplement function table • Log modified settings • Log the new checksum • Countersignature
Transfer of inverter settings to other identical machines by means of series commissioning.	Check the control and feedback signal of all safety functions.	• Supplement machine description • Log modified settings • Check the checksums • Check the firmware versions

See also Section: Reduced acceptance test after component replacement (Page 266).

Operation

<div style="text-align: right; font-size: 3em;">6</div>

6.1 Overview and relevant inverter signals

About this chapter

This chapter answers the following questions:

- How must you regularly test the drive in order to maintain the assured probability of failure of the safety functions?

- How does the drive respond when you select and deselect one of the safety functions?

- What do I need to observe when the motor is switched off or switched on with a safety function active?

- How do the safety functions mutually influence one another, if you select more than one safety function?

- How does the drive respond to a discrepant input signal?

- How does the drive respond to limit value violations or if internal monitoring functions respond?

Inverter signals

Most of the inverter signals in this chapter are contained in the PROFIsafe telegram, can be connected with a safety input or output – and are assigned the following parameters:

Inverter signals	PROFIsafe	F-DI	F-DO	Parameter
Internal event	✓	---	✓	r9723
STO active (basic functions)	✓	---	✓	r9773.1
STO deselection (basic functions)	✓	✓	---	r9773.0
STO active (extended functions)	✓	---	✓	r9722.0
Deselect STO (extended functions)	✓	✓	---	r9720.0
SBC requested (basic functions)	---	---	---	r9773.4
SS1 active (basic functions)	✓	---	✓	r9773.6
Deselect SS1 (basic functions)	✓	✓	---	r9773.5
SS1 active (extended functions)	✓	---	✓	r9722.1
Deselect SS1 (extended functions)	✓	✓	---	r9720.1
SLS active	✓	---	✓	r9722.4
Deselect SLS	✓	✓	---	r9720.4
SLS level active	✓	---	✓	r9722.9, r9722.10
Select SLS level	✓	✓	---	r97209, r9720.10
SSM feedback signal active (speed below limit value)	✓	---	✓	r9722.15
SDI+ active	✓	---	✓	r9722.12
SDI+ deselect	✓	✓	---	r9720.12
SDI- active	✓	---	✓	r9722.13
Deselect SDI-	✓	✓	---	r9720.13
SAM/SBR active	---	---	---	r9723.16
Forced dormant error detection is required (basic functions)	---	---	---	r9773.31
Forced dormant error detection is required (extended functions)	---	---	---	r9723.0
Start forced dormant error detection (extended functions)	---	---	---	p9705
"Standard" acknowledgment	---	---	---	p2103
Fail-safe acknowledgment	✓	✓	---	r9720.7
Ready to switch on	---	---	---	r0052.0
ON/OFF1	---	---	---	r0054.0
OFF2	---	---	---	r0054.1
OFF3	---	---	---	r0054.2

6.2 Regularly testing the safety functions

6.2.1 Overview

Overview

You must initiate the following function tests as a minimum once per year in order to maintain the assured failure probability of the safety functions:

● The inverter must test its safety input if you are using a safety input.

→ Testing safety inputs (Page 161)

● The inverter must test its safety functions:

→ Testing the basic functions (Page 162)

→ Testing the extended functions (Page 163)

● The inverter must test its safety output if you are using a safety output.

→ Testing a safety output (Page 165)

6.2.2 Testing safety inputs

Testing sensors and safety inputs

The inverter tests its safety inputs and the connected sensors with a signal change at the inputs. We recommend that you test the safety inputs together with the forced dormant error detection (test stop).

Procedure

To test the safety inputs, proceed as follows:

1. Actuate the relevant sensor.

2. Check the following:

   – The expected safety function is active.

   – The inverter signals a fault.

You have checked the safety inputs.

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6.2.3 Testing the basic functions

Time

The inverter monitors as to whether the self test (= forced dormant error detection, test stop) is regularly started.
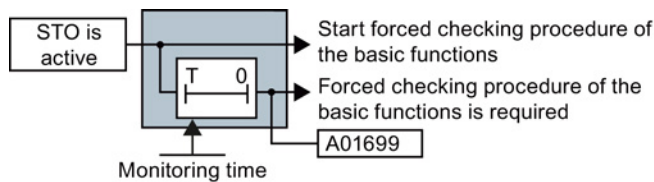
Figure 6-1   Starting and monitoring the forced dormant error detection (test stop)

In the case of alarm A01699, you must initiate a self test at the next opportunity, e.g.:

- When the drives are at a standstill after the system has been switched on.
- When a protective door is opened.
- At specified regular intervals before the monitoring time expires.

Performing a forced dormant error detection (test stop)

Preconditions

- STO is not active.
- The motor is switched on (ON/OFF1 = 1), and is at a standstill (speed setpoint = 0).

Procedure

To start the forced dormant error detection, proceed as follows:

1. Select the STO function.
2. The inverter checks its safety-related circuits. This check takes several milliseconds.
3. Deselect the STO function.
4. Check that alarm A01699 is no longer present.
5. Check the safety inputs of the inverter if you are using the safety inputs of the inverter. See also: Testing safety inputs (Page 161).

You have performed the forced dormant error detection.

6.2.4 Testing the extended functions

Time

The inverter monitors as to whether the self test (= forced dormant error detection, test stop) is regularly started.
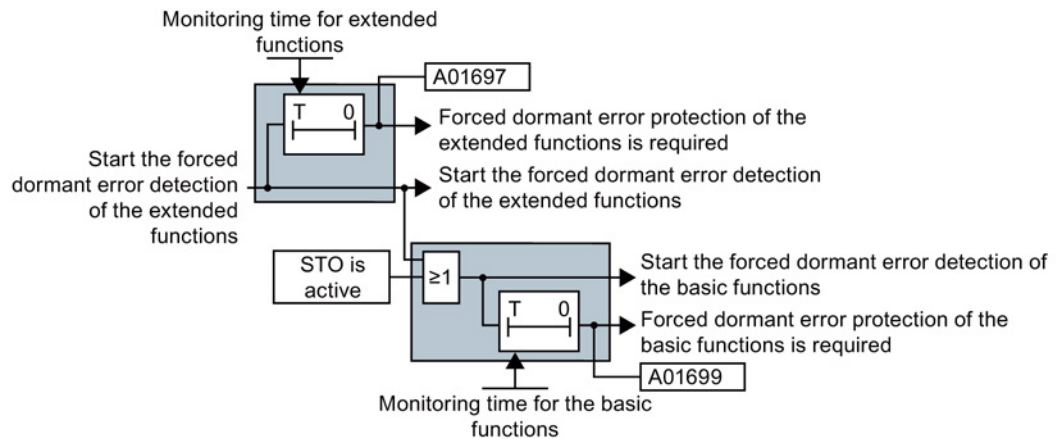
Figure 6-2   Starting and monitoring the forced dormant error detection (test stop)

If the inverter outputs alarm A01699 or A01697, you must initiate a forced dormant error detection at the next opportunity, e.g.:

● When the system is switched on.

● At specified regular intervals before the monitoring time expires.

Performing a forced dormant error detection (test stop)

When testing the extended functions, the inverter switches the motor into a no-torque condition.

Preconditions

- STO is not active.

  If you start the forced dormant error detection with STO active, then the inverter responds with a fault.

- The motor is switched on (ON/OFF1 = 1), and is at a standstill (speed setpoint = 0).

Procedure

To start the forced dormant error detection of the extended functions, proceed as follows:

1. Start the forced dormant error detection using a signal of your choice, for example a digital input.

2. The inverter checks its safety-related circuits. During the check, the inverter outputs alarms C01798 and C30798. This check takes several milliseconds.

3. Set the signal to start the forced dormant error detection to zero.

4. Check that neither alarm A01699 nor alarm A01697 is active.

5. Check the safety inputs of the inverter, also see: Testing safety inputs (Page 161).

6. Check the safety output of the inverter, also see: Testing a safety output (Page 165).

You have performed the forced dormant error detection of the extended functions.

6.2.5 Testing a safety output

Time of the test

The inverter monitors that the test is regularly performed using a time block.
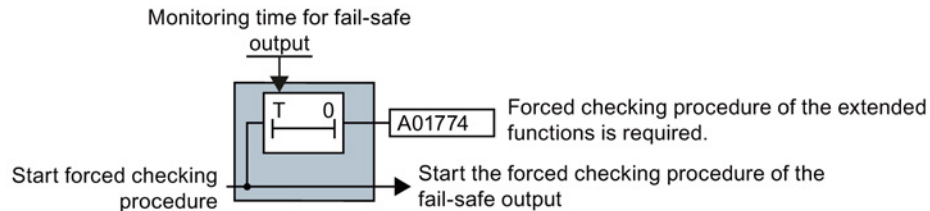
Figure 6-3   Start and monitoring of the forced dormant error detection (test stop) of the safety output

If the inverter outputs alarm A01774, you must initiate the test at the next opportunity, e.g.:

● When the system is switched on.

● At specified regular intervals before the monitoring time expires.

Testing the safety output and the connected actuator

The inverter tests its safety output and the connected actuator with a signal change at the output.

Procedure

To test the safety output, proceed as follows:

1. Switch on the motor (ON/OFF1 command = 1).

   If you wish to carry out the forced dormant error detection at standstill, the speed setpoint must be = 0

2. Start the test using a signal of your choice, for example a digital input.

3. The inverter briefly switches off the safety output. This test takes several milliseconds.

4. Set the signal to start the forced dormant error detection to zero.

5. Check that alarm A01774 is no longer present.

You have checked the safety output.

The response of the safety output depends on the test stop mode that has been selected.
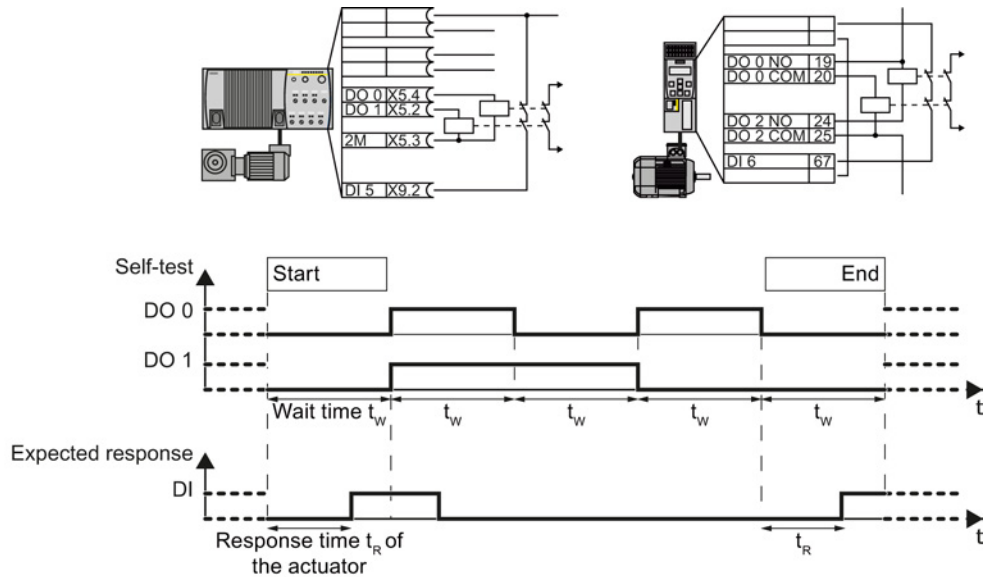
Figure 6-4   Test stop mode 2
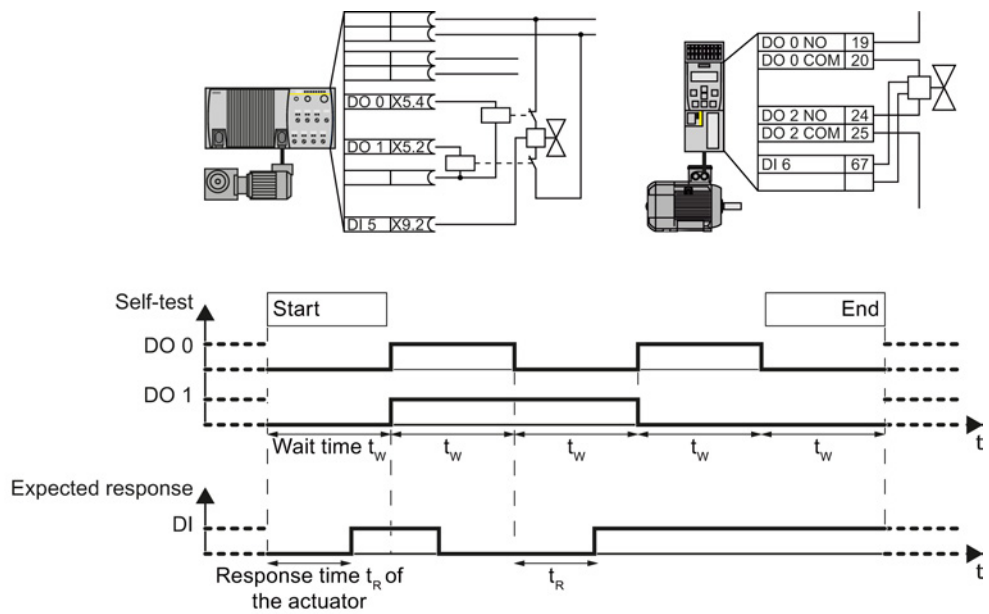
Figure 6-5   Test stop mode 3
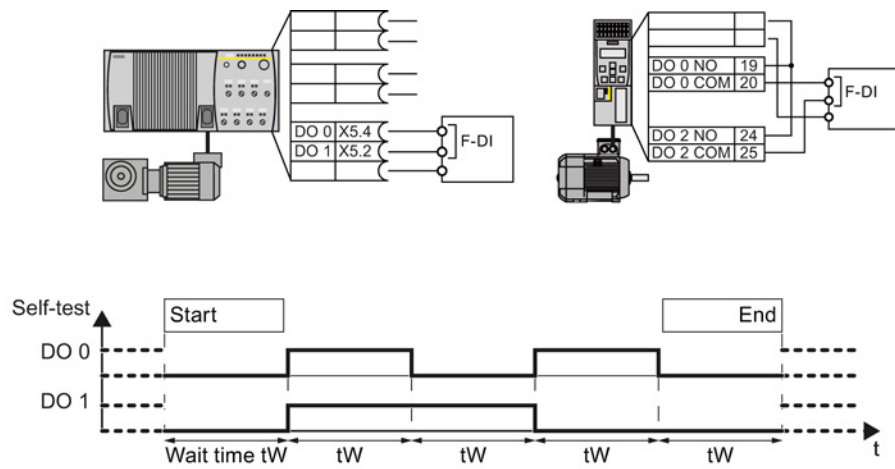
Figure 6-6   Test stop mode 4

6.3 Safe Torque Off (STO)

6.3.1 Overview

What can you find in this Chapter?

The relevant operating cases for the STO function are described in this chapter.

Table 6- 1   Operating cases for the STO function when the motor is switched on (ON/OFF1 = 1)

Selecting and deselecting STO	→ Selecting and deselecting STO when the motor is switched on (Page 169)
Discrepancy in the input signal	The safety input to select STO identifies an error. → Response to a discrepancy when STO is active (Page 170)

Table 6- 2   Switching the motor on and off when STO is active or not active

	Switching on the motor (ON/OFF1 = 0 → 1)	Switching off the motor (ON/OFF1, OFF2 or OFF3 = 1 → 0)
STO is not active	If STO is not active, then there are no restrictions for switching on and switching off the motor.	
STO is active	The active STO function prevents the motor from being switched on.	The motor is always switched off when STO is active. The OFF1, OFF2 and OFF3 signals have no effect.

6.3.2 Selecting and deselecting STO when the motor is switched on

Select STO

Function

1. The machine control selects the STO safety function via a safety input or via PROFIsafe (safety-related bus communication).

2. The inverter then safely switches off the motor torque.
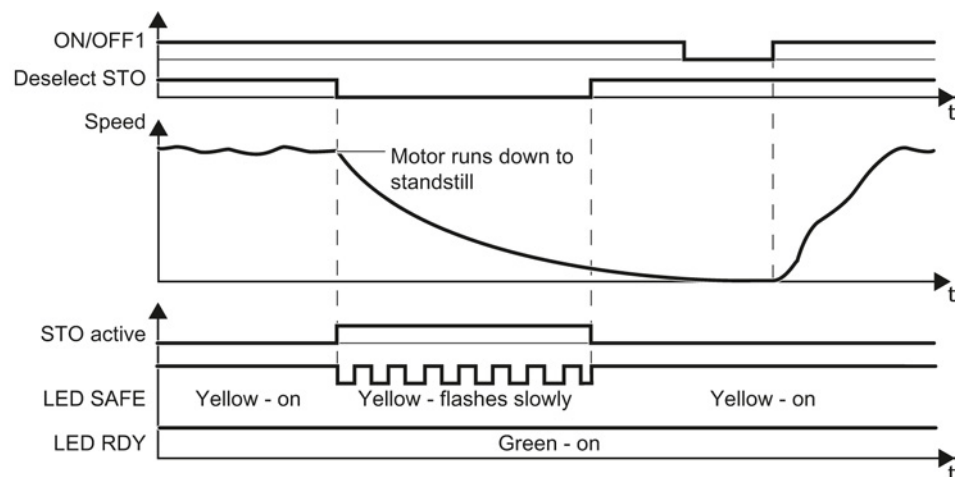
Figure 6-7   Time response of the STO safety function (Safe Torque Off)

Switching on the motor once STO is active

Procedure

To switch on the motor again once STO is active, proceed as follows:

1. Deselect STO.

2. Switch on the motor: ON/OFF1 = 1.

You have switched on the motor.

6.3.3 Response to a discrepancy when STO is active

The inverter responds to a discrepancy at the safety input by activating safety function STO.

The inverter response depends on the setting of the inverter:

- You are using the basic functions → case 1.
- You are using the extended functions → case 2.

Case 1: Response of the drive for STO of the basic functions

You have selected one of the following settings:

- Basic Functions via onboard terminals
- Basic Functions via PROFIsafe and onboard terminals
- Extended Functions via PROFIsafe and Basic Functions via onboard terminals
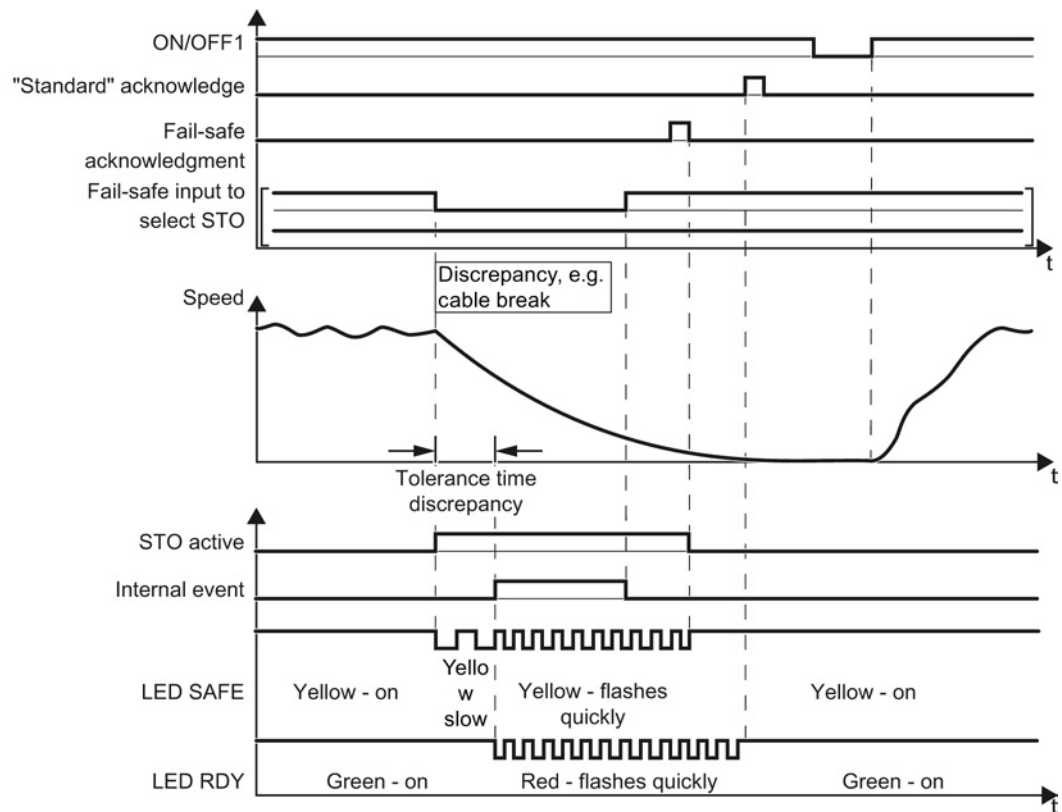
Figure 6-8   Inverter response for discrepancy of the input signal for STO (example: Cable break in the channel of processor P1)

Inverter messages after the tolerance time has expired:

- Discrepancy (fault F01611 or F30611 with fault values r0949 = 2000 or 2002)
- The inverter sets the error bit of the safety functions (= internal event).

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Case 1: Switching on the motor after a discrepancy

Procedure

To switch the motor on again, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the internal event.

Selected setting	How can the internal event be acknowledged?		
	F-DI	PROFIsafe	Alternative
Basic functions via onboard terminals	Select and deselect STO (F-DI = 1 → 0 → 1)	---	Power on reset
Basic functions via PROFIsafe and onboard terminals	Select and deselect STO (F-DI = 1 → 0 → 1)	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset
Extended Functions via PROFIsafe and Basic Functions via onboard terminals	Select and deselect STO (F-DI = 1 → 0 → 1)	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset

3. Acknowledge the inverter with the "standard" acknowledge signal.

4. Issue an OFF1 command (ON/OFF1 = 0).

5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the discrepancy message, and switched on the motor again.

Case 2: Response of the drive for STO of the extended functions

You have selected the extended functions via onboard terminals.
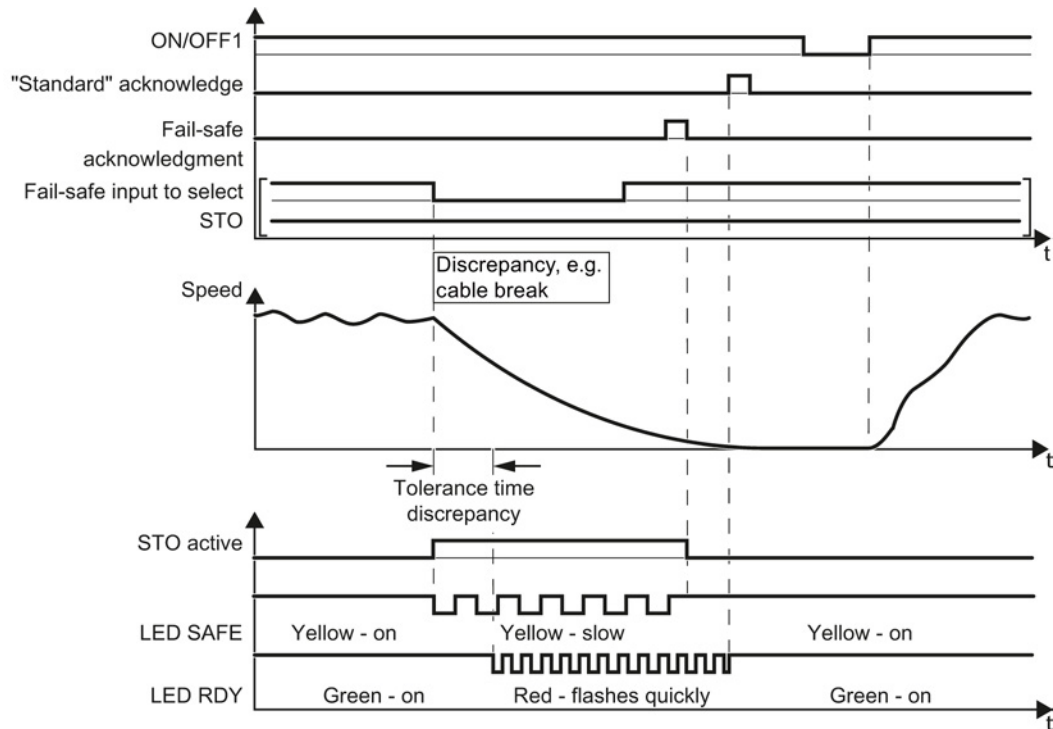
Figure 6-9   Response of safety function STO in the event of a discrepancy

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (fault C01770 or C30770).

Case 2: Switching on the motor after a discrepancy

Procedure

To switch the motor on again, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the discrepancy message with a fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.
   Alternatively: Power on reset.

3. Acknowledge the inverter with the "standard" acknowledge signal.

4. Issue an OFF1 command (ON/OFF1 = 0).

5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the discrepancy message, and switched on the motor again.

6.4 Safe Brake Control (SBC)

6.4.1 Selecting and deselecting SBC when the motor is switched on

If you have connected the motor holding brake to the inverter via the Safe Brake Relay, then the SBC function is active under the following conditions:

1. You have activated the "motor holding brake" function in the inverter.

2. You have enabled the SBC function.

3. The STO function is active in the inverter.

Selecting STO when the motor is at a standstill

Function

1. The higher-level control switches the motor off: ON/OFF1 = 0 or OFF3 = 0.

2. When the drive has come to a standstill, the control selects the STO function.
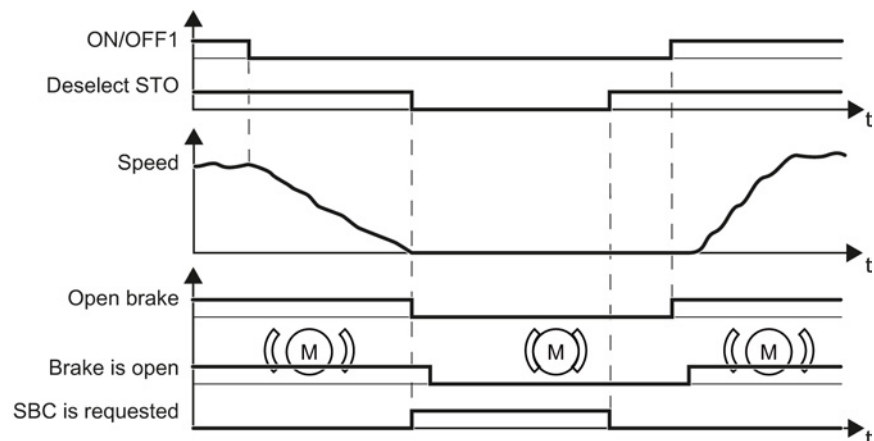
Figure 6-10   Wait until standstill is reached and activate SBC with STO

Before you can switch on the motor again, you must deselect the STO function.

Selecting SS1 when the motor is rotating

Function

1. The higher-level control selects the SS1 function

2. The inverter brakes the motor with the OFF3 ramp-down time.

3. The inverter closes the motor holding brake once the motor is at a standstill.

4. If the standstill monitoring is undershot, or once the delay time has expired, the inverter activates the STO function and controls the brake with the SBC function.
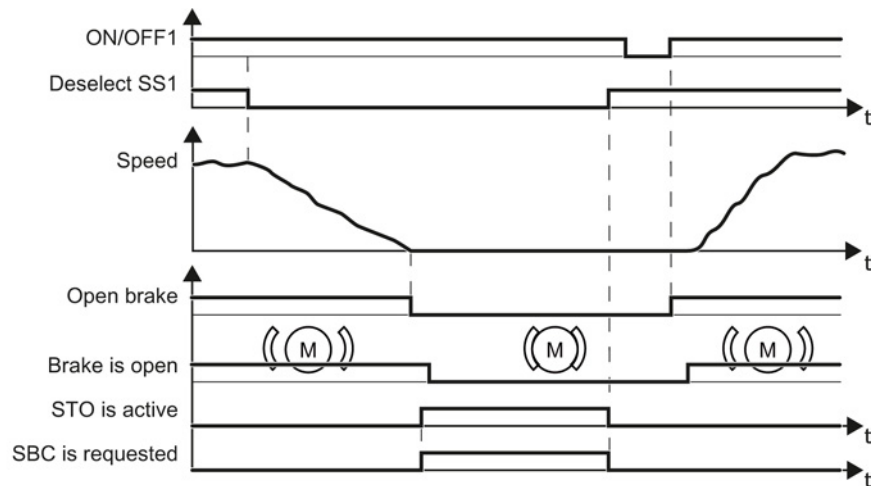
Figure 6-11   When selecting SS1, the motor holding brake closes at standstill

Before you can switch on the motor again, you must deselect the SS1 function.

Selecting STO when the motor is rotating

Function

1. The higher-level control selects the STO function.

2. The inverter closes the brake without taking the current speed into consideration.
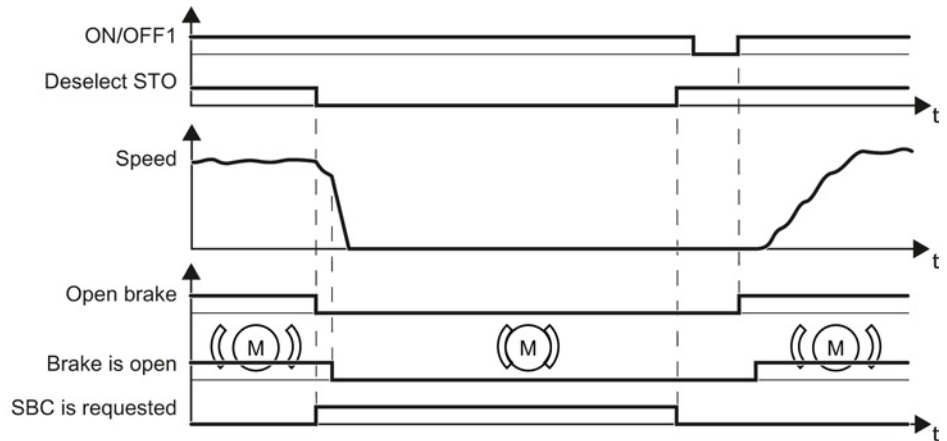
Figure 6-12   The motor holding brake closes after selecting STO

Before you can switch on the motor again, you must deselect the STO function.

6.4.2 Response to faults in the brake control

Faults in the brake control

When opening or closing the brake, the inverter identifies faults in the brake cable and in the brake winding.
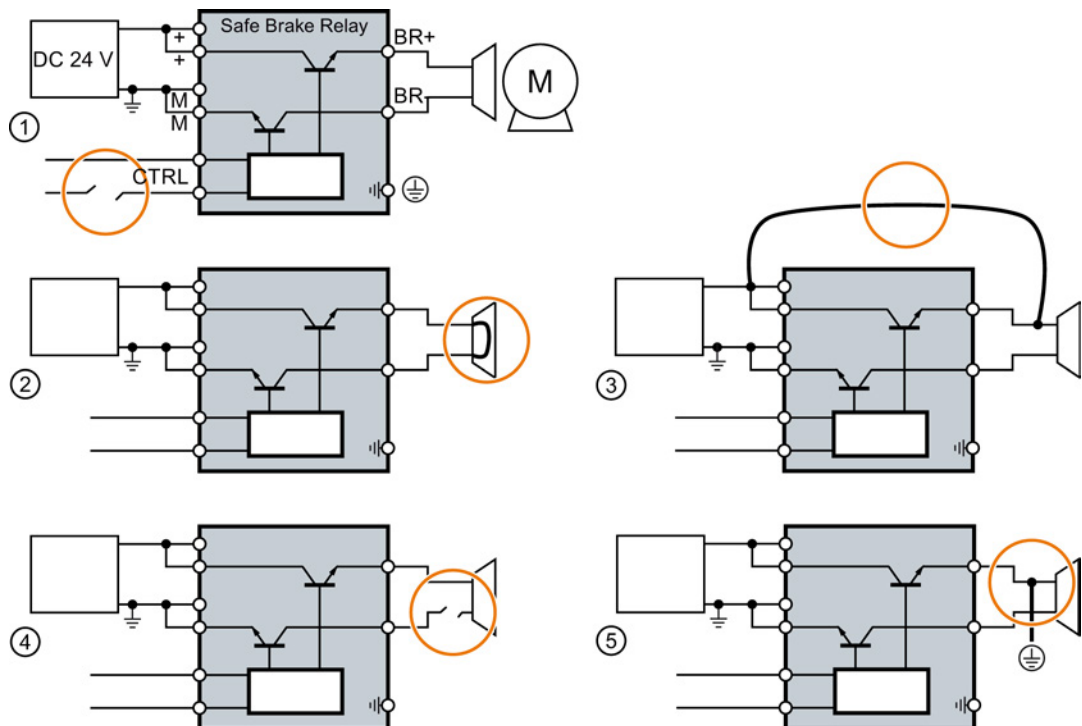
① Control cable from the inverter to the Safe Brake Relay is interrupted

② Short-circuit in the brake winding

③ Cross circuit between the brake cable and the 24 V supply voltage

④ Brake cable is interrupted

⑤ Ground fault on the brake cable

Figure 6-13   Examples of faults in the brake control

Drive response

If the inverter detects a fault in the brake control, it responds with a STOP A (message F01630 or F30630) and closes the brake.

6.5 Safe Stop 1 (SS1)

6.5.1 Overview

What can you find in this Chapter?

The relevant operating cases for the SS1 function are described in this chapter.

Table 6- 3   Response of the SS1 function when the motor is switched on (ON/OFF1 = 1)

Select and deselect SS1	→ Selecting and deselecting SS1 when the motor is switched on (Page 178)
Discrepancy in the input signal	The safety input to select SS1 identifies an error.
	→ Response to a discrepancy when SS1 is active (Page 183)
Limit value violation	The speed of the motor violates the SS1 monitoring that has been set.
	→ Limit value violation when SS1 is active (Page 187)
	The basic SS1 function does not monitor the motor speed. The limit value violation is not relevant in this particular case.

Table 6- 4   Switching the motor on and off when SS1 is active or not active

	Switching on the motor (ON/OFF1 = 0 → 1)	Switching off the motor (ON/OFF1, OFF2 or OFF3 = 1 → 0)
SS1 is not active	If SS1 is not active, then there are no restrictions for switching on and switching off the motor.	
SS1 is active	The active SS1 function prevents the motor from being switched on.	The drive response depends on the signal that you use to switch off the motor.
		→ Switching off the motor when SS1 is active (Page 182)

6.5.2 Selecting and deselecting SS1 when the motor is switched on

6.5.2.1 SS1 without monitoring

Select SS1

Function

1. The higher-level control selects the SS1 function via a safety input or via the PROFIsafe safe communication.

2. If the motor is switched on when SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time.

3. After the delay time, the inverter safely switches off the motor torque with the STO safety function.
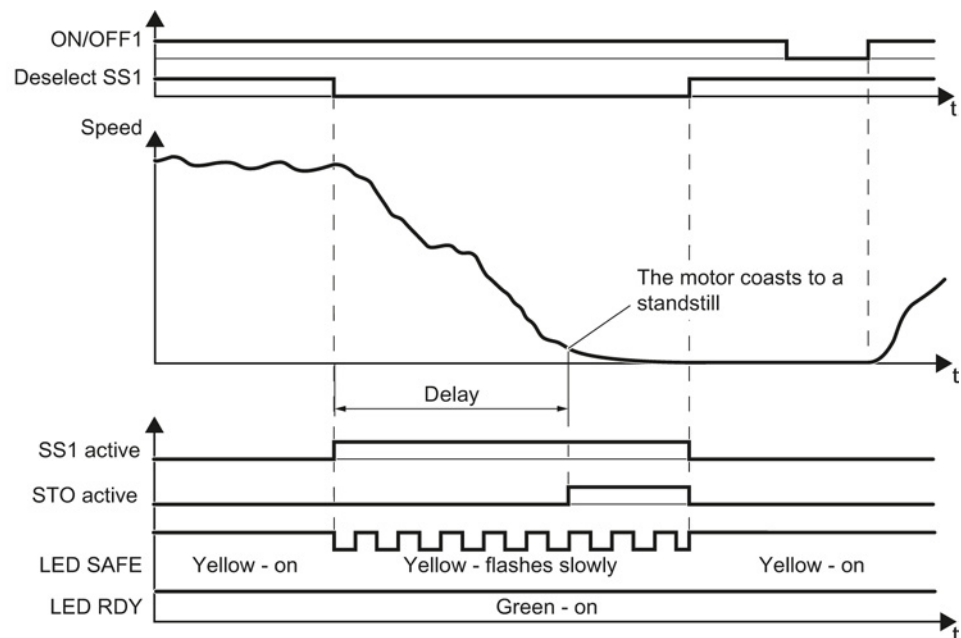
Figure 6-14   Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

Switching on the motor once SS1 is active

Procedure

To switch on the motor again once SS1 is active, proceed as follows:

1. Deselect SS1.

2. Switch on the motor: ON/OFF1 = 1.

You have switched on the motor.

6.5.2.2 SS1 with braking ramp monitoring

Select SS1

Function

1. The higher-level control selects the SS1 safety function via a safety input or via the PROFIsafe safe communication.

2. If the motor has already been switched off when selecting SS1, then the inverter safely switches off the motor torque with the safety function STO.

   If the motor is switched on when SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time. The inverter monitors whether the load speed decreases using the SBR function.

3. The inverter safely switches off the motor torque using the STO safety function if the load speed reaches the "standstill monitoring".
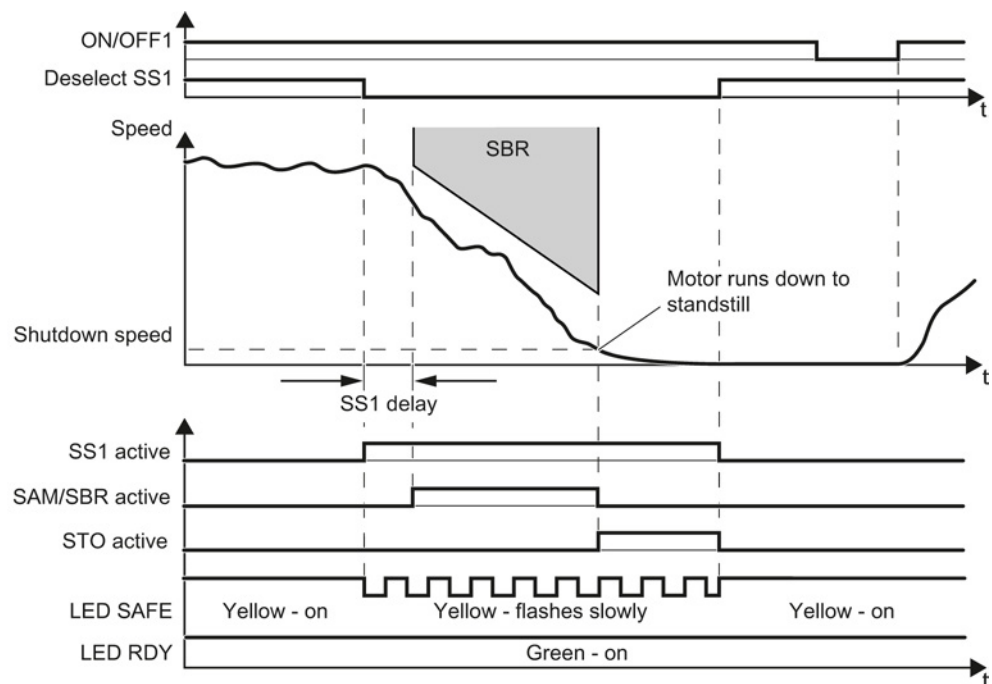
Figure 6-15   Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

Switching on the motor once SS1 is active

Procedure

To switch on the motor again once SS1 is active, proceed as follows:

1. Deselect SS1.

2. Switch on the motor: ON/OFF1 = 1.

You have switched on the motor.

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6.5.2.3 SS1 with acceleration monitoring

Select SS1

Function

1. The higher-level control selects the SS1 safety function via a safety input or via the PROFIsafe safe communication.

2. If the motor has already been switched off when selecting SS1, then the inverter safely switches off the motor torque with the safety function STO.

   If the motor is switched on when SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time. The inverter monitors braking using the SAM function (Safe Acceleration Monitor).

3. The inverter safely switches off the motor torque with the STO safety function if one of the two conditions is fulfilled:

   – The actual speed reaches the value of the "standstill monitoring".

   – The delay time has expired.
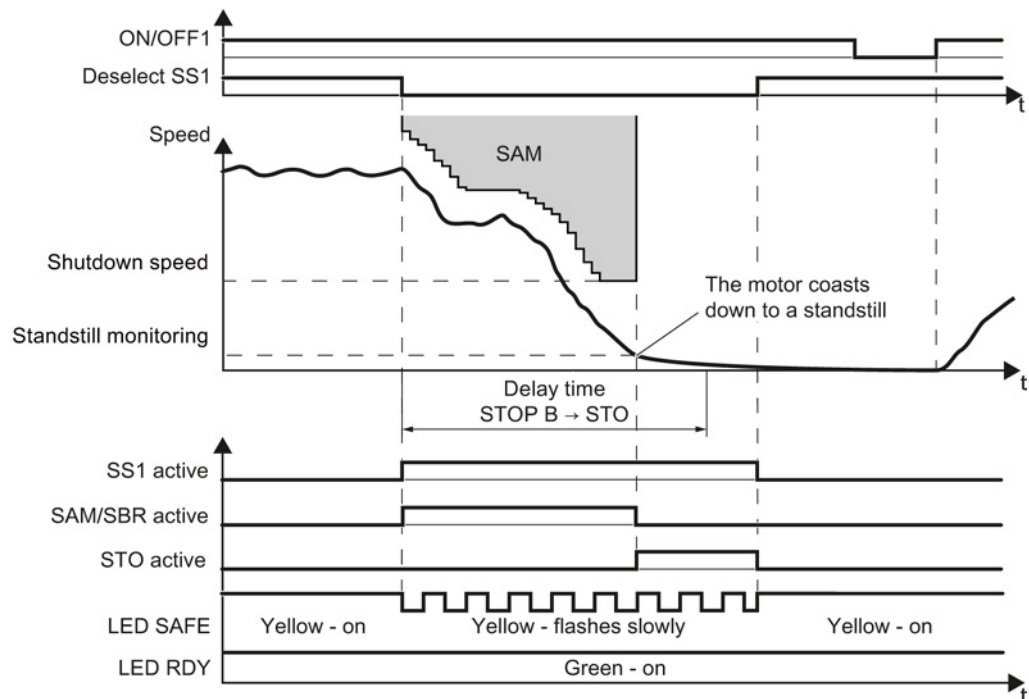
Figure 6-16   Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

Switching on the motor once SS1 is active

Procedure

To switch on the motor again once SS1 is active, proceed as follows:

1. Deselect SS1.

2. Switch on the motor: ON/OFF1 = 1.

You have switched on the motor.

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6.5.3 Switching off the motor when SS1 is active

Description

If you switch the motor off with the OFF1 or OFF3 command while the SS1 safety function is active, for example when limit switches are reached, this does not affect how the motor behaves. SS1 remains active and the inverter brakes the motor until the standstill detection threshold is reached.

If you switch off the motor with the safety SS1 function active using the OFF2 command, then the behavior of the drive is dependent on the setting of the SS1 safety function:

- SS1 without speed monitoring:

  The inverter switches off the motor torque. The motor then coasts to a standstill. After the delay time, STO is active.

- SS1 with speed monitoring:

  The inverter switches off the motor torque with the STO safety function. The motor then coasts to a standstill.
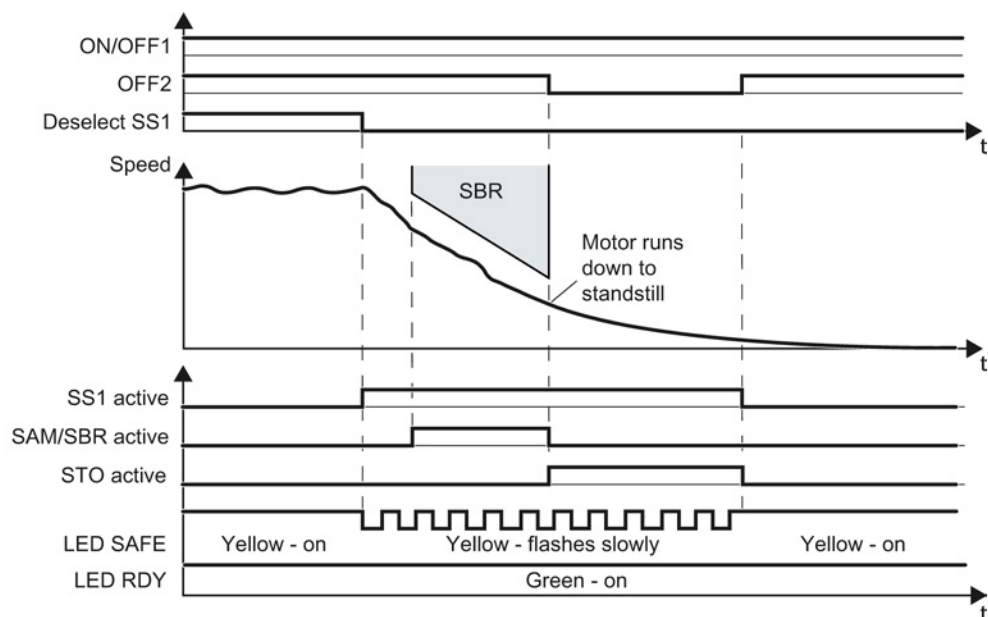
Figure 6-17   OFF2 command when the SS1 safety function is active (example: SS1 with braking ramp monitoring)

6.5.4 Response to a discrepancy when SS1 is active

The inverter responds with the active safety function SS1 to a discrepancy at the safety input.

The behavior of the drive depends on the setting of the inverter.

1. case: Response of the drive for SS1 of the basic functions

You have selected one of the following settings:

- Basic functions via onboard terminals
- Basic Functions via PROFIsafe and onboard terminals
- Extended Functions via PROFIsafe and Basic Functions via onboard terminals
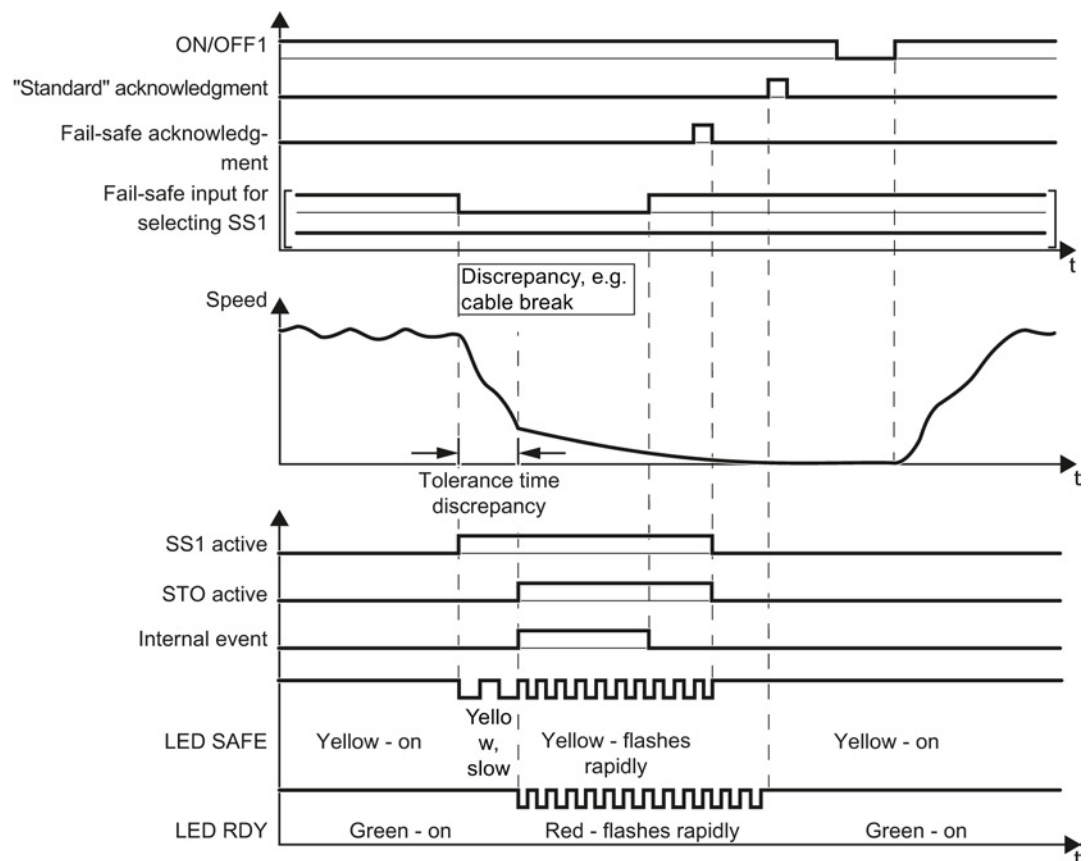
Figure 6-18   Inverter response for discrepancy of the input signal for SS1 (example: cable break in the channel of processor P1)

Inverter messages after the tolerance time has expired:

- Discrepancy (fault F01611 or F30611 with fault value r0949 = 2002)
- The inverter sets the error bit of the safety functions (= internal event).

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Switching on the motor after a discrepancy

Procedure

To switch the motor on again, proceed as follows:

1. Remove the discrepancy.
2. Acknowledge the internal event.

Selected setting	How can the internal event be acknowledged?		
	F-DI	PROFIsafe	Alternative
Basic Functions via onboard terminals	Select and deselect SS1 (F-DI = 1 → 0 → 1)	---	Power on reset
Basic Functions via PROFIsafe and onboard terminals	Select and deselect SS1 (F-DI = 1 → 0 → 1)	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset
Extended Functions via PROFIsafe and Basic Functions via onboard terminals	Select and deselect SS1 (F-DI = 1 → 0 → 1)	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset

3. Acknowledge the inverter with the "standard" acknowledge signal.
4. Issue an OFF1 command (ON/OFF1 = 0).
5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the discrepancy message, and switched on the motor again.

2. case: Response of the drive for SS1 of the extended functions

You have selected the extended functions via onboard terminals.
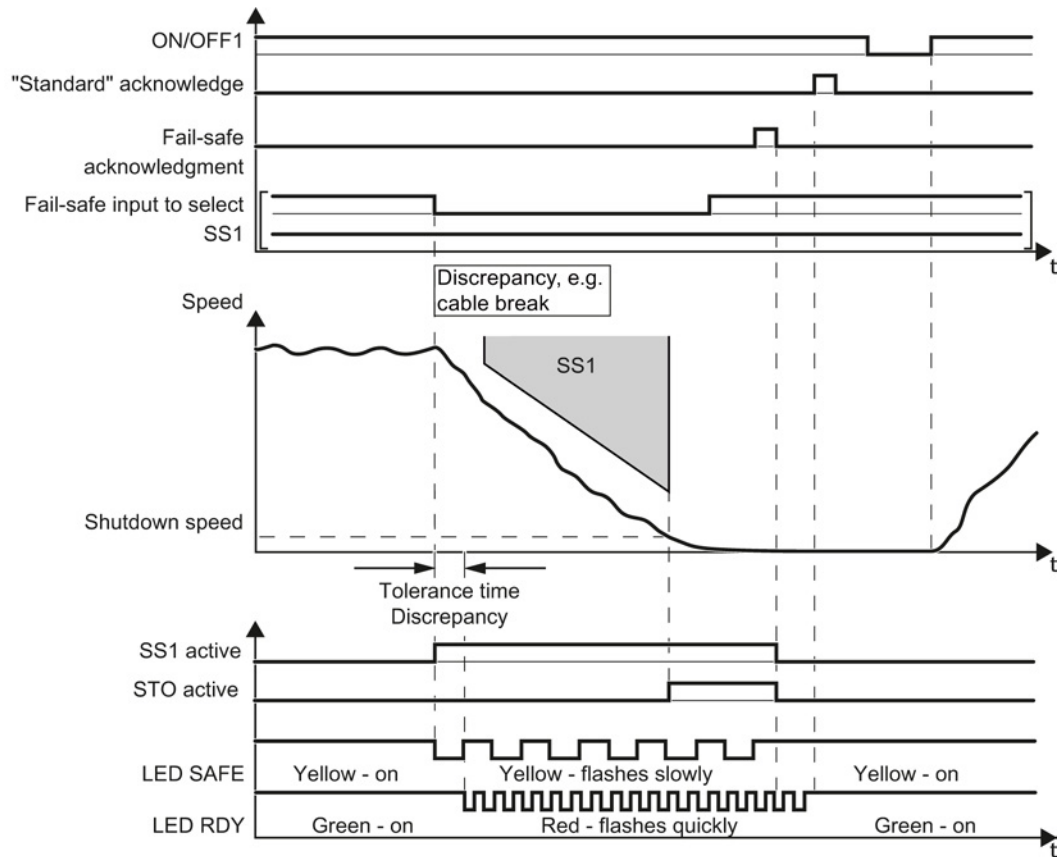
Figure 6-19   Inverter response for discrepancy of the input signal for SS1 (as example: SS1 with braking ramp monitoring)

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (message C01770 or C30770) but does not interrupt the braking operation for the motor.

Switching on the motor after a discrepancy

Procedure

To switch the motor on again, proceed as follows:

1. Remove the discrepancy.
2. Acknowledge the discrepancy message with the fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.

    Alternatively: Power on reset.
3. Acknowledge the inverter with the "standard" acknowledge signal.
4. Issue an OFF1 command (ON/OFF1 = 0).
5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the discrepancy message, and switched on the motor again.

6.5.5 Limit value violation when SS1 is active

Drive response

If motion monitoring detects a fault when SS1 is active, the inverter safely switches off the motor torque (STOP A).
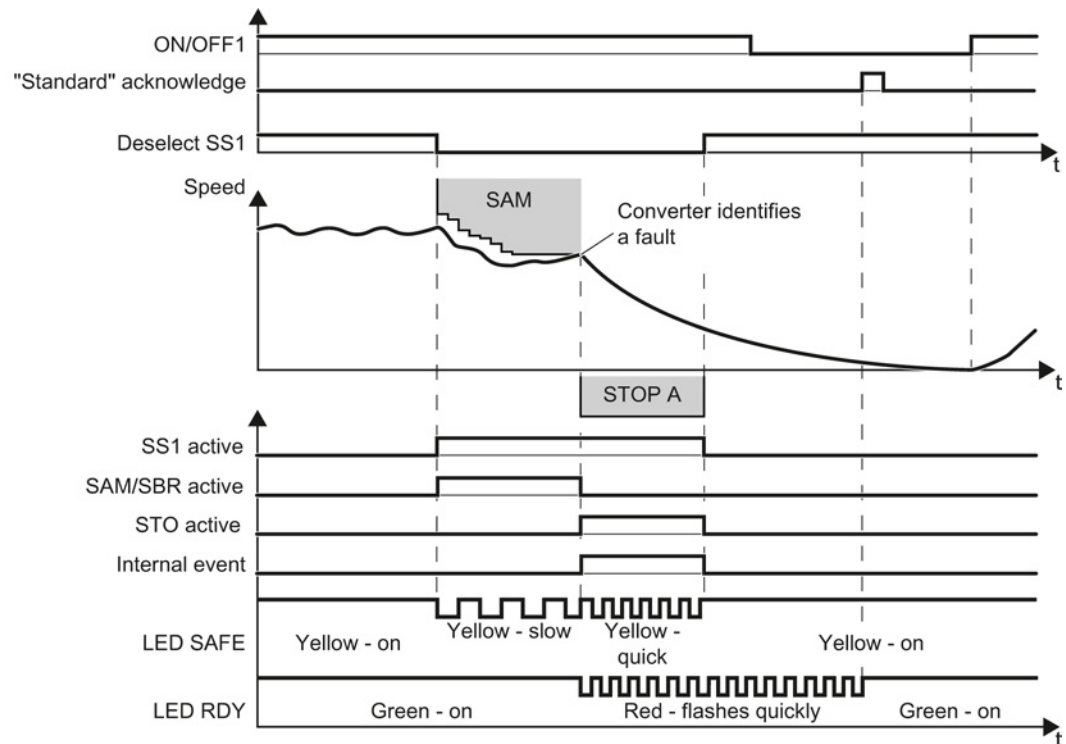
Figure 6-20   General fault response of safety function SS1 (as an example: SS1 with acceleration monitoring)

Switching the motor on after an internal event

Procedure

To switch the motor on after an internal event while SS1 is active, proceed as follows:

1. Deselect function SS1.

2. Issue an OFF1 command (ON/OFF1 = 0).

3. Acknowledge the inverter with the "standard" acknowledge signal.

4. Switch on the motor again (ON/OFF1 = 1).

You have acknowledged the internal event and switched on the motor again.

6.6 Safely Limited Speed (SLS)

6.6.1 Overview

What can you find in this Chapter?

The relevant operating cases for the SLS function are described in this chapter.

Table 6- 5   Response of the SLS function when the motor is switched on (ON/OFF1 = 1)

Selecting and deselecting SLS	→ Selecting and deselecting SLS when the motor is switched on (Page 189)
Switching over SLS levels when SLS is active	Switching over from a higher SLS level to a lower SLS level (and vice versa).
	→ Switching over SLS levels (Page 195)
Discrepancy in the input signal	The safety input to select SLS identifies an error.
	→ Response to a discrepancy when SLS is active (Page 202)
Limit value violation	The speed of the motor exceeds the set SLS limit value.
	→ Limit value violation when SLS is active (Page 204)

Table 6- 6   Switching the motor on and off when SLS is active or not active

	Switching on the motor (ON/OFF1 = 0 → 1)	**Switching off the motor (ON/OFF1, OFF2 or OFF3 = 1 → 0)**
SLS is not active	If SLS is not active, then there are no restrictions for switching on and switching off the motor.	
SLS is active	If your application requires that SLS always remains active, then you must take into account several special issues when switching on the motor. → Switching on the motor when SLS is active (Page 201).	The drive response depends on the signal that you use to switch off the motor. → Switching off the motor when SLS is active (Page 199)

6.6.2 Selecting and deselecting SLS when the motor is switched on

Selecting SLS when the motor is switched on

As soon as the inverter detects the selection of SLS via a safety input or via the PROFIsafe safe communication, the following happens:

- The inverter limits the speed to a value below the SLS monitoring and brakes the motor with the OFF3 ramp-down time.

- You can select whether the inverter monitors motor braking using the SMR (Safe Brake Ramp) function or not.

With braking ramp monitoring	Without braking ramp monitoring
After the adjustable "Delay time for braking ramp" has elapsed, the inverter uses the SBR (Safe Brake Ramp) function to determine whether the speed has decreased. The inverter switches from SBR to SLS as soon as one of the following two conditions is fulfilled: • The SBR monitoring ramp has reached the value of the speed monitoring. This case is shown in the diagram above. • The actual load speed reaches the value of the speed monitoring and the "delay time for braking ramp" has expired.	The inverter monitors the load speed after an adjustable delay time has expired.
Advantages: • Already during braking, the inverter detects as to whether the load speed decreases too slowly. • The feedback signal "SLS active" generally comes earlier than for the alternative acceleration monitoring.	Advantage: • Commissioning is simplified, because instead of the SBR subfunction of the alternative brake ramp monitoring, you only have to set the delay time.

Selecting SLS at low motor speeds

If the motor speed when selecting SLS is less than the SLS limit, then the drive responds as follows:

With braking ramp monitoring	Without braking ramp monitoring
The inverter monitors the speed after the "delay time for the braking ramp".	The inverter monitors the load speed after an adjustable delay time has expired.
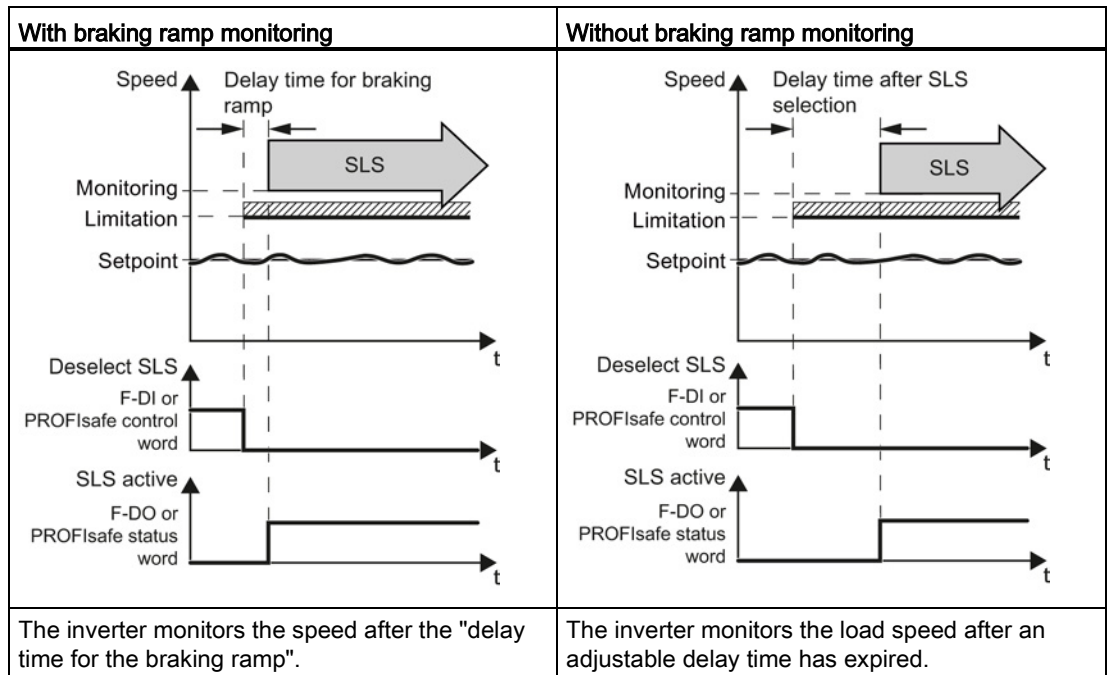
Deselect SLS

If the higher-level controller deselects SLS, then the inverter deactivates limiting and monitoring.

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6.6.2.1   SLS with braking ramp monitoring

Selecting and deselecting SLS

If the machine control selects the SLS safety function via a safety input or via the PROFIsafe safe communication , then the motor behaves differently depending on the absolute value of the load speed. These two scenarios are described below.

Scenario 1: The absolute value of the load speed is less than the setpoint speed limit.

Function

1. The motor continues to follow the speed setpoint.

2. The inverter monitors the speed after the delay time has expired.
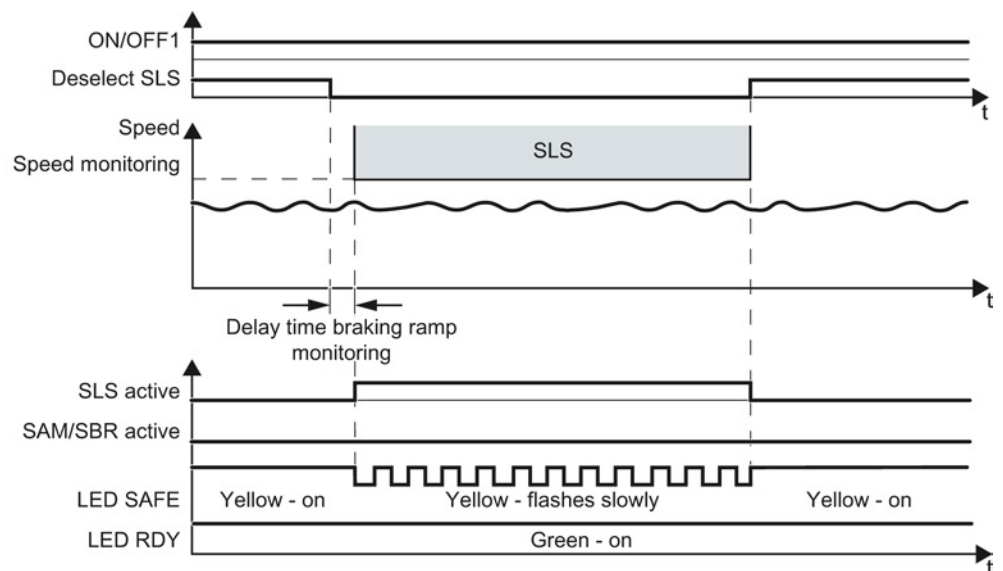
Figure 6-21   Selecting and deselecting the SLS safety function at low speeds

Scenario 2: The absolute value of the load speed is higher than the setpoint speed limit.

Function

1. The inverter brakes the motor.

2. The inverter monitors the speed after the delay time has expired.

3. If you deselect SLS, then the motor accelerates again up to the speed setpoint.
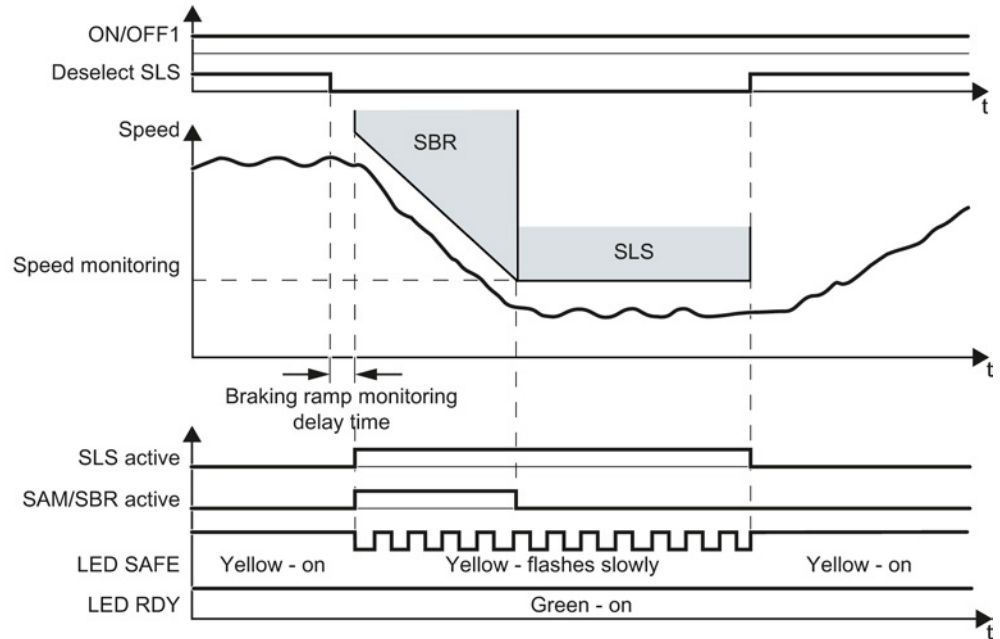
Figure 6-22   Selecting and deselecting the SLS safety function at high speeds

6.6.2.2 SLS without braking ramp monitoring

Selecting and deselecting SLS

If the machine control selects the SLS safety function via a safety input or via the PROFIsafe safe communication , then the motor behaves differently depending on the absolute value of the load speed. These two scenarios are described below.

Scenario 1: The absolute value of the load speed is less than the setpoint speed limit.

Function

1. The motor continues to follow the speed setpoint.

2. The inverter monitors the speed after the delay time has expired.
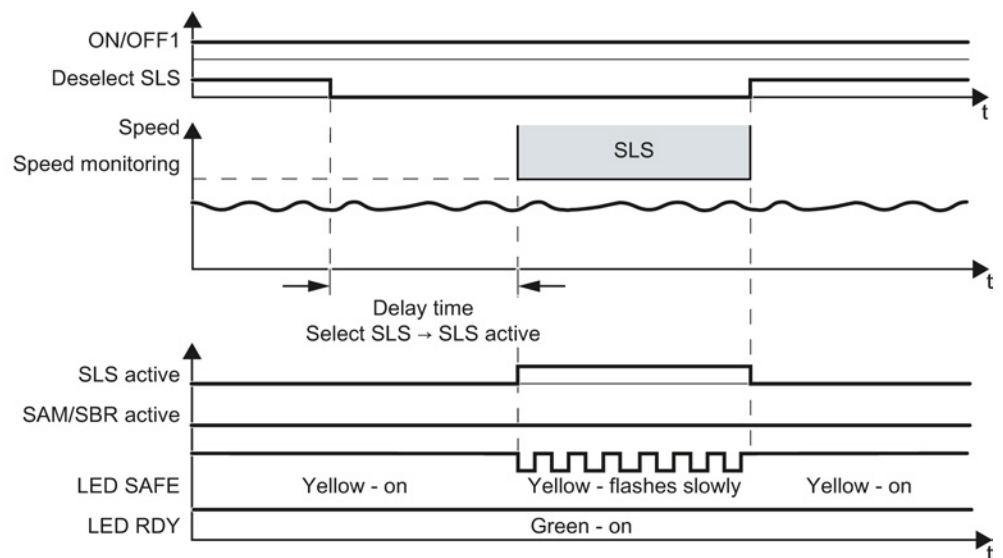
Figure 6-23   Selecting and deselecting the SLS safety function at low speeds

Scenario 2: The absolute value of the load speed is higher than the monitoring threshold.

Function

1. The inverter brakes the motor.

2. The inverter monitors the speed after the delay time has expired.

3. If you deselect SLS, then the motor accelerates again up to the speed setpoint.
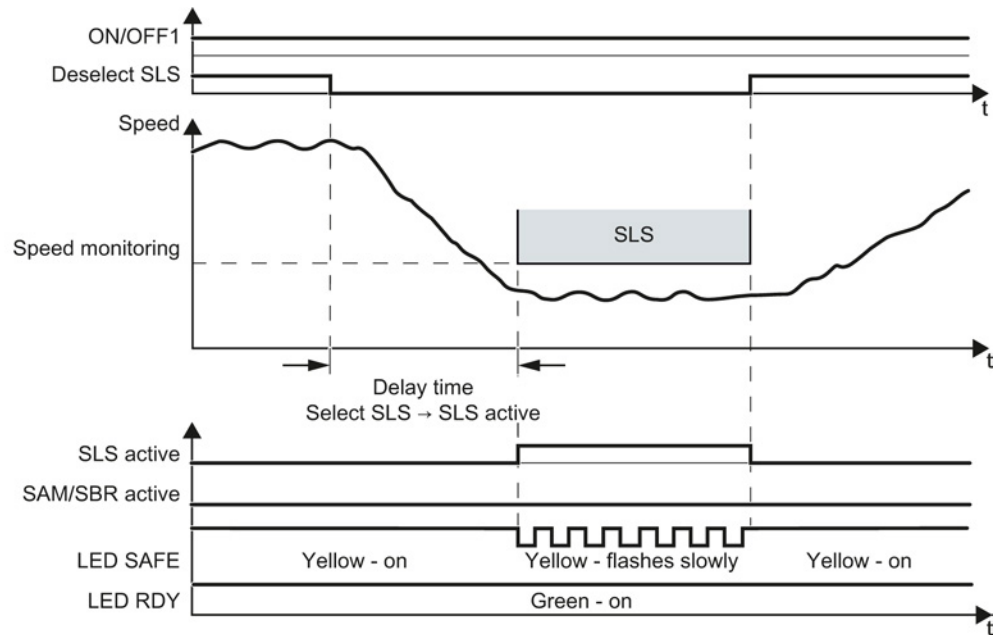
Figure 6-24   Selecting and deselecting the SLS safety function at high speeds

6.6.3   Switching over SLS levels

Overview

When SLS is active, you can switch between four different speed levels via PROFIsafe.

The drive response when switching over to a lower SLS level depends on whether you have selected SLS with or without braking ramp monitoring.

With braking ramp monitoring	Without braking ramp monitoring
The inverter monitors the motor as it brakes using the SBR (Safe Brake Ramp) function.	After an adjustable time, the inverter switches the SLS monitoring from the higher SLS level to the lower SLS level.
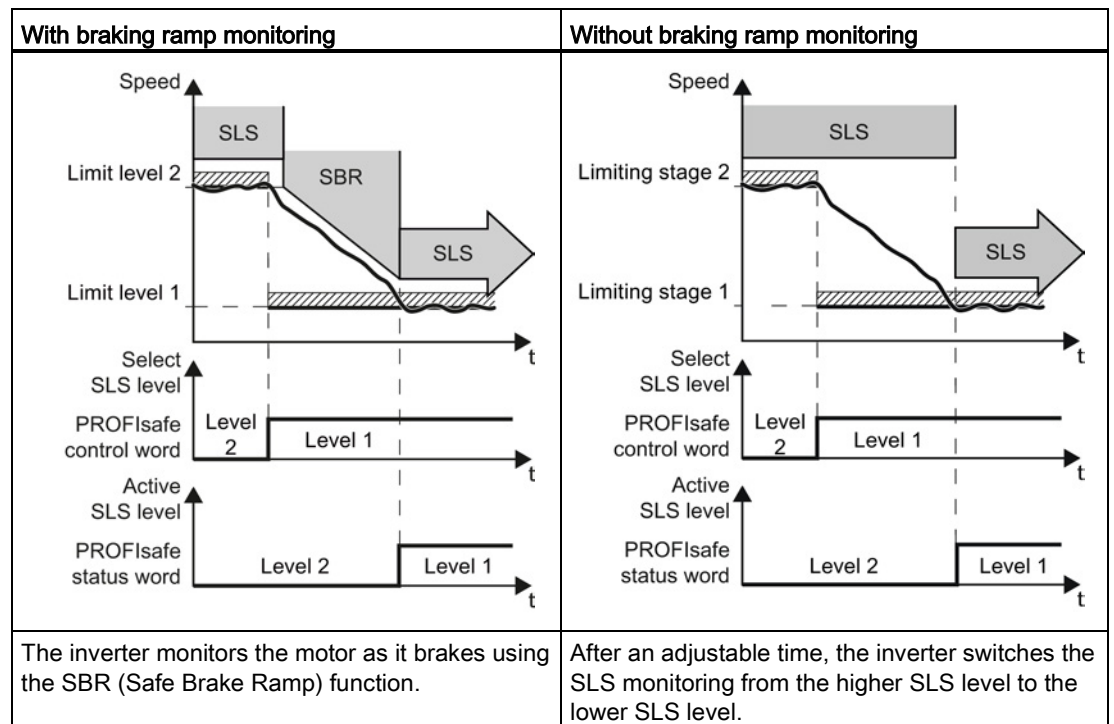
6.6.3.1 SLS with braking ramp monitoring

Switching over SLS levels

When is SLS is active, you can switch between four different speed monitoring levels (SLS levels).

Note

Switching over SLS levels is only possible via PROFIsafe with control word 1. See also Section: Control word 1 and status word 1 (extended functions) (Page 48).

Function

When you switch from a higher to a lower speed monitoring level (SLS level), the following takes place:

1. The inverter brakes the motor.

2. Once the delay time has expired, the inverter monitors the motor speed using the SBR (Safe Brake Ramp) function.

3. The inverter switches from SBR monitoring to SLS monitoring as soon as one of the following two conditions is fulfilled:

    – The SBR monitoring ramp has reached the value of the SLS monitoring.
      This case is shown in the diagram above.

    – The load speed has decreased down to the value SLS monitoring and the "delay time for braking ramp" has expired.

When you switch from one of the lower monitoring level to a higher speed monitoring level, then the inverter immediately monitors the speed with the higher SLS level.
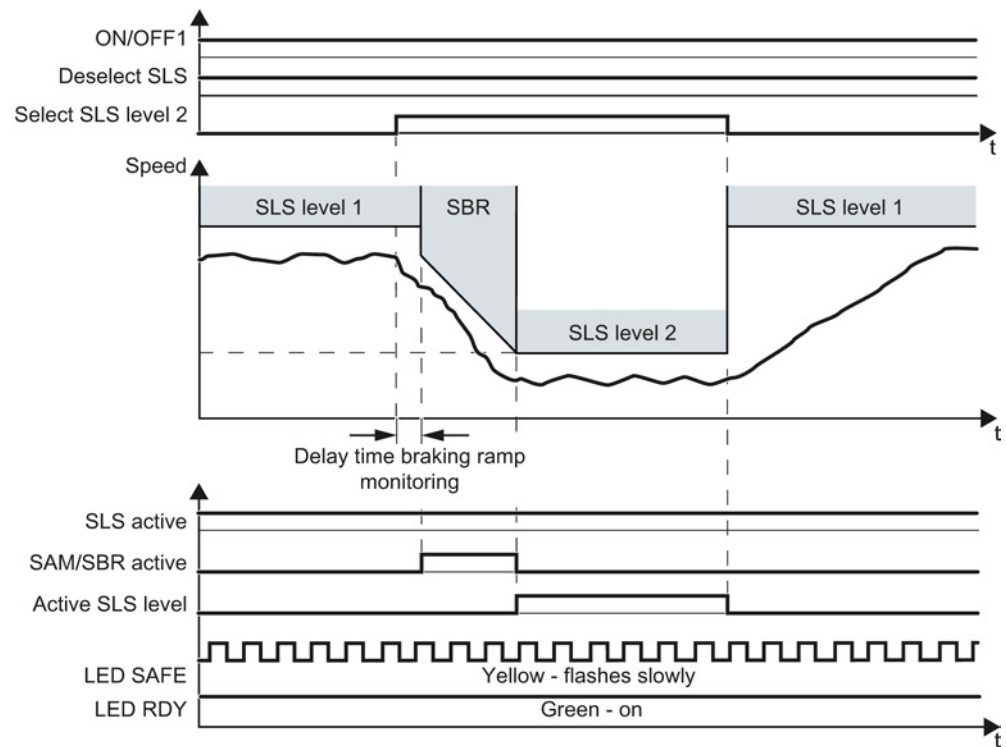
Figure 6-25   Switching between different monitoring thresholds

The inverter signals the active SLS level via PROFIsafe to the higher-level control. See also Section: Control word 1 and status word 1 (extended functions) (Page 48).

6.6.3.2 SLS without braking ramp monitoring

Switching over SLS levels

When is SLS is active, you can switch between four different speed monitoring levels (SLS levels).

Note

Switching over SLS levels is only possible via PROFIsafe with control word 1. See also Section: Control word 1 and status word 1 (extended functions) (Page 48).

Function

When you switch from a higher to a lower speed monitoring level (SLS level), the following takes place:

1. The inverter brakes the motor.

2. Once the delay time has expired, the inverter monitors the speed using the lower speed monitoring level.

When you switch from one of the lower monitoring level to a higher speed monitoring level, then the inverter immediately monitors the speed with the higher SLS level.
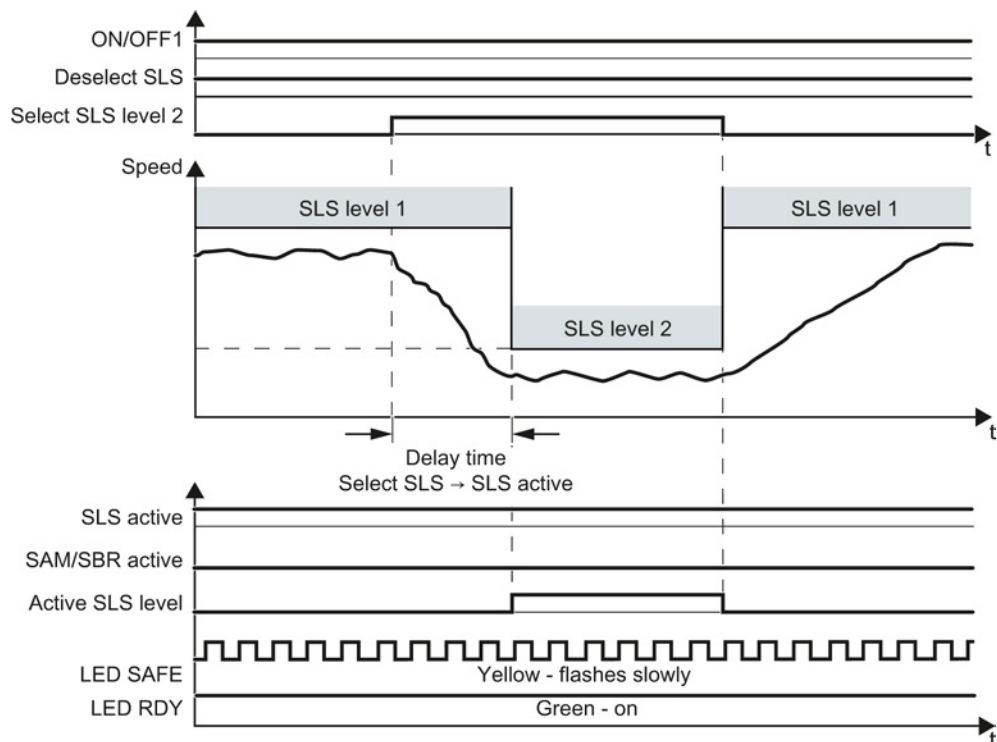
Figure 6-26   Switching between different monitoring thresholds

The inverter signals the active SLS level via PROFIsafe to the higher-level control. See also Section: Control word 1 and status word 1 (extended functions) (Page 48).

6.6.4 Switching off the motor when SLS is active

Description

If you switch off the motor with the SLS function active using the OFF1 or OFF3 command, e.g. when reaching limit switches, the following happens:

1. The inverter brakes the motor with the OFF1 or OFF3 ramp-down time.

2. Also while braking, the inverter monitors the motor speed.

3. When reaching the standstill monitoring, the inverter safely switches off the motor torque with the STO safety function.

4. The motor coasts down to a standstill.
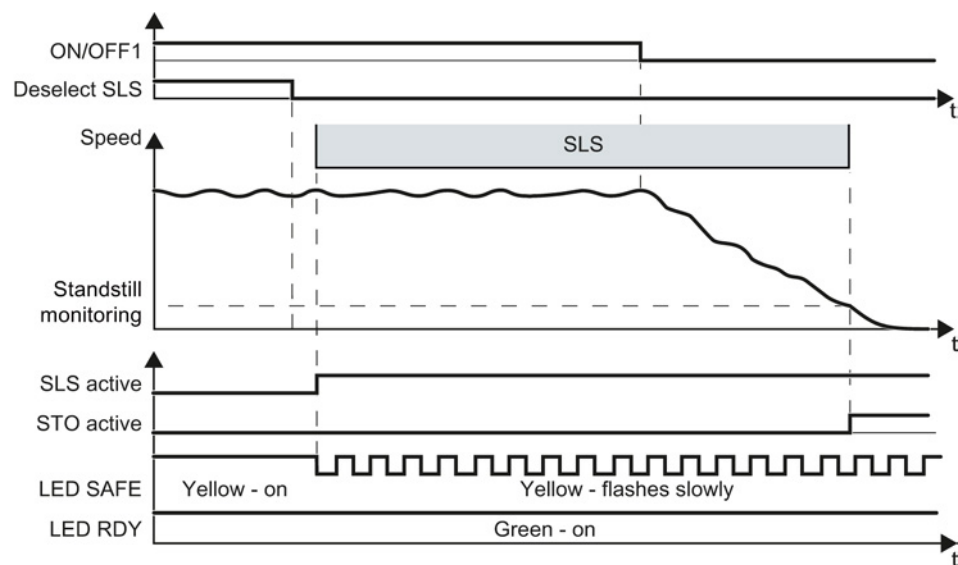
Figure 6-27   OFF1 command when the SLS safety function is active

If you switch off the motor using the OFF2 command, then the inverter immediately safely switches off the motor torque using the STO safety function.
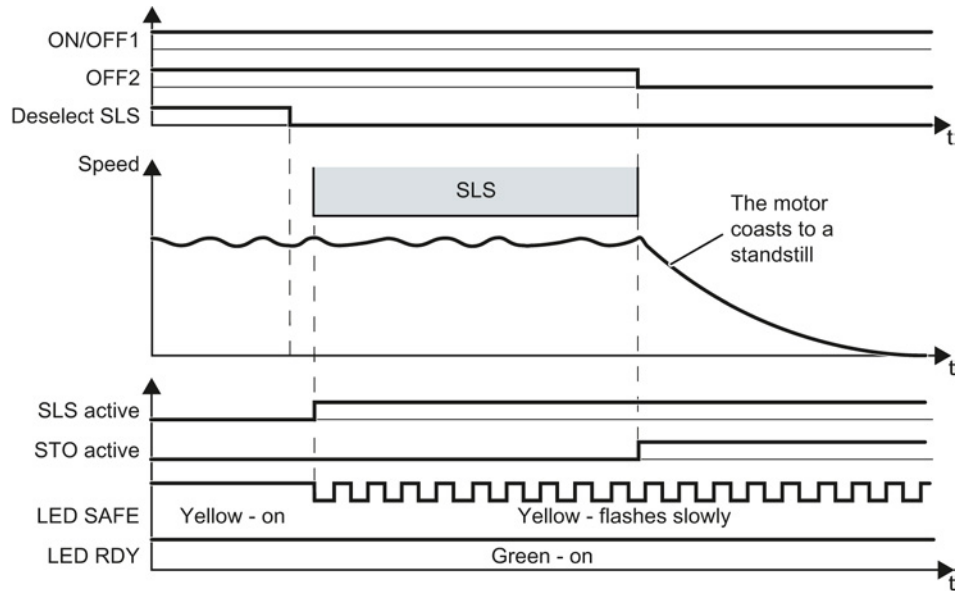
Figure 6-28   OFF2 command when the SLS safety function is active

6.6.5 Switching on the motor when SLS is active

Switch on motor

Procedure

To switch the motor on with SLS active, proceed as follows:

1. Select STO (or SS1).

2. Deselect STO (or SS1).

3. After deselecting STO, wait until the inverter is "ready to switch on".

   Alternatively: After deselecting STO, wait a certain time before switching on. We recommend a wait time of 200 ms.

4. Switch on motor within 5 s after deselecting STO (ON command).
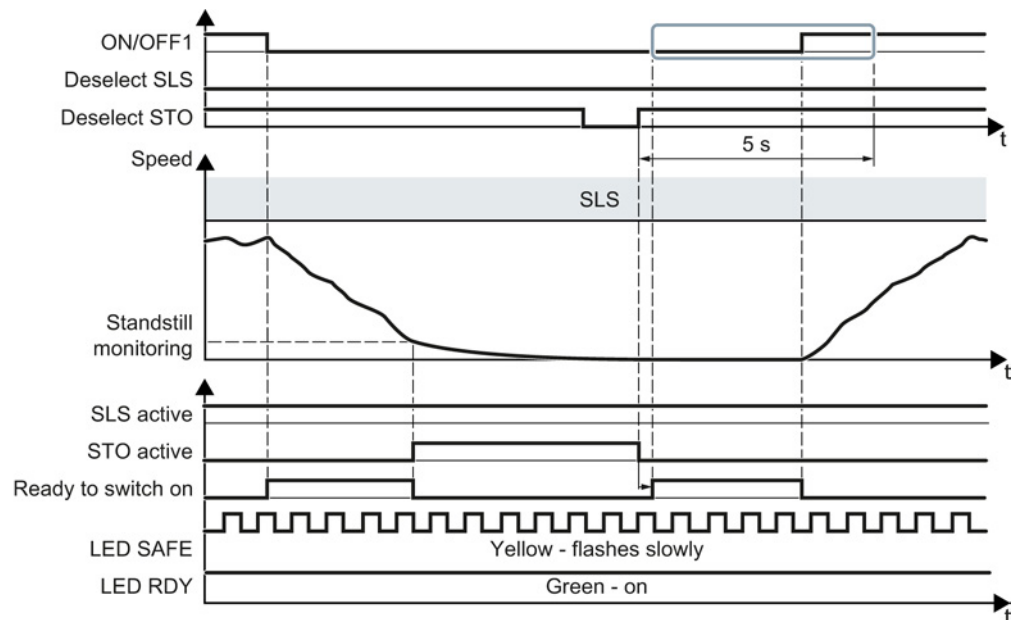
Figure 6-29   Switching the motor off and on (ON/OFF1) when SLS is active

You have switched on the motor.

You have not switched on the motor within 5 seconds

If you do not switch on the motor within 5 seconds after deselecting STO, the following happens:

- The inverter goes back into the STO state.

- The inverter no longer responds to the ON command.

- The inverter outputs Alarm A01795.

To switch on the motor you must repeat the procedure described above.

6.6.6 Response to a discrepancy when SLS is active

Drive response

The inverter responds with the active SLS safety function to a discrepancy at the safety input.
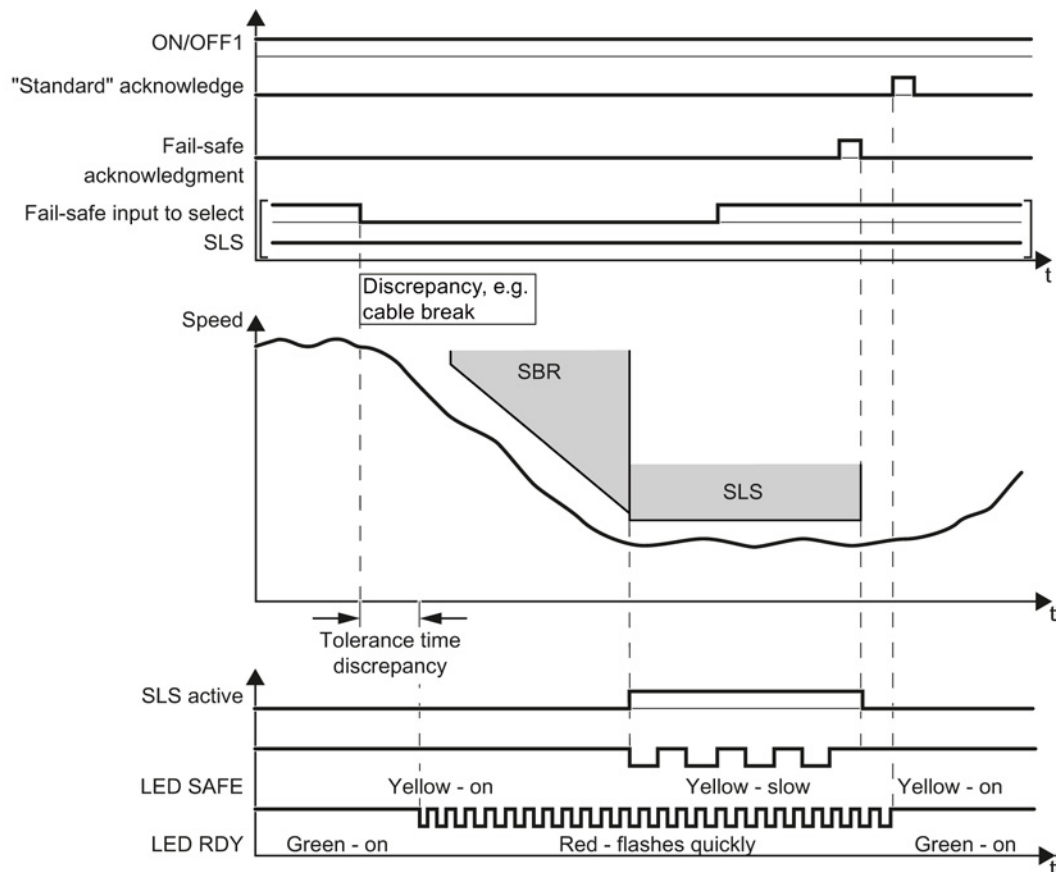
Figure 6-30   Behavior of the inverter for discrepancy of the input signal for SLS

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (Alarm C01770 or C30770). The SLS function remains active, and the motor remains switched on.

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Deselecting SLS after a discrepancy

Procedure

To deselect SLS, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the discrepancy message with the fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.

   Alternatively, you can acknowledge the message in one of the following ways. However, the drive stops in these cases:

   – Select the STO function and then deselect again: F-DI = 1 → 0 → 1.

   – Select the SS1 function and then deselect again: F-DI = 1 → 0 → 1.

   – Switch off the inverter supply voltage and on again (power on reset).

3. Acknowledge the inverter with the "standard" acknowledge signal.

You have acknowledged the discrepancy message and deselected SLS.

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6.6.7 Limit value violation when SLS is active

Drive response

When motion monitoring detects a fault when SLS is active, the inverter responds by triggering a STOP A or STOP B. The inverter response is parameterized during commissioning. The various STOP variants are described in the section Stop responses (Page 227).
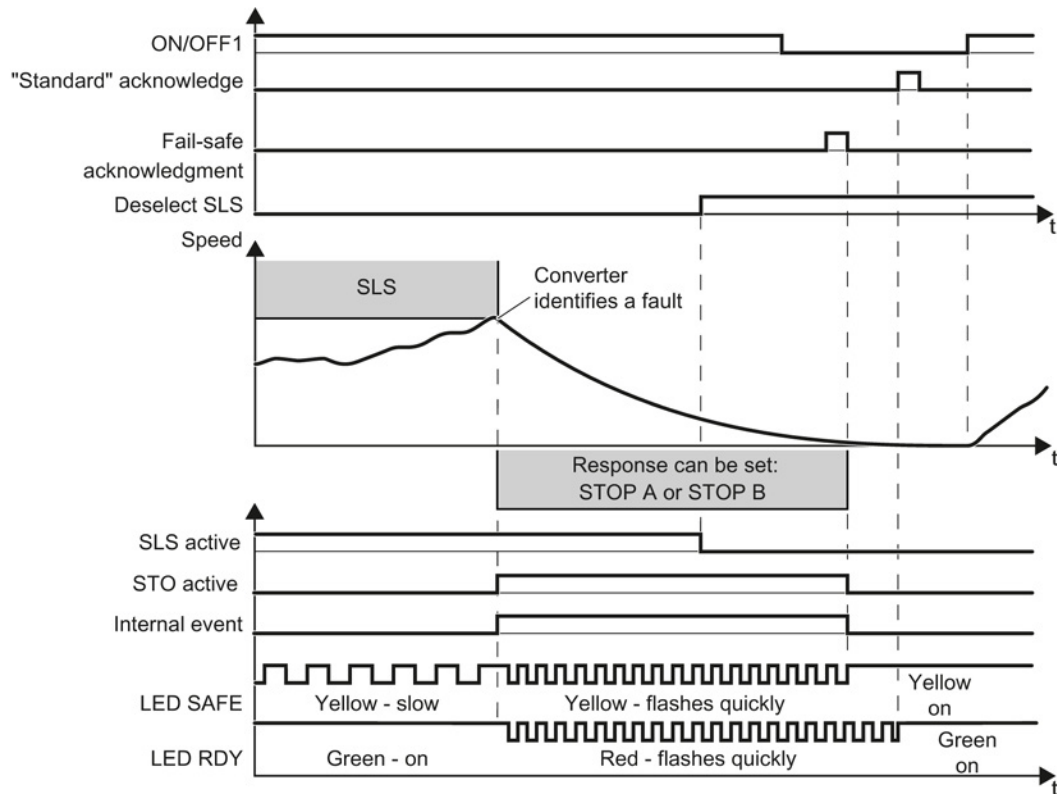
Figure 6-31   Limit value violation of safety function SLS. Example with STOP A as fault response

Switching the motor on after an internal event

Procedure

To switch the motor on after an internal event while SLS is active, proceed as follows:

1. Deselect the SLS function.

2. Issue an OFF1 command (ON/OFF1 = 0).

3. Acknowledge the internal event in one of the following ways:

   – Fail-safe acknowledgment using PROFIsafe control word 0, bit 7 = 0 → 1 → 0

   – Fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.

   – Select the STO function and deselect again (PROFIsafe control word 0, bit 0 or F-DI). 1 → 0 → 1).

   – Select the SS1 function and deselect again (PROFIsafe control word 0, bit 1 or F-DI). 1 → 0 → 1).

   – Switch off the inverter supply voltage and on again (power on reset).

4. Acknowledge the inverter with the "standard" acknowledge signal.

5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the internal event and switched on the motor again.

6.7 Safe Speed Monitor (SSM)

6.7.1 Overview

What can you find in this Chapter?

The relevant operating cases for the SSM function are described in this chapter.

Table 6- 7   Response of the SSM function when the motor is switched on (ON/OFF1 = 1)

Feedback signal	The SSM function signals as to whether the motor speed is above or below the set SSM limit value.
	→ Selecting SSM when the motor is switched on (Page 207)

Table 6- 8   Switching the motor on and off when SSM is active or not active

	Switching on the motor (ON/OFF1 = 0 → 1)	Switching off the motor (ON/OFF1, OFF2 or OFF3 = 1 → 0)
SSM is not active	If SSM is not active, then there are no restrictions for switching on and switching off the motor.	
SSM is active	If SSM is active, you must take into account several special issues when switching on the motor. → Switching on the motor when SSM is active (Page 213).	The drive response depends on the signal that you use to switch off the motor. → Switching off the motor when SSM is active (Page 208)

6.7.2 Selecting SSM when the motor is switched on

Description

The safety function SSM cannot be selected or deselected using external control signals. SSM is active if all of the following conditions are met:

● You have enabled one or several extended safety functions.

● For the SSM function, you have set a monitoring speed of > 0.

Before you switch on the motor for the first time after a power-on reset, the feedback signal "speed below limit value" of the SSM function is always equal to 0.

When the motor is switched on, the inverter compares the load speed with the speed limit.
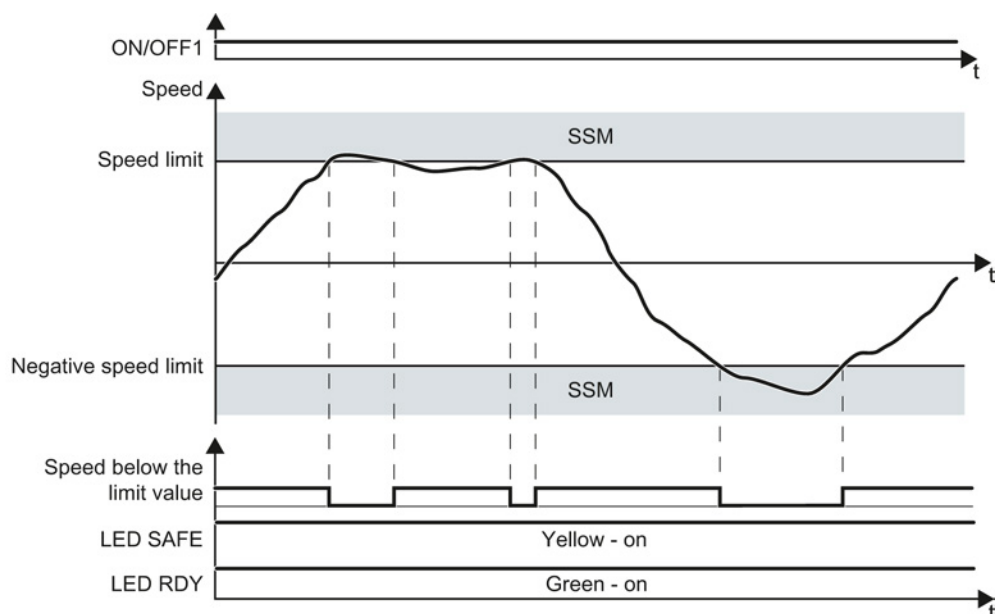
Figure 6-32   Time response of the safety function SSM (Safe Speed Monitor)

6.7.3   Switching off the motor when SSM is active

Description

If you switch off the motor with the SSM function active using the OFF1 or OFF3 command, e.g. when reaching limit switches, the following happens:

1. The inverter brakes the motor with the OFF1 or OFF3 ramp-down time.

2. Also while braking, the inverter monitors the motor speed.

The inverter responds differently depending on the speed at the instant of switch off.

When switching off, the speed is less than the SSM limit value

You can set the behavior of the inverter after switching-off the motor in two different ways:

1. Feedback signal "SSM active" for pulse inhibit *remains active:*

   When the motor is switched off, the inverter prevents the motor from accelerating by issuing an STO. When the motor is switched off, "Status SSM" = 1.

2. Feedback signal "SSM active" for pulse inhibit *becomes inactive:*

   When the motor is switched off, the inverter sets "Status SSM" = 0.

The inverter brakes the motor down to a standstill using the OFF1 or OFF3 command and then switches it off.

If the "SSM active" feedback signal should remain active when the pulses are inhibited, then the inverter safely switches off the motor torque using the safety function STO.
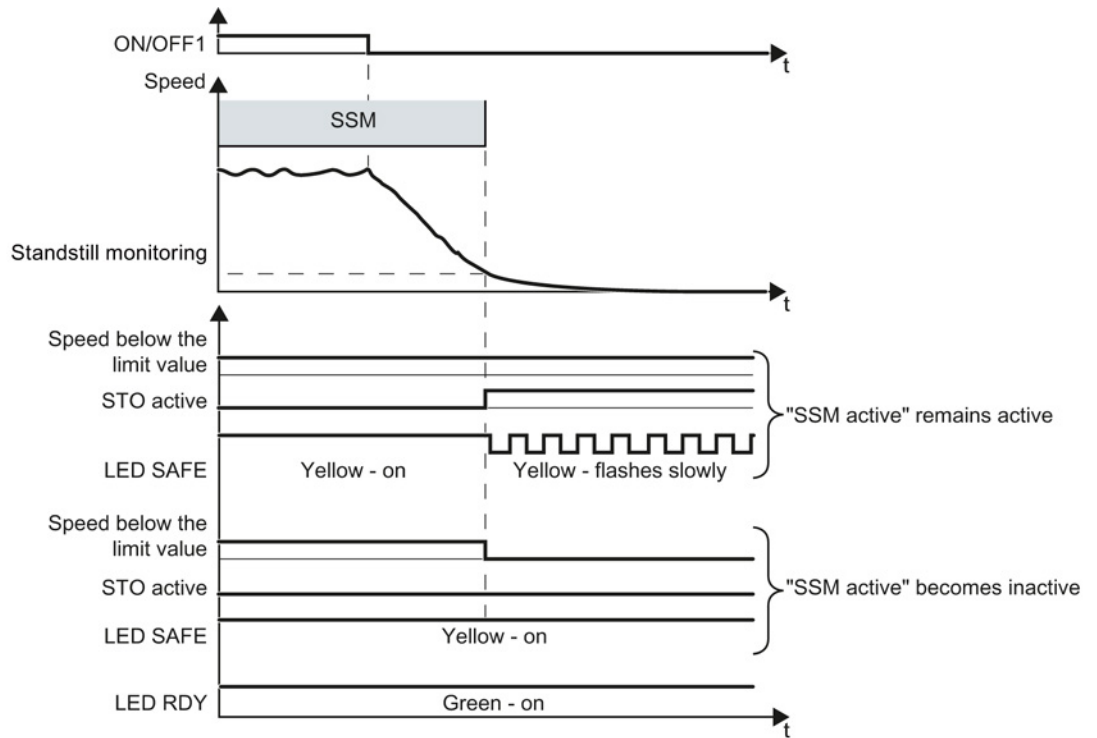
Figure 6-33   OFF1 command when the SSM safety function is active

The inverter immediately switches off the motor with the OFF2 command.

If the "SSM active" feedback signal should remain active when the pulses are inhibited, then the inverter safely switches off the motor torque using the safety function STO.
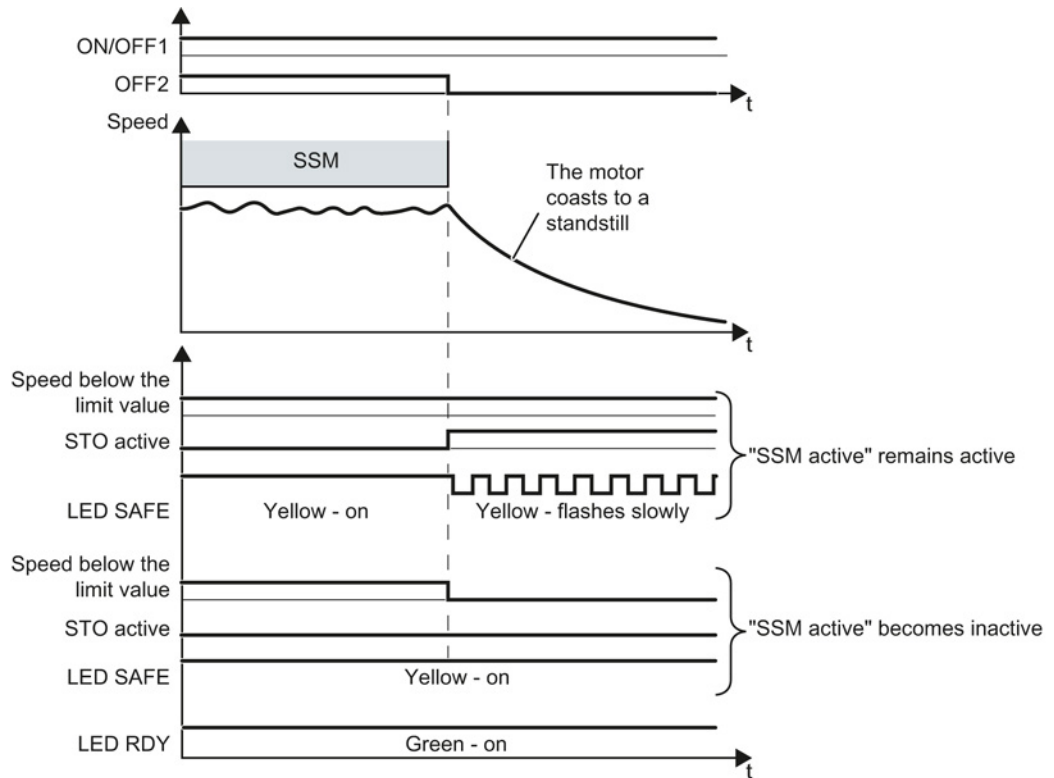
Figure 6-34   OFF2 command when the SSM safety function is active

When switching off, the speed is higher than the SSM limit value

The inverter brakes the motor down to a standstill using the OFF1 or OFF3 command and then switches it off.

If the "SSM active" feedback signal should remain active when the pulses are inhibited, then the inverter safely switches off the motor torque using the safety function STO.
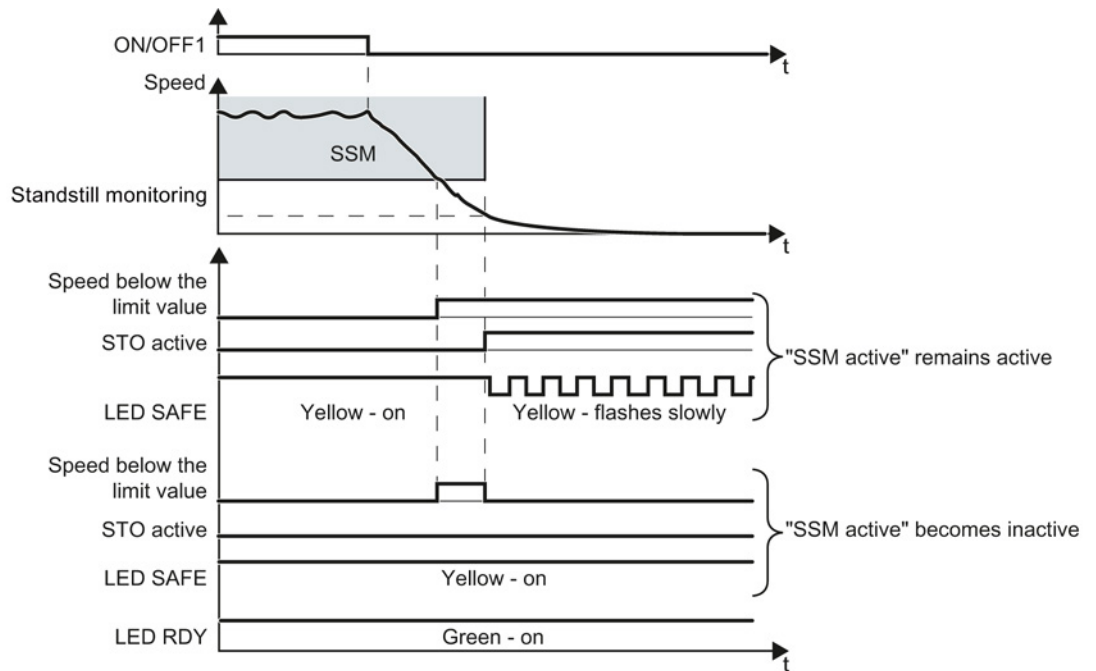
Figure 6-35   OFF1 command when the SSM safety function is active

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The inverter immediately switches off the motor with the OFF2 command.

If the "SSM active" feedback signal should remain active when the pulses are inhibited, then the inverter safely switches off the motor torque using the safety function STO.

The feedback signal "SSM active" remains = 0.
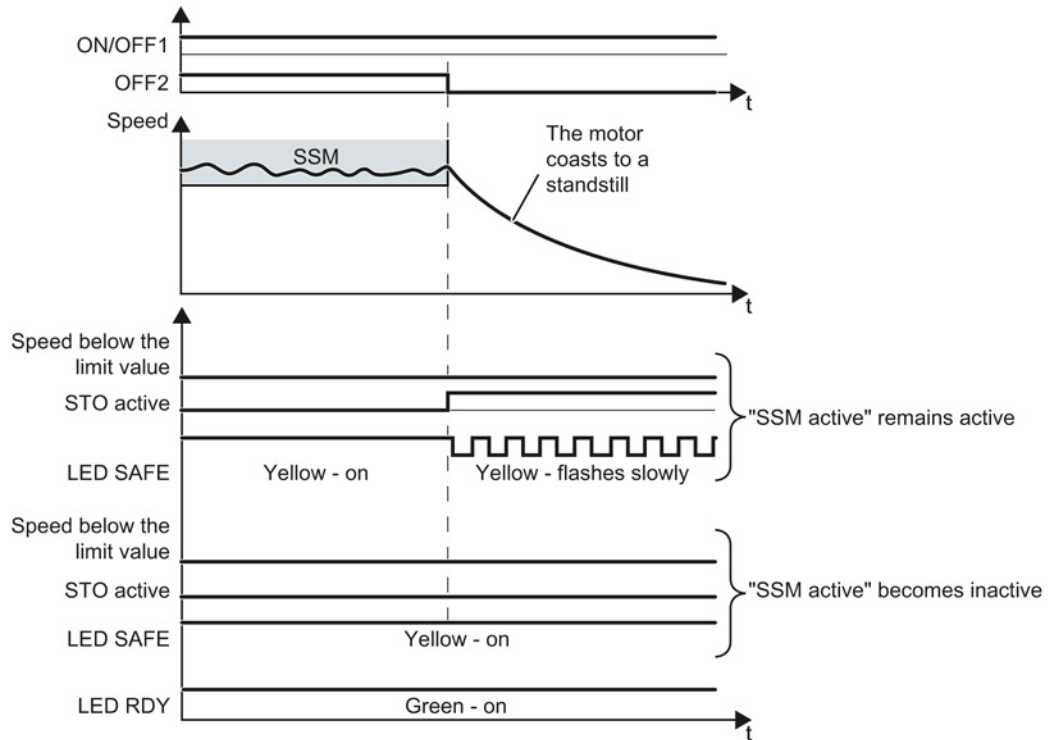
Figure 6-36   OFF2 command when the SSM safety function is active

6.7.4 Switching on the motor when SSM is active

The procedure for switching on the motor depends on how you have set the SSM function.

The feedback signal "SSM active" for pulse inhibit becomes inactive

With this setting, the SSM function does not influence switching on the motor. SSM is active when you switch on the motor.
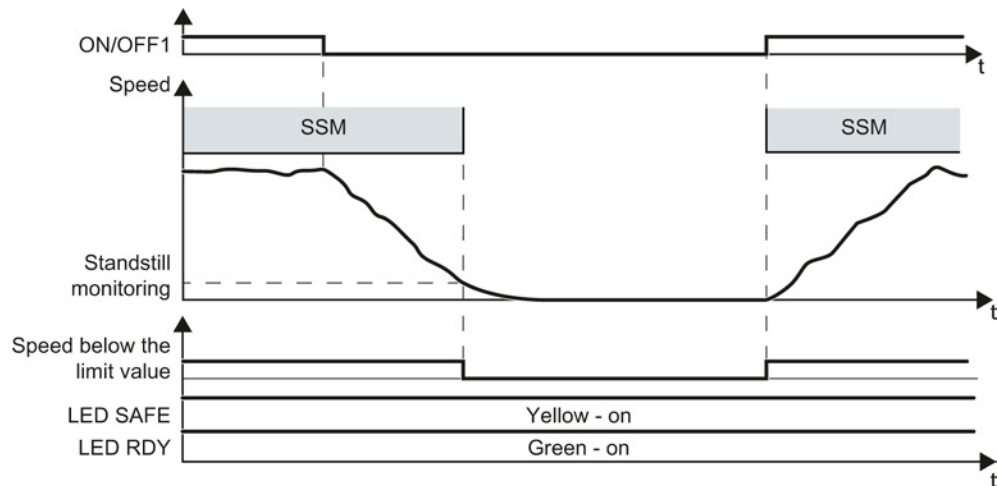
Figure 6-37   Switching on the motor when the SSM function is active, interrupting SSM

The feedback signal "SSM active" for pulse inhibit remains active

With this setting, you must maintain a certain sequence before switching on the motor.

Procedure

To switch the motor on, proceed as follows:

1. Select STO (or SS1) after the motor has been switched off.

2. Deselect STO (or SS1) again before you switch on the motor.

3. After deselecting STO, wait until the inverter is "ready to switch on".

   Alternatively: After deselecting STO, wait a certain time before switching on. We recommend a wait time of 200 ms.

4. Switch on motor within 5 s after deselecting STO (ON command).
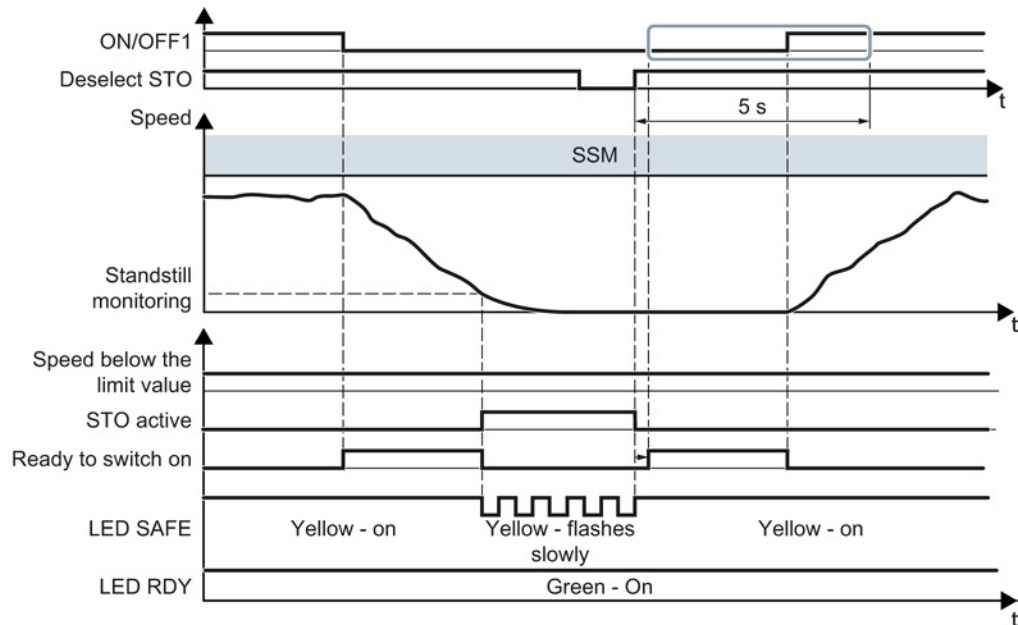
Figure 6-38   Switching on the motor when SSM is active

You have switched on the motor.

You have not switched on the motor within 5 seconds

If you do not switch on the motor within 5 seconds after deselecting STO, the following happens:

● The inverter goes back into the STO state.

● The inverter no longer responds to the ON command.

● The inverter outputs Alarm A01795.

To switch on the motor you must repeat the procedure described above.

6.8 Safe Direction (SDI)

6.8.1 Overview

What can you find in this Chapter?

The relevant operating cases for the SDI function are described in this chapter.

Table 6- 9   Response of the SDI function when the motor is switched on (ON/OFF1 = 1)

Selecting and deselecting SDI	→ Selecting and deselecting SDI when the motor is switched on (Page 216)
Discrepancy in the input signal	The safety input to select SDI identifies an error. → Response to a discrepancy when Safe Direction is active (SDI) (Page 221)
Limit value violation	The motor rotates in the monitored direction. → Limit value violation when Safe Direction (SDI) is active (Page 223)

Table 6- 10   Switching the motor on and off when SDI is active or not active

	Switching on the motor (ON/OFF1 = 0 → 1)	Switching off the motor (ON/OFF1, OFF2 or OFF3 = 1 → 0)
SDI is not active	If SDI is not active, then there are no restrictions for switching on and switching off the motor.	
SDI is active	If your application requires that SDI always remains active, then you must take into account several special issues when switching on the motor. → Switching on the motor when SDI is active (Page 219).	The drive response depends on the signal that you use to switch off the motor. → Switching off the motor when SDI is active (Page 217)

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6.8.2 Selecting and deselecting SDI when the motor is switched on

Select SDI

Function

1. The higher-level control selects the SDI safety function via a safety input or via the PROFIsafe safe communication.

2. The inverter limits the speed to the permitted direction of rotation. When SDI is selected, if the motor rotates in the impermissible direction, then the inverter brakes the motor down to standstill.

3. After the delay time has expired, the inverter monitors the selected direction of rotation of the motor.

   The inverter tolerates brief motion in the monitored direction of rotation up to an adjustable angle of rotation of the motor shaft.
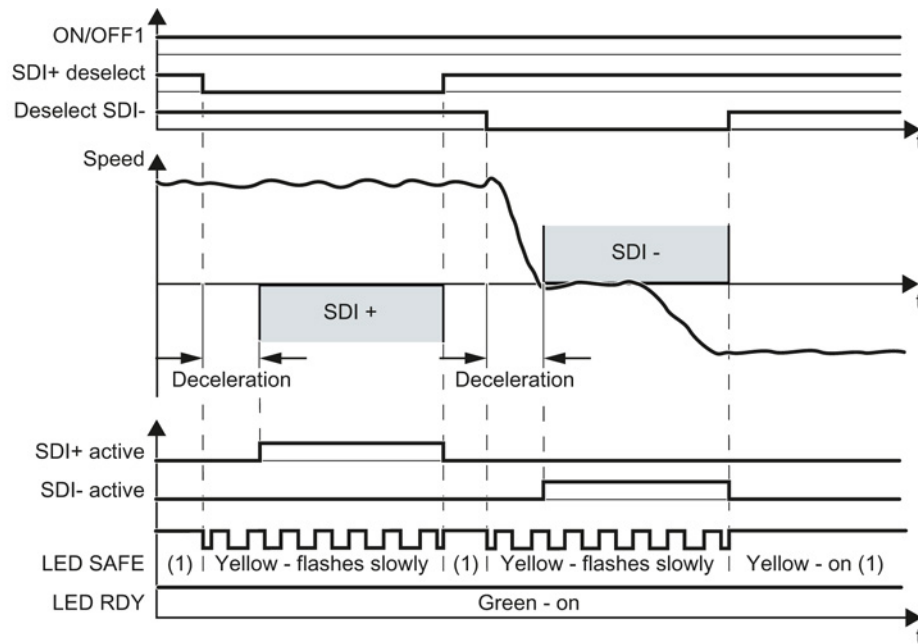
Figure 6-39   Time response of the safety function SDI (Safe direction)

6.8.3 Switching off the motor when SDI is active

Description

If you switch off the motor with the SDI function active using the OFF1 or OFF3 command, e.g. when reaching limit switches, the following happens:

1. The inverter brakes the motor with the OFF1 or OFF3 ramp-down time until the speed reaches the standstill monitoring threshold.

2. Also while braking, the inverter monitors the direction of rotation.

You can set the behavior of the inverter after switching-off the motor in two different ways:

1. Feedback signal "SDI active" for pulse inhibit *remains active*
   With this setting, the inverter safely switches off the motor torque when reaching the standstill monitoring using the STO safety function. The inverter ensures that the motor does not actively accelerate. The "SDI active" signal also remains at 1 for a motor that has been switched off.

2. Feedback signal "SDI active" for pulse inhibit *becomes inactive*
   With this setting the inverter inverter off the motor torque, but not safely. The system does not safely prevent that the motor actively accelerates. Therefore, the inverter sets the "SDI active" signal to 0 when the motor is switched off.
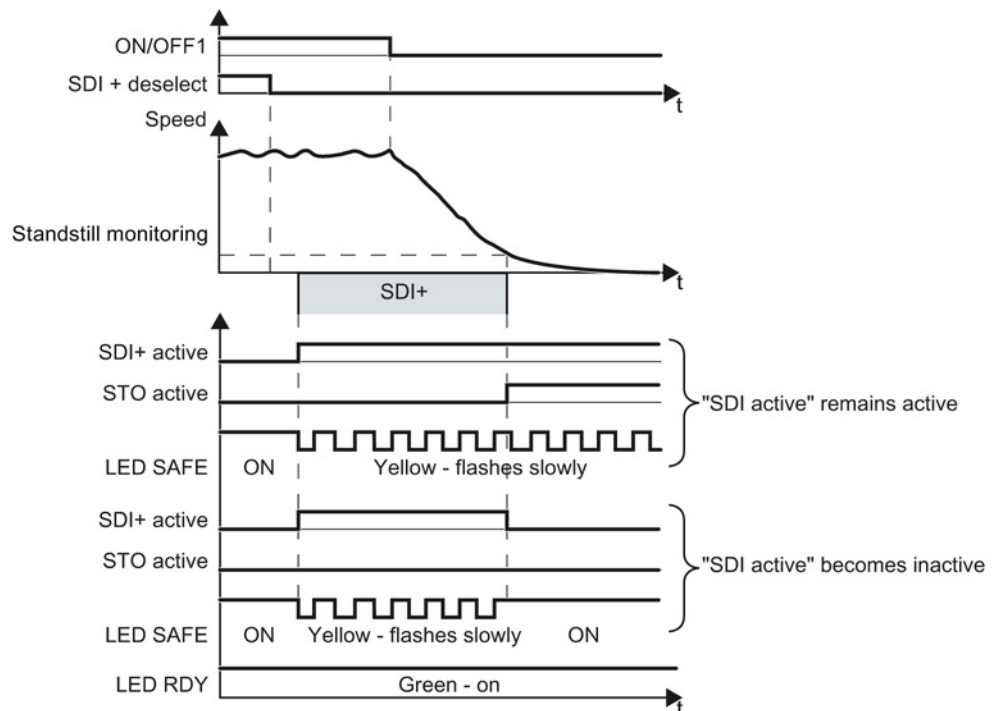
Figure 6-40   OFF1 command when the SDI safety function is active

If you switch the motor off with the OFF2 command when the SDI safety function is active, the inverter immediately switches off the motor. Depending on the selected setting, the inverter immediately switches off the motor torque with the STO safety function.
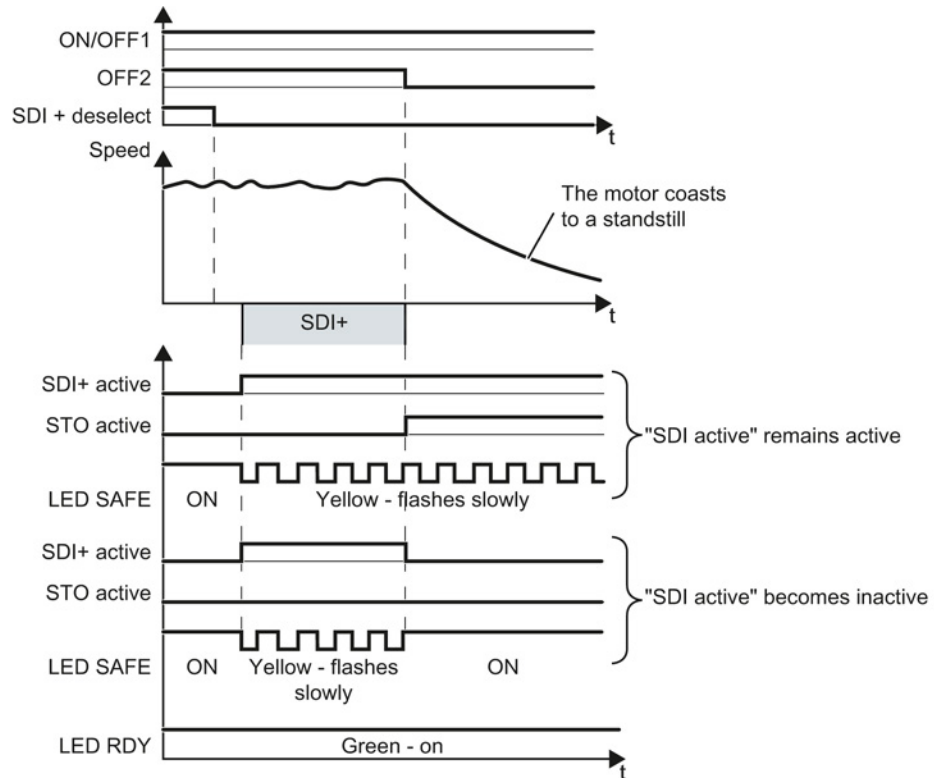
Figure 6-41   OFF2 command when the SDI safety function is active

6.8.4 Switching on the motor when SDI is active

The procedure for switching on the motor depends on how you have set the SDI function.

The feedback signal "SDI active" for pulse inhibit becomes inactive

With this setting, the SDI function does not influence switching on the motor. SDI is active when you switch on the motor.
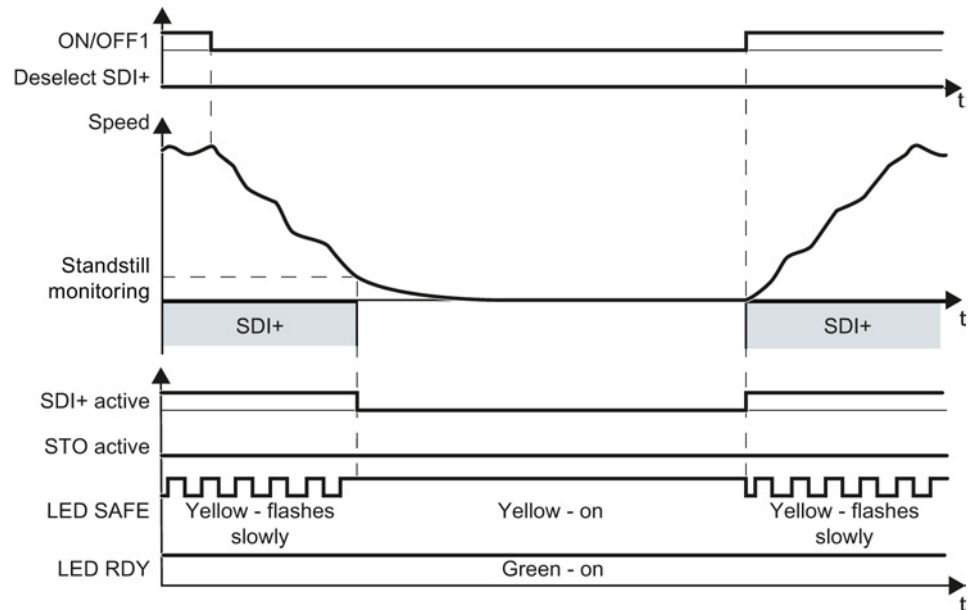
Figure 6-42   Switching the motor off and on when SDI is active, interrupts the feedback signal from SDI

The feedback signal "SDI active" for pulse inhibit remains active

Procedure

To switch the motor on, proceed as follows:

1. Select STO (or SS1).

2. Deselect STO (or SS1) again.

3. After deselecting STO, wait until the inverter is "ready to switch on".

   Alternatively: After deselecting STO, wait a certain time before switching on. We recommend a wait time of 200 ms.

4. Switch on motor within 5 s after deselecting STO (ON command).
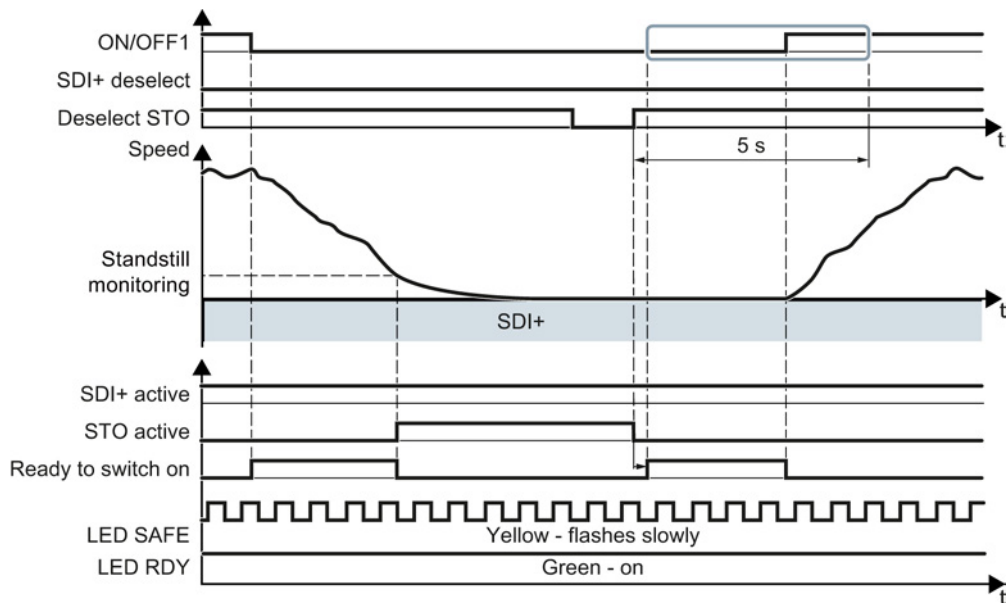
Figure 6-43   Switching the motor off and on when SDI is active

You have switched on the motor again.

You have not switched on the motor within 5 seconds

If you do not switch on the motor within 5 seconds after deselecting STO, the following happens:

- The inverter goes back into the STO state.

- The inverter no longer responds to the ON command.

- The inverter outputs Alarm A01795.

To switch on the motor you must repeat the procedure described above.

6.8.5 Response to a discrepancy when Safe Direction is active (SDI)

Drive response

The inverter responds with the active SDI safety function to a discrepancy at the safety input.
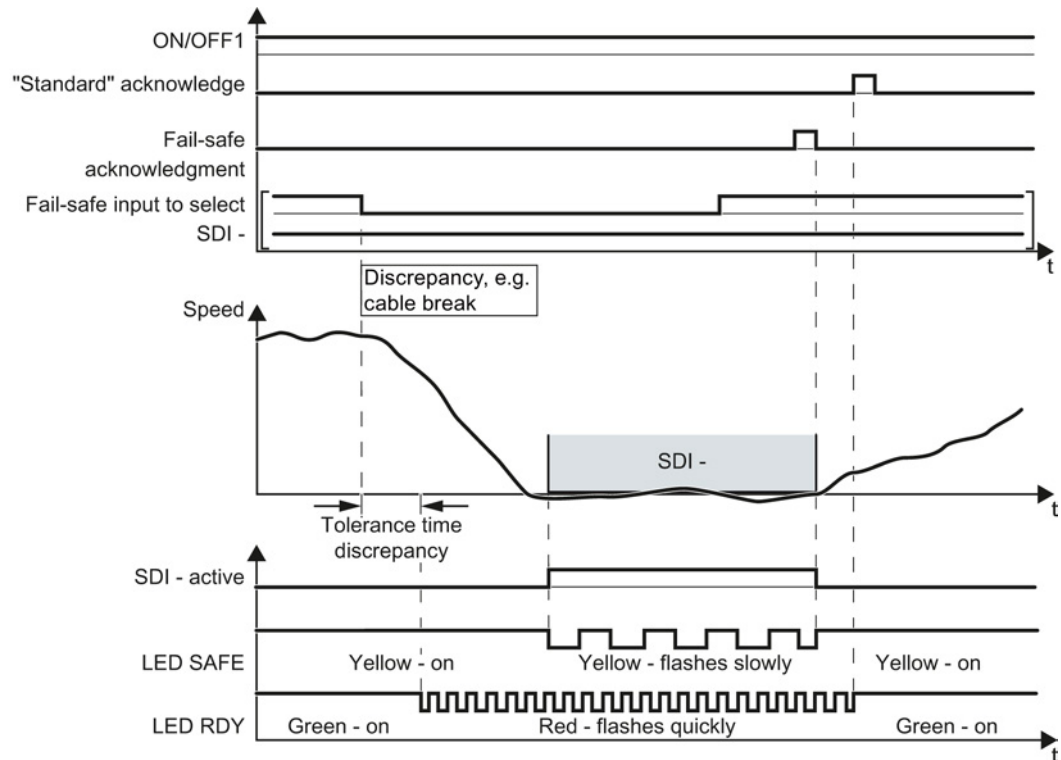
Figure 6-44   Behavior of the inverter for discrepancy of the input signal for SDI (SDI - as example)

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (Alarm C01770 or C30770). The SDI function remains active, and the motor remains switched on.

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Deselecting SDI after a discrepancy

Procedure

To deselect SDI, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the discrepancy message with the fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.

   Alternatively, you can acknowledge the message in one of the following ways. However, the drive stops in these cases:

   – Select the STO function and then deselect again: F-DI = 1 → 0 → 1.

   – Select the SS1 function and then deselect again: F-DI = 1 → 0 → 1.

   – Switch off the inverter supply voltage and on again (power on reset).

3. Acknowledge the inverter with the "standard" acknowledge signal.

You have acknowledged the discrepancy message and deselected SDI.

6.8.6 Limit value violation when Safe Direction (SDI) is active

Drive response

When motion monitoring detects a fault when SDI is active, the inverter responds by triggering a STOP A or STOP B. The inverter response is parameterized during commissioning. The various STOP variants are described in the section Stop responses (Page 227).
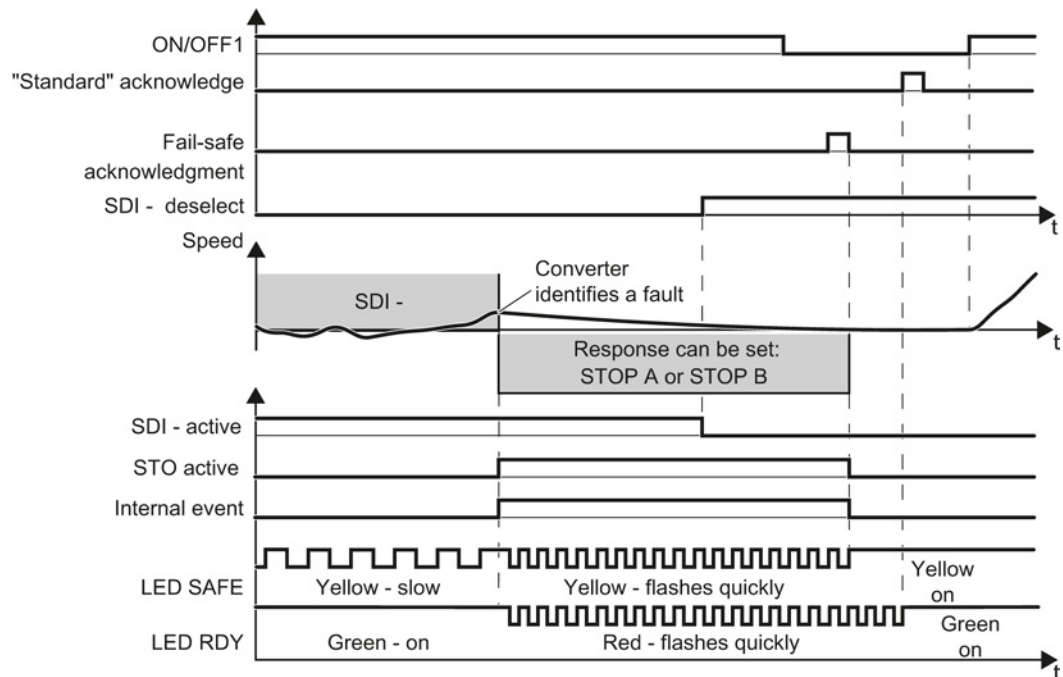
Figure 6-45   Limit value violation of safety function SDI. Example with STOP A as fault response

Switching the motor on after an internal event

Procedure

To switch the motor on after an internal event while SDI is active, proceed as follows:

1. Deselect the SDI function.

2. Issue an OFF1 command (ON/OFF1 = 0).

3. Acknowledge the internal event in one of the following ways:

   – Fail-safe acknowledgment using PROFIsafe control word 0, bit 7 = 0 → 1 → 0

   – Fail-safe acknowledge signal via a safety input: F-DI = 0 → 1 → 0.

   – Select the STO function and deselect again (PROFIsafe control word 0, bit 0 or F-DI). 1 → 0 → 1).

   – Select the SS1 function and deselect again (PROFIsafe control word 0, bit 1 or F-DI). 1 → 0 → 1).

   – Switch off the inverter supply voltage and on again (power on reset).

4. Acknowledge the inverter with the "standard" acknowledge signal.

5. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the internal event and switched on the motor again.

6.9   Response to a discrepancy in the signals transferred via PROFIsafe

Drive response
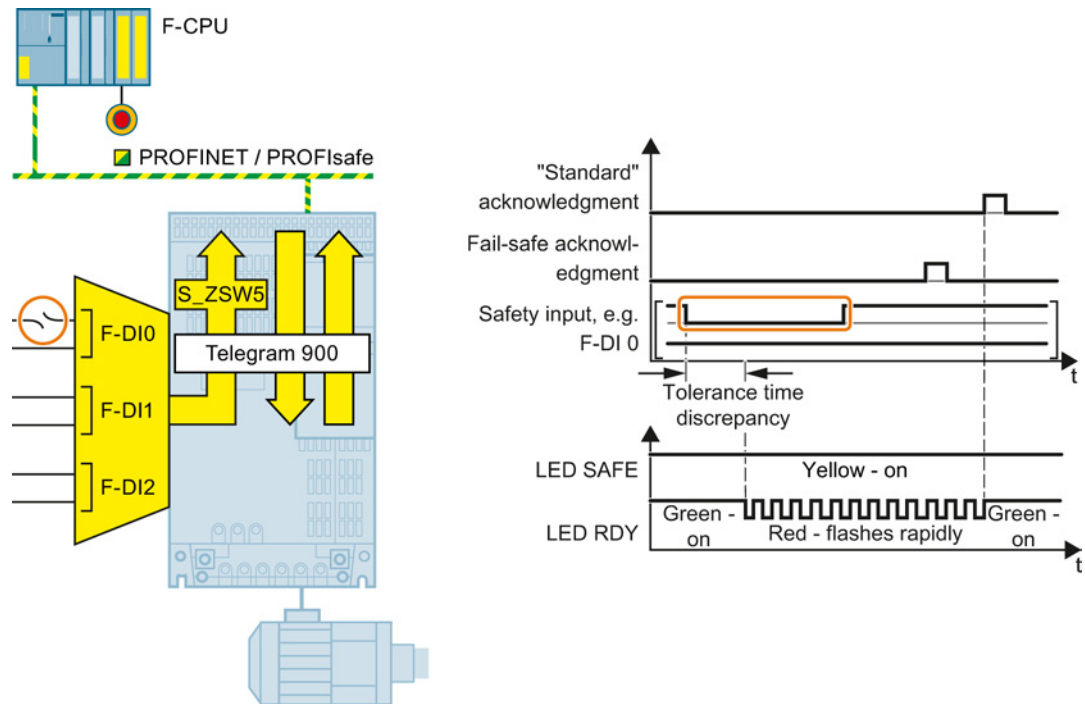
Figure 6-46   Behavior of the inverter in the event of a discrepancy in a safety input in PROFIsafe telegram 900

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (fault C01770 or C30770).

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Acknowledging a discrepancy message

Procedure

To acknowledge the discrepancy message, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the discrepancy message in one of the following ways:

Selected setting	How can the internal event be acknowledged?		
	F-DI	PROFIsafe	Alternative
Extended Functions via PROFIsafe	---	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset
Extended Functions via PROFIsafe and Basic Functions via onboard terminals	Select and deselect STO (F-DI = 1 → 0 → 1)	Select and deselect STO (PROFIsafe control word 1, bit 0 = 1 → 0 → 1) or Select and deselect SS1 (PROFIsafe control word 1, bit 1 = 1 → 0 → 1) or Fail-safe acknowledgment (PROFIsafe control word 1, bit 7 = 0 → 1 → 0)	Power on reset

3. Acknowledge the inverter with the "standard" acknowledge signal.

You have acknowledged the discrepancy message

6.10 Stop responses

Internal event

An "internal event" is a major fault that causes the inverter to bring the motor to a standstill as quickly as possible by triggering a STOP reaction. For example, an "internal event" can be caused by one of the following:

● The inverter detects an internal fault in its hardware or its firmware on the basis of a data cross-check (F01611).

● The inverter identifies when a limit value is violated as a result of an inadmissible motor speed (C01714).

An "internal event" can only be acknowledged using a fail-safe signal. See also: Fail-safe acknowledgment signal (Page 232).

STOP A

For a STOP A, the inverter safely switches off the torque of the connected motor immediately.

STOP B

For a STOP B, the inverter brakes the motor with the OFF3 ramp-down time until standstill is detected. This is then followed by a STOP A.

If you operate the motor with torque control, then the inverter switches over the control mode to speed control.

The inverter monitors the braking of the motor. The type of monitoring corresponds to the monitoring mode of SS1, also see section Setting SS1 (Page 130).
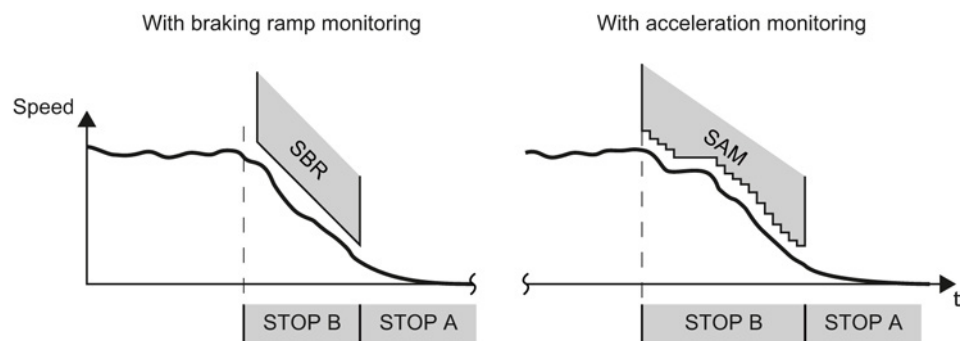
Figure 6-47 Speed monitoring for a STOP B

If the motor does not follow the defined braking ramp, the inverter interrupts the braking of the motor and responds with a STOP A.

STOP F

If a safety function is active [1], a STOP F initiates a STOP A or STOP B:

● Fault F01611 immediately initiates a STOP A.

● For message C01711, the inverter response depends on the active safety function:

    – When STO is active, then the inverter initiates a STOP A.

    – In all other cases, the inverter initiates a STOP B.

If none of the safety functions are active, then the inverter responds as follows:

● Fault F01611 immediately initiates a STOP A.

● There is no immediate stop response for message C01711. However, the message is kept. When selecting a safety function, the inverter responds with a stop as described above.

[1] The SSM function is considered as active safety function if the SSM filter and the SSM hysteresis have been enabled.

6.10.1 Example 1: Internal event with STO active

Drive response
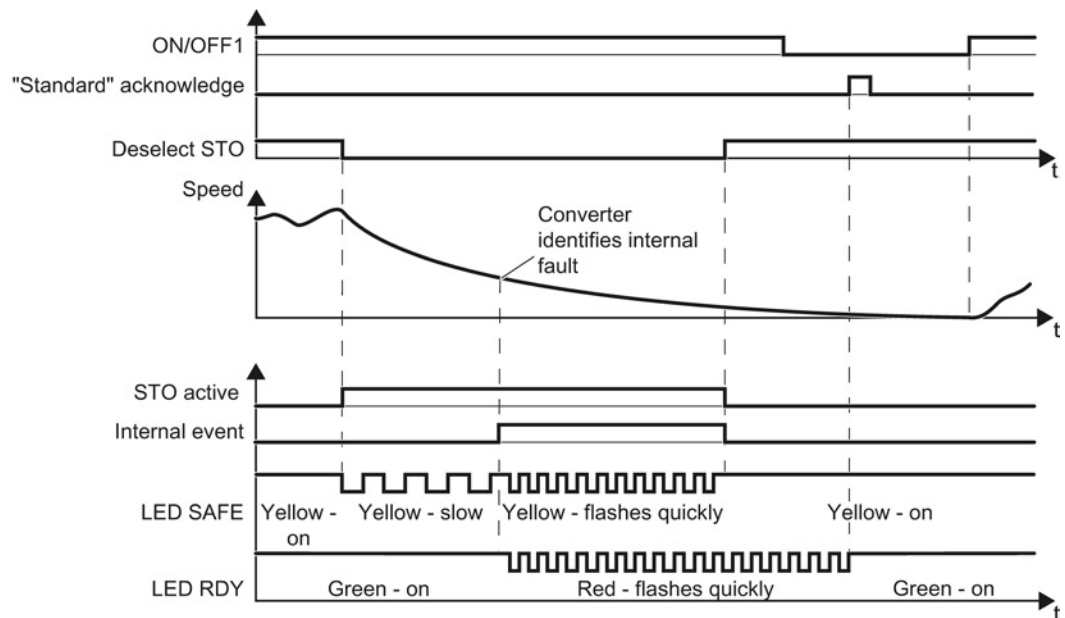
Figure 6-48   Internal event when the STO safety function is active

The inverter signals an internal event.

Switching the motor on after an internal event

Procedure

To switch the motor on after an internal event, proceed as follows:

1. Deselect the STO function.

2. Issue an OFF1 command (ON/OFF1 = 0).

3. Acknowledge the inverter with the "standard" acknowledge signal.

4. Switch on the motor (ON/OFF1 = 1).

You have acknowledged the internal event and switched on the motor again.

6.10.2 Example 2: Internal event with SSM active

Internal event when the motion monitoring function is active

If an active safety function with motion monitoring (SS1, SSL, SDI or SSM) is interrupted with an internal event, the inverter responds with a STOP F.

A STOP F does not necessarily mean that the motor is stopped. See also: Stop responses (Page 227).

The drive response

The motor behavior is explained using the SSM function and a STOP B with acceleration monitoring as an example:
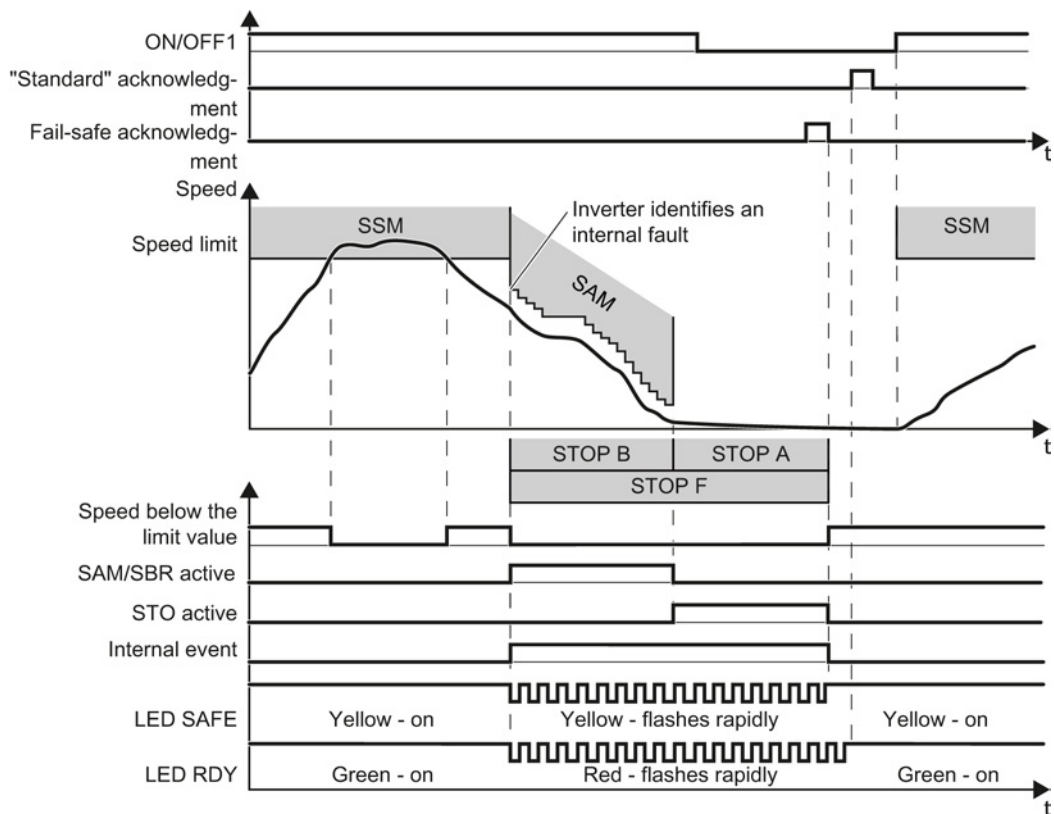
Figure 6-49   Response of the SSM safety function to an internal event

Switching the motor on after an internal event

Procedure

To switch the motor in the example above on again, proceed as follows:

1. Issue an OFF1 command (ON/OFF1 = 0).

2. Acknowledge the internal event in one of the following ways:

   – Fail-safe acknowledgment using PROFIsafe control word 0, bit 7 = $0 \rightarrow 1 \rightarrow 0$

   – Fail-safe acknowledge signal via a safety input: F-DI = $0 \rightarrow 1 \rightarrow 0$.

   – Select the STO function and deselect again (PROFIsafe control word 0, bit 0 or F-DI). $1 \rightarrow 0 \rightarrow 1$).

   – Select the SS1 function and deselect again (PROFIsafe control word 0, bit 1 or F-DI). $1 \rightarrow 0 \rightarrow 1$).

   – Switch off the inverter supply voltage and on again (power on reset).

3. Acknowledge the inverter with the "standard" acknowledge signal.

4. Switch on the motor (ON/OFF1 = 1).
   Also see section: Switching on the motor when SSM is active (Page 213).

You have acknowledged the internal event and switched on the motor again.

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6.11 Fail-safe acknowledgment signal

6.11.1 Acknowledging using a fail-safe signal

You must acknowledge the majority of safety function faults using a fail-safe signal. The following options are available.

- Acknowledging using a safety input F-DI
- Acknowledging via PROFIsafe
- Acknowledging by selecting and deselecting STO
- Acknowledging by switching the power supply on and off

Acknowledging using a safety input F-DI

Procedure

To acknowledge the inverter using a safety input F-DI, proceed as follows:

1. Acknowledge the fault with F-DI = 0 → 1 → 0.
2. Then, acknowledge the inverter with the "standard" acknowledgement signal.

You have acknowledged the inverter in a fail-safe fashion.

Acknowledging via PROFIsafe

Procedure

To acknowledge the inverter via PROFIsafe, proceed as follows:

1. Acknowledge the fault with bit 7 of the control word 0: Bit 7 = 0 → 1 → 0.
2. Then, acknowledge the inverter with the "standard" acknowledgement signal.

You have acknowledged the inverter in a fail-safe fashion.

Acknowledging by selecting and deselecting STO

Procedure

To acknowledge the inverter by selecting and deselecting STO, proceed as follows:

1. Select the safety function STO or SS1 and then deselect again.
   - F-DI = 1 → 0 → 1
     or
   - PROFIsafe control word 1, bit 0 or 1 = 1 → 0 → 1
2. Then, acknowledge the inverter with the "standard" acknowledgement signal.

You have acknowledged the inverter in a fail-safe fashion.

Acknowledging by switching the power supply on and off

You can acknowledge faults by temporarily switching off the power supply to the inverter and then switching it on again (power on reset).

6.11.2 Response to a discrepancy of the fail-safe acknowledge signal

Drive response
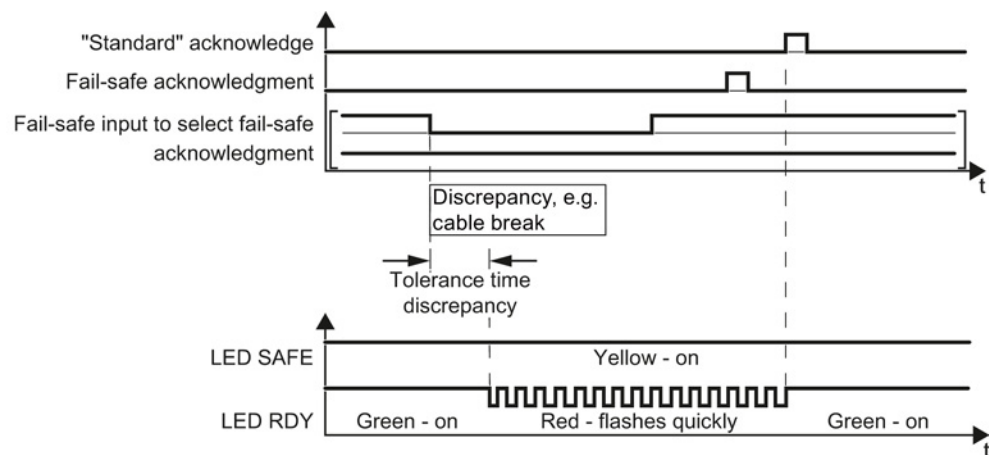
Figure 6-50   Behavior of the inverter for discrepancy of the input signal for fail-safe acknowledgment

The inverter does not set the error bit of the safety functions (= internal event).

After the tolerance time has expired, the inverter signals the discrepancy (fault C01770 or C30770).

Independent of the voltage levels available, the inverter sets the evaluation of the discrepant F-DI into the safe state (=zero) until you acknowledge the inverter using a fail-safe signal or using a power-on reset.

Acknowledging a discrepancy message

Procedure

To acknowledge the discrepancy message, proceed as follows:

1. Remove the discrepancy.

2. Acknowledge the discrepancy message in one of the following ways:

   – Select the STO function and then deselect again: F-DI = 1 → 0 → 1.

   – Select the SS1 function and then deselect again: F-DI = 1 → 0 → 1.

   – Switch off the inverter supply voltage and on again (power on reset).

3. Acknowledge the inverter with the "standard" acknowledge signal.

You have acknowledged the discrepancy message

6.12 Selecting safety function when a safety function is active

The table below lists the notes regarding the behavior of your drive if you select more than one safety function at the same time.

Some cases do not affect the behavior of your drive. If, for example, the safety function STO is active, the motor torque remains switched off regardless of which inverter function you also select.

Table 6- 11 Interaction between two safety functions

	Select STO	Select SS1	Select SLS	Select SDI
STO is active	---	No effect	No effect	No effect
SS1 is active	See below	---	No effect	No effect
SLS is active	See below	See below	---	See below
SDI is active	See below	See below	See below	---
SSM is active	See below	See below	See below	See below

	Select STO
SS1 is active	

Example: SS1 with acceleration monitoring

	Select STO
SLS is active	Deselect SLS Deselect STO Speed — SLS — Motor runs down to standstill SLS active STO active LED SAFE — Yellow - on — Yellow - flashes slowly LED RDY — Green - on

	Select STO
SDI is active	Deselect SS1 Deselect STO Speed — The motor coasts to a standstill SDI + SDI+ active — "SDI active" remains active SDI+ active — "SDI active" becomes inactive STO active LED SAFE — Yellow - on — Yellow - flashes slowly LED RDY — Green - on

	Select STO
SSM is active	Example for speed < SSM monitoring speed Example for speed > SSM monitoring speed

	Select SS1
SLS is active

Example: SS1 with braking ramp monitoring |

	Select SS1
SDI is active	 Example: SS1 with acceleration monitoring SAM

	Select SS1
SSM is active	Example: SS1 with brake ramp monitoring < SSM monitoring speed Example: SS1 with brake ramp monitoring, speed < SSM monitoring speed

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	Select SLS
SDI is active	

	Select SLS
SSM is active	

	Select SDI
SLS is active	

	Select SDI
SSM is active	

6.13 List of alarms and faults
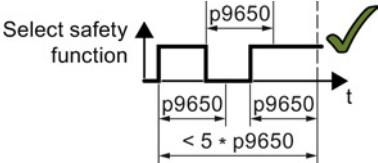
Syntax for faults and alarms

F12345	Fault 12345
A67890	Alarm 67890
C01700	Message 1700 for safety functions
	These messages are either alarms or faults, see the following table.

The table in this manual only contains the alarms and faults of the safety functions. The complete list of all alarms and faults of the inverter, detailed causes and remedial measures can be found in the List Manual.

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
F01600	STOP A initiated.	1. Select STO and then deselect again. 2. If it cannot be acknowledged, replace the Control Unit.
F01611	Defect in a monitoring channel. More detailed information is provided by fault value r0949.	The complete list of the fault values is provided in the List Manual. 0: Stop request from processor 2. 1 … 999: Fault in data cross-check between processor 1 and processor 2. Details and remedy: Please refer to the List Manual. 1000: Check (watchdog) timer has expired. When selecting a safety function, the signal changed too frequently. The inverter monitors the signal to select a safety function after a signal change. If the signal state continues to change in shorter intervals than entered in p9650, after the time 5 × p9650 the inverter outputs fault F1611:

Signal	Cause	Remedy
Complete information on the messages is available in the List Manual.		
		Remedy:

Remedy:

- Check the F-DI wiring (contact problems).

- Resolve the contact problems or faults at the PROFIBUS master/PROFINET controller.

The inverter terminates the monitoring and does not signal any faults if the signal state remains stable before the time 5 × p9650 expires, longer than p9650:

1001, 1002: Initialization error, change timer/check timer.

Remedy: Power on reset2000: Status of the STO selection in the the two monitoring channels is different.
See also: Response to a discrepancy when STO is active
(Page 170).2001: Checkback signal of the safe pulse suppression for the two monitoring channels is different.

2002: Status of the delay timer SS1 in the two monitoring channels is different.
See also: Response to a discrepancy when STO is active
(Page 170).
See also: Response to a discrepancy when SS1 is active
(Page 183).

2003: Status of the STO terminal at processor 1 and processor 2 is different.Remedy for 2000, 2001, and 2003:

- Check the F-DI changeover tolerance time. Increase the value (p9650).

- Check the F-DI wiring (contact problems).

- Check the causes of the STO selection in r9772.

6000: Internal software fault

- Power on reset

- Upgrade firmware to later version

- Replace Control Unit

6064: Target address and PROFIsafe address differ (F_Dest_Add).

- Check the value of the F_Dest_Add F-parameter in the inverter

- Check the PROFIsafe address at processor 1 (p9610) and processor 2 (p9810).

6065: Target address invalid (F_Dest_Add).

- The target address must not be 0 or FFFF.

6066: Source address invalid (F_Source_Add).

- The source address must not be 0 or FFFF.

6067: Watchdog time value invalid (F_WD_Time).

- The watchdog time value must not be 0.

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
		6165: Fault in reception of the PROFIsafe telegram. This fault can also arise if the inverter has received an inconsistent or out-of-date PROFIsafe telegram after a power on reset or after the PROFIBUS/PROFINET line has been connected.
		• Check the configuration and communication in the inverter.
		• Check the value of the F_WD_Time F-parameter in the inverter. Increase the value.
		6166: Time monitoring fault in reception of the PROFIsafe telegram.
		• Check the configuration of the communication in the inverter.
		• Check the setting of the F_WD_Time value in the inverter. Increase the value.
		• Evaluate the diagnostic information in the F host.
		• Check the PROFIsafe connection.
A01620, F01620	Safe torque off active	Not necessary.
A01621, F01621	Safe Stop 1 active	Not necessary.
F01625	Sign-of-life error in the Safety data	1. Select STO, and then deselect again. 2. If it cannot be acknowledged, replace the Control Unit.
F01630	Brake control defective Fault value r0949 provides more detailed information.	Depending on the fault value, check the following: 10, 11: p1278 ≠ 0, brake not connected, cable interrupted or ground fault 20: Short-circuit in the brake winding 30, 31, 40: Brake not connected or a short-circuit in the brake winding 50: Fault in the Safe Brake Relay, in the Control Unit or in the Power Module.
A01631	Motor holding brake / SBC configuration does not make sense	Check and correct the parameterization of the motor holding brake: The following settings can result in this message: • p1215 = 0 and p9602 = 1. • p1215 = 3 and p9602 = 1.
F01640, F01641	It has been identified that a component has been replaced, acknowledgment/data save is necessary	See Section Corrective maintenance (Page 251).
F01649	Internal software error	1. Switch off the Control Unit power supply and then on again. 2. If it cannot be acknowledged, replace the Control Unit.
F01650	Acceptance test required	See Section Acceptance tests for the safety functions (Page 156).
F01651	Synchronization, safety time slices unsuccessful.	1. Switch off the Control Unit power supply and then on again. 2. If it cannot be acknowledged, replace the Control Unit.
F01653	PROFIBUS configuration error	Check the PROFIBUS configuration of the safety slot on the master side and on the Control Unit.

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
A01654	PROFIBUS configuration differs	Check the PROFIsafe configuring in the higher-level control. • Alarm value r2124 = 1: In the higher-level F control, remove the PROFIsafe configuring, or enable PROFIsafe in the drive. • Alarm value r2124 = 2: In the higher-level F control, configure the appropriate PROFIsafe telegram.
F01655	Aligning the monitoring functions	1. Check that the control cabinet design and cable routing are in compliance with EMC regulations. 2. Switch off the Control Unit power supply and then on again.
F01656	Motor Module parameter error	1. Recommission the safety functions. 2. If this is not successful, then replace the Control Unit.
F01658	PROFIsafe telegram number unsuitable	The PROFIsafe telegram number in p60022 is not suitable for the enabled safety functions. Check the following: • If PROFIsafe is not enabled (p9601.3 = 0), PROFIsafe telegrams must not be selected in p60022. • If PROFIsafe is enabled (p9601.3 = 1), you must select a PROFIsafe telegram in p60022. • If transfer of the F-DI via PROFIsafe is selected (p9501.30 = 1), you must select telegram 900 in p60022.
F01659	Write task for parameter rejected	Check the setting of the safety functions. You can find possible reasons for the message in the List Manual.
F01660	Safety functions not supported	Use a Power Module that supports the safety functions.
F01661	Simulation of the safety inputs active	Exit the simulation of the digital inputs of the Control Unit for the F-DI (p0795).
F01662	Error, internal communications	1. Switch off the Control Unit power supply and then on again. 2. Contact Technical Support if it cannot be acknowledged.
F01663	Copying the SI parameters rejected	1. Set p9700 = 0. 2. Check: p9501 ≠ 0 and/or p9601 ≠ 0. If this is the case, then correct both parameters. 3. Start the copy function again by entering the corresponding value into p9700.
F01665	System is defective	1. Switch off the Control Unit power supply and then on again. 2. Contact Technical Support if it cannot be acknowledged.
A01666, F01666	Static 1 signal at the F-DI for safe acknowledgement	Set the signal at the F-DI to acknowledge the safety functions for a logical 0 signal.
F01680	Checksum error safe monitoring functions	1. Check the safety-related parameters. 2. Power on reset

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Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
F01681	Incorrect parameter value	Correct the parameter value:
		Fault value (r0949) yyyyxxxx decimal, yyyy = supplementary information, xxxx = parameter
F01682	Monitoring function not supported	Deselect the monitoring function involved (p9501, p9601, p9801).
F01683	SLS enable missing	1. Enable the SLS function (p9501.0).
		2. Save the setting (copy RAM to ROM).
		3. Power on reset
F01690	Data backup problem involving the NVRAM	Please contact Technical Support.
F01692	Parameter value not permitted for encoderless	1. From r0949, read out the (decimal) parameter number with the incorrect value.
		2. Correct the parameter value of the checksums.
A01693, F01693	Safety parameter settings changed, warm restart/POWER ON required.	1. Save the parameters so that they are protected against power failure (RAM → ROM).
		2. Switch off the Control Unit power supply and then on again.
A01696	Select the motion monitoring function test when powering up	Deselect the forced dormant error detection of the extended functions and then select again.
A01697, F01697	Forced dormant error protection of the extended functions is required	Start the forced dormant error detection. The signal source to initiate this is parameterized in p9705.
A01698	Commissioning mode active	Not necessary.
A01699	Forced dormant error protection of the basic functions is required	Deselect STO, and then select again.
C01700 (fault)	STOP A initiated	Generally, this fault is a consequence of C01701, C01706, C01714 or C01716.
C01701 (fault)	STOP B initiated	Generally, this fault is a consequence of C01706, C01714 or C01716.
C01706 (alarm or fault) [1]	SAM/SBR limit exceeded	1. Check the motor braking response.
		2. Adapt the tolerance for the parameterization of the "safe braking ramp".

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
C01711 (alarm) [1]	Defect in a monitoring channel Fault value r2124 provides more detailed information.	The complete list of the r2124 fault values is provided in the List Manual. 0 … 2: Fault in data cross-check between processor 1 and processor 2. Remedy: Please refer to the List Manual. 3: Difference of the position actual value (r9713) between the two monitoring channels is greater than the tolerance in p9542. See also Section: Setting the gear ratio and actual value tolerance (Page 107). 4 … 43: Fault in data cross-check between processor 1 and processor 2. Remedy: Please refer to the List Manual. 44 … 57: The tolerance value for the monitoring function differs between the two monitoring channels. See also Section: Setting the gear ratio and actual value tolerance (Page 107). 58 … 999: Fault in data cross-check between processor 1 and processor 2. Remedy: Please refer to the List Manual. 1000: Check (watchdog) timer has expired. • Too many signal changes at the F-DI Remedy: • Check the F-DI wiring (contact problems). 1001: Initialization error of the check timer. • Remedy: Power on reset • Upgrade inverter firmware 1005: Pulses already canceled for test stop selection. 1011: Acceptance test status between the monitoring channels differ. • Diagnostics in the List Manual under r9571. 1020: Cyclic communication failure between the monitoring channels. • Remedy: Power on reset • Replace the Control Unit or the inverter. 1040: Pulses in active encoderless monitoring functions canceled. • Deselect the active safety function. Select and then deselect STO. • When the SLS monitoring function is active, you must switch on the motor within 5 s of deselecting STO. 1041: Current value too low for encoderless actual value acquisition. • Reduce the minimum current (p9588). 1042: Current or voltage plausibility error. • Increase the ramp-up and ramp-down time (p1120/p1121). • Check whether the current and speed control settings are correct (torque-forming, field-forming current and actual speed value must not fluctuate). • Reduce the dynamic response of the setpoint. • Increase the minimum current (p9588). • Maintain an adequate wait time before switching on the motor, also see: – Switching on the motor when SLS is active (Page 201) – Switching on the motor when SSM is active (Page 213) – Switching on the motor when SDI is active (Page 219) 1043: Too many acceleration processes. • Increase the voltage tolerance (p9589).

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
C01712 (alarm) [1]	Defect when processing F-IO	1. Check the F-DI wiring. 2. Check the setting of the safety functions. 3. Perform an acceptance test.
C01714 (alarm) [1]	Safely limited speed exceeded	1. Check the speed setpoint received from the higher-level control. 2. Check the SLS limits.
C01716 (fault)	Tolerance for safe direction of motion exceeded	Check the tolerance setting for the SDI function.
C01770 (fault)	Discrepancy error of the safety inputs or outputs.	Check the F-DI wiring.
A01772	Test stop safety inputs/outputs active.	The alarm automatically disappears after successfully ending or canceling (error) the forced dormant error detection (test stop).
F01773	Test stop error	1. Check the wiring of the safety output. 2. Start the forced dormant error detection.
A01774	Test stop required	The time to carry out the forced dormant error detection (test stop) has expired (p10003). Start the forced dormant error detection of the safety output.
A01795	Wait time after exiting safe pulse suppression expired	The wait time of 5 seconds has expired, and the motor was not switched on. See also the sections: • Switching on the motor when SLS is active (Page 201) • Switching on the motor when SSM is active (Page 213) • Switching on the motor when SDI is active (Page 219)
A01796	Waiting for communication	• Check the operating state of the F host. • Check the communication connection to the F host.
C01798 (alarm)	Test stop running	Not necessary. The inverter withdraws the message after the forced dormant error detection has been completed.
C01799 (alarm)	Acceptance test mode active	Not necessary. The inverter withdraws the message after the end of the acceptance test mode.
F30600	STOP A initiated. More detailed information is provided by fault value r0949	1. Select STO. 2. Deselect STO. 3. If it cannot be acknowledged, replace the Control Unit.
F30611	Defect in a monitoring channel. More detailed information is provided by fault value r0949.	Fault values and remedies are described under fault F01611.
A30620, F30620	Safe torque off active	Not necessary.
A30621, F30621	Safe Stop 1 active	Not necessary.
F30625	Sign-of-life error in the Safety data	1. Select STO. 2. Deselect STO. 3. If it cannot be acknowledged, replace the Control Unit.

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	

F30630	Brake control defective	1. Check the following:
		  – p1278 = 0.
		  – Motor holding brake connection
		  – Motor holding brake function
		  – EMC-compliant control cabinet design and cable routing
		2. Select STO, and then deselect again.

F30631		
F30649	Internal software error	1. Switch off the Control Unit power supply and then on again. 2. Contact Technical Support if it cannot be acknowledged.
F30650	Acceptance test required	See Section Acceptance tests for the safety functions (Page 156).
F30651	Synchronization with Control Unit unsuccessful.	1. Switch off the Control Unit power supply and then on again. 2. Contact Technical Support if it cannot be acknowledged.
F30655	Aligning the monitoring functions	1. Check that the control cabinet design and cable routing are in compliance with EMC regulations. 2. Switch off the Control Unit power supply and then on again.
F30656	Motor Module parameter error	1. Recommission the safety functions. 2. If this is not successful, then replace the Control Unit.
F30659	Write task for parameter rejected	Check the following: • Password • Only restore factory settings with the safety functions inhibited
F30662	Error, internal communications	1. Switch off the Control Unit power supply and then on again. 2. Contact Technical Support if it cannot be acknowledged.
F30664	Fault during power-up	Power on reset. Contact Technical Support if it cannot be acknowledged.
F30665	System is defective	1. Switch off the Control Unit power supply and then on again. 2. If it cannot be acknowledged, replace the Control Unit.
A30666, F30666	Static 1 signal at the F-DI for safe acknowledgement	Set the F-DI input to a 0 signal for acknowledging the safety functions.
F30672	Control Unit software incompatible	The Control Unit being used does not support the safety functions. Use the appropriate Control Unit.
F30680	Checksum error safe monitoring functions	1. Check the setting of the safety functions. 2. Switch off the Control Unit power supply and then on again.
F30681	Incorrect parameter value	Correct the parameter value: Fault value (r0949) yyyyxxxx decimal, yyyy = supplementary information, xxxx = parameter
F30682	Monitoring function not supported	Deselect the monitoring function involved (p9501, p9601, p9801).
F30683	SLS enable missing	1. Enable the SLS function (p9501.0). 2. Save the setting (copy RAM to ROM). 3. Switch off the Control Unit power supply and then on again.

Signal	Cause	Remedy
	Complete information on the messages is available in the List Manual.	
F30692	Parameter value incorrect for encoderless	Correct the parameter value.
A30693, F30693	Safety parameter settings changed, warm restart/POWER ON required.	1. Save the settings so that they are protected against power failure (RAM → ROM). 2. Switch off the Control Unit power supply and then on again.
C30700 (fault)	STOP A initiated	Generally, this fault is a consequence of C30701, C30706, C30714 or C30716.
C30701 (fault)	STOP B initiated	Generally, this fault is a consequence of C30706, C30714 or C30716.
C30706 (alarm or fault) [1]	SAM/SBR limit exceeded	1. Check the motor braking response. 2. Adapt the tolerance for the parameterization of the "safe braking ramp".
C30711 (alarm) [1]	Defect in a monitoring channel. Fault value r2124 provides more detailed information.	Diagnostics for the fault values and remedies are described under message C01711.
C30712 (alarm) [1]	Defect when processing F-IO	1. Check the F-DI wiring. 2. Check the setting of the safety functions. 3. Perform an acceptance test.
C30714 (alarm) [1]	Safely limited speed exceeded	1. Check the speed setpoint received from the higher-level control. 2. Check the SLS limits.
C30716 (fault)	Tolerance for safe direction of motion exceeded	Check the tolerance for the "SDI" function.
30730		
C30770 (fault)	Discrepancy error of the safety inputs or outputs.	Check the F-DI wiring.
C30798 (alarm)	Test stop running	Not necessary. The inverter withdraws the message after the forced dormant error detection has been completed.
C30799 (alarm)	Acceptance test mode active	Not necessary. The inverter withdraws the message after the end of the acceptance test mode.
[1] If the safety functions of the inverter have been enabled, then this alarm initiates a STOP response and an inverter fault.		

Corrective maintenance

7

7.1 Maintaining operational safety

Responsibility for operational safety

As company operating plants or machines or as supplier of plants and machines with safety-related equipment, you are responsible for the operational safety of your plant or machine. As a consequence, you are obliged to continually inform yourself about the products used.

> ⚠ **WARNING**
>
> **Risk of death by using incorrect components in safety-related plants and systems**
>
> Disregarding current product developments and features can result in an increased risk of accidents in safety-related plants and machines.
>
> • Register to receive the appropriate newsletters on these topics.
> • If necessary, modify your plant or machine so that the requirements of the safety functions are always complied with.

Registering to receive the newsletter

Procedure

Proceed as follows to register to receive a newsletter for inverters with integrated safety technology:

1. In the Internet, open the following page: Siemens automation technology (www.automation.siemens.com).
2. On this page, open the "Support" folder.
3. In the "Support" folder, select the "Newsletter" link.
4. Select "Login" and log in with your access data.

   If you have still not registered, then select "Register" and enter your access data.
5. Select the document type you wish to be informed about under "Select document type for topic and product newsletters".
6. Under "Product support", open the "Safety technology - Safety Integrated" folder.

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7. As a minimum, select the "Drive technology" Newsletter.
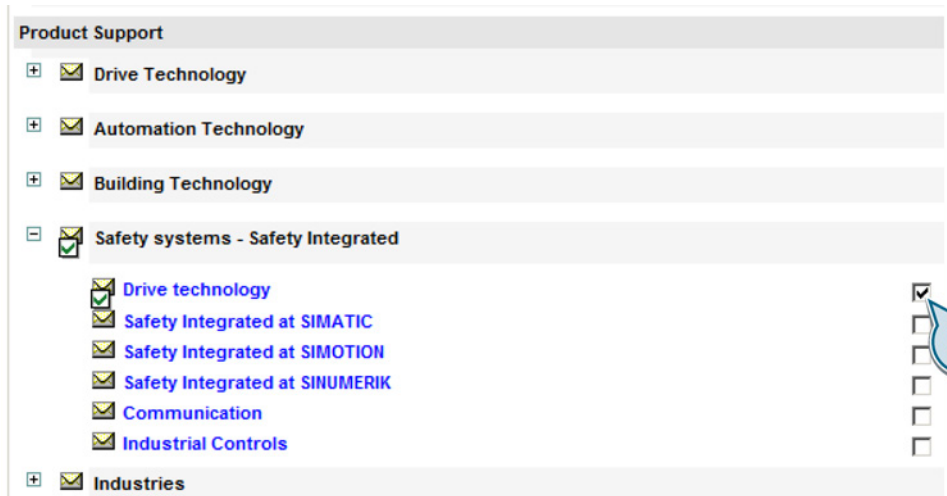
8. You can select additional Newsletters if you so desire.

9. Save your settings by pressing the appropriate button.
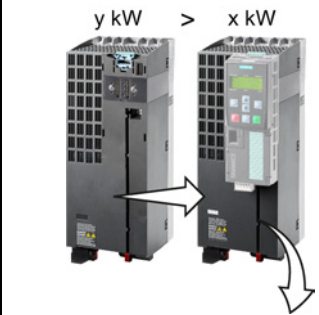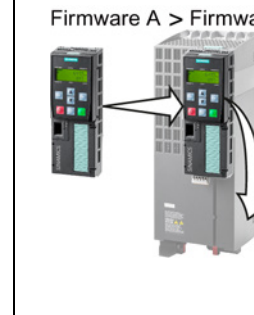
You have registered to receive the Newsletter for inverters with integrated safety technology.

7.2 Replacing components of the modular SINAMICS G120/G120D/G110M inverters

7.2.1 Overview of replacing converter components

Permissible replacement of components

In the event of a long-term function fault, you must replace the Power Module or Control Unit. The inverter's Power Module and Control Unit can be replaced independently of each other.

Replacing the Power Module		Replacing the Control Unit	
Replacement: • Same type • Same power rating	Replacement: • Same type • Same frame size • *Higher* power rating	Replacement: • Same type • Same firmware version	Replacement: • Same type • *higher* firmware version (e.g. replace FW V4.2 by FW V4.3)
	Power Module and motor must be adapted to one another (ratio of motor and Power Module rated power > 1/8)	After replacing the Control Unit, you must restore the inverter's settings.	

> ⚠ **WARNING**
>
> **Risk of injury due to uncontrolled drive motion**
>
> Replacing inverters of different types can result in uncontrolled motion of the drive.
>
> • In all cases that are not permitted according to the table above, recommission the drive after replacing an inverter.

Special issue relating to communication via PROFINET: Device replacement without removable data storage medium

The inverter supports the PROFINET functionality, replacing the device without data storage medium.

Precondition

The topology of the PROFINET IO system with the IO device involved is configured in your higher-level control system.

Replacing the device

The Control Unit can be replaced without having to insert a removable data storage medium (e.g. a memory card) with the saved device names in the inverter – or having to reassign the device names with a PG.

Details of the device replacement without removable storage medium can be found in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127).

7.2.2 Replacing a Control Unit with enabled safety function

Replacing a Control Unit with data backup on a memory card

Precondition

You have a memory card with the actual settings of the Control unit to be replaced.

If you use a memory card with firmware, after the replacement, you obtain a precise copy (firmware and settings) of the replaced Control Unit.

Procedure

To replace the Control Unit, proceed as follows:

1. Disconnect the line voltage to the Power Module and (if installed) the external 24 V supply or the voltage for the digital outputs of the Control Unit.

2. Remove the signal cables from the Control Unit.

3. Remove the defective Control Unit.

4. Remove the memory card from the old Control Unit and insert it in the new Control Unit.

5. Mount the new Control Unit on the Power Module. The new Control Unit must have the same order number and the same or higher firmware version as the Control Unit that was replaced.

6. Reconnect the signal cables of the Control Unit.

7. Connect up the line voltage again.

8. The inverter loads the settings from the memory card.

9. Check what the inverter reports after loading.

   – Alarm A01028:

     The loaded settings are not compatible with the inverter.

     Clear the alarm with p0971 = 1 and recommission the drive.

   – Fault F01641:

     Acknowledge the message.

     Carry out a **reduced** acceptance test; see Section: Reduced acceptance test after component replacement (Page 266).

You have replaced the Control Unit and transferred the safety function settings from the memory card to the new Control Unit.

Replacing a Control Unit with data backup in the PC

Precondition

You have backed up the actual settings of the Control Unit to be replaced to a PC using STARTER.

Procedure

To replace the Control Unit, proceed as follows:

1. Disconnect the line voltage to the Power Module and (if installed) the external 24 V supply or the voltage for the digital outputs of the Control Unit.

2. Remove the signal cables of the Control Unit.

3. Remove the defective Control Unit.

4. Mount the new Control Unit on the Power Module.

5. Reconnect the signal cables of the Control Unit.

6. Connect up the line voltage again.

7. Open the right project for the drive in STARTER.

8. Go online and transfer the settings from the PC to the inverter by pressing the ⬇ button. The inverter signals faults after the download. Ignore these faults, as they will be automatically acknowledged by the following steps.

9. In STARTER, select the screen form for the safety functions.

10. Select the "Change settings" button.

11. Select the "Activate settings" button.

12. Save your settings (copy RAM to ROM).

13. Switch off the inverter power supply.

14. Wait until all LEDs on the inverter go dark.

15. Switch on the inverter power supply again (power on reset).

16. Perform a **reduced** acceptance test, see the section Reduced acceptance test after component replacement (Page 266).

You have replaced the Control Unit and transferred the safety function settings from the PC to the new Control Unit.

Replacing the Control Unit with data backup in the operator Panel

Precondition

You have backed up the actual settings of the Control Unit to be replaced to an operator panel.

Procedure

To replace the Control Unit, proceed as follows:

1. Disconnect the line voltage to the Power Module and (if installed) the external 24 V supply or the voltage for the digital outputs of the Control Unit.

2. Remove the signal cables of the Control Unit.

3. Remove the defective Control Unit.

4. Mount the new Control Unit on the Power Module.

5. Reconnect the signal cables of the Control Unit.

6. Connect up the line voltage again.

7. Plug the Operator Panel into the Control Unit or connect the Operator Panel handheld device with the inverter.

8. Transfer the settings from the Operator Panel to the inverter.

9. Wait until the transfer is complete.

10. After loading, check whether the inverter outputs alarm A01028.

    – Alarm A01028:

      The loaded settings are not compatible with the inverter.

      Clear the alarm with p0971 = 1 and recommission the drive.

    – No alarm A01028: Proceed with the next step.

11. Switch off the inverter power supply.

12. Wait until all LEDs on the inverter go dark.

13. Switch on the inverter power supply again (power on reset).

    The inverter reports the faults F01641, F01650, F01680 and F30680. Ignore these faults, as they will be automatically acknowledged by the following steps.

14. Set p0010 to 95.

15. Set p9761 to the safety password.

16. Set p9701 to AC hex.

17. Set p0010 to 0.

18. Back up the settings so they are powerfail proof.

    – BOP-2 in the menu "EXTRAS" - "RAM-ROM".

    – IOP in the menu "SAVE RAM TO ROM".

19. Switch off the inverter power supply.

20. Wait until all LEDs on the inverter go dark.

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21. Switch on the inverter power supply again (power on reset).

22. Perform a **reduced** acceptance test, see the section Reduced acceptance test after component replacement (Page 266).

You have replaced the Control Unit and transferred the safety function settings from the operator panel to the new Control Unit.

7.2.3   Replacing the Control Unit without data backup

If you do not backup the settings, then you must recommission the drive after replacing the Control Unit.

Procedure

To replace the Control Unit without backed-up settings, proceed as follows:

1. Disconnect the line voltage to the Power Module and (if installed) the external 24 V supply or the voltage for the digital outputs of the Control Unit.

2. Remove the signal cables of the Control Unit.

3. Remove the defective Control Unit.

4. Mount the new Control Unit on the Power Module.

5. Reconnect the signal cables of the Control Unit.

6. Connect up the line voltage again.

7. Recommission the drive.

The Control Unit replacement has been completed after the drive has been successfully commissioned.

7.2.4   Replacing a Power Module with enabled safety function

⚠️DANGER

Danger from touching energized Power Module connections

After switching off the mains voltage, it will take up to 5 minutes until the capacitors in the Power Module are sufficiently discharged for the residual voltage to be safe. Death or serious injury will result if energized parts are touched.

- Check the safe isolation of the Power Module connections before carrying out installation work.

NOTICE

Material damage from swapping the motor's connection lines

The direction in which the motor rotates switches if you swap the two phases of the motor line. A motor running backwards may damage the machine or installation.

- Connect the three phases of the motor lines in the right order.
- After replacing the Power Module, check the direction in which the motor rotates.

Procedure

To replace the Power Module, proceed as follows:

1. Switch off the main voltage of the Power Module.
   You can leave any external 24 V supply to the Control Unit switched on.

2. Remove the connecting cables of the Power Module.

3. Remove the Control Unit from the Power Module.

4. Replace the Power Module.

5. Mount the Control Unit onto the new Power Module.

6. Connect up the new Power Module using the connecting cables.

7. Switch on the line supply and, if necessary, the 24 V supply for the Control Unit.

8. The inverter reports F01641.

9. Perform a reduced acceptance test, see the Section Reduced acceptance test after component replacement (Page 266).

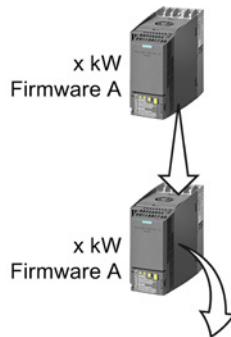You have successfully replaced the Power Module.
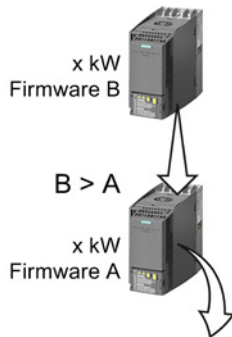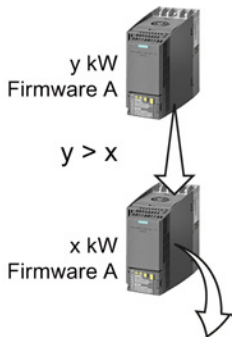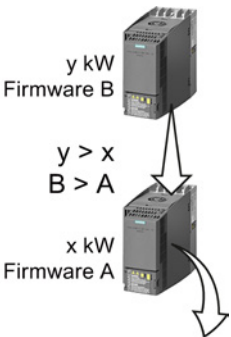
7.3 Replacing SINAMICS G120C inverters or SIMATIC ET 200pro FC-2 converters

7.3.1 Overview of how to replace an inverter

You must replace the inverter if it continually malfunctions.

Overview

In the following cases you will need to replace the inverter:

Replacement: • Same fieldbus interface • Same power rating • Same firmware version	Replacement: • Same fieldbus interface • Same power rating • *Higher* firmware version (e.g. replace FW V4.2 by FW V4.3)	Replacement: • Same fieldbus interface • Same frame size • *Higher* power rating • Same firmware version	Replacement: • Same fieldbus interface • Same frame size • *Higher* power rating • *higher* firmware version (e.g. replace FW V4.2 by FW V4.3)
		inverter and motor must be adapted to one another (ratio of the motor and inverter rated power > 1/8)	

After you have carried out the replacement, you must restore the inverter's settings.

> ⚠ **WARNING**
>
> **Risk of injury due to uncontrolled drive motion**
>
> Replacing inverters of different types can result in uncontrolled motion of the drive.
> • In all cases that are not permitted according to the table above, recommission the drive after replacing an inverter.

Special issue relating to communication via PROFINET: Device replacement without removable data storage medium

The inverter supports the PROFINET functionality, replacing the device without data storage medium.

Precondition

The topology of the PROFINET IO system with the IO device involved is configured in your higher-level control system.

Replacing the device

The inverter can be replaced without having to insert a removable data storage medium (e.g. a memory card) with the saved device names in the inverter – or having to reassign the device names with a PG.

Details of the device replacement without removable storage medium can be found in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127).

7.3.2 Replacing a converter with enabled safety function

⚠ DANGER
Risk of fatal injury when touching energized Power Module connections
After the power supply has been switched off, it takes up to 5 min. until the capacitors in the inverter have discharged so that the remaining voltage is at a non-hazardous level. Death or serious injury can result when live parts are touched.
• Check that the inverter connections are in a no-voltage condition before you carry out any installation work.

NOTICE
Material damage caused by interchanging the motor connecting cables
The direction in which the motor rotates changes if you interchange the two phases of the motor cable. A motor running backwards may damage the machine or installation.
• Connect the three phases of the motor cables in the correct sequence.
• After replacing the Power Module, check the direction in which the motor rotates.

Replacing an inverter with data backup on a memory card

Procedure

To replace the inverter, proceed as follows:

1. Disconnect the line voltage to the inverter and (if installed) the external 24 V supply or the voltage for the digital outputs of the inverter.

2. Remove the connecting cables of the inverter.

3. Remove the defective inverter.

4. Install the new inverter.

5. Remove the memory card from the old inverter, and insert this into the new inverter.

6. Connect all of the cables to the inverter.

7. Reconnect the line voltage, and (if being used) the external 24 V supply or the voltage for the digital outputs of the inverter.

8. The inverter loads the settings from the memory card.

9. After loading, check whether the inverter outputs Alarm A01028.

   – Alarm A01028:

   The loaded settings are not compatible with the inverter.

   Clear the alarm with p0971 = 1 and recommission the drive.

   – No alarm A01028:

   Carry out a **reduced** acceptance test; see Section: Reduced acceptance test after component replacement (Page 266).

You have replaced the inverter and transferred the safety function settings from the memory card to the new inverter.

Replacing an inverter with data backup in the PC

Procedure

To replace the inverter, proceed as follows:

1. Disconnect the line voltage to the inverter and (if installed) the external 24 V supply or the voltage for the digital outputs of the inverter.

2. Remove the connecting cables of the inverter.

3. Remove the defective inverter.

4. Install the new inverter.

5. Connect all of the cables to the inverter.

6. Reconnect the line voltage, and (if being used) the external 24 V supply or the voltage for the digital outputs of the inverter.

7. Open the right project for the drive in STARTER.

8. Go online and transfer the settings from the PC into the inverter by pressing the button.
   The inverter signals faults after the download. Ignore these faults, as they will be automatically acknowledged by the following steps.

9. In STARTER, select the screen form for the safety functions.

10. Select the "Change settings" button.

11. Select the "Activate settings" button.

12. Save your settings (copy RAM to ROM).

13. Switch off the inverter power supply.

14. Wait until all LEDs on the inverter are dark.

15. Switch on the inverter power supply again (power on reset).

16. Perform a **reduced** acceptance test, see the section Reduced acceptance test after component replacement (Page 266).

You have replaced the inverter and transferred the safety function settings from the PC to the new inverter.

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Replacing the inverter with data backup in the operator panel (BOP-2 or IOP)

Procedure

To replace the inverter, proceed as follows:

1. Disconnect the line voltage to the inverter and (if installed) the external 24 V supply or the voltage for the digital outputs of the inverter.

2. Remove the connecting cables of the inverter.

3. Remove the defective inverter.

4. Install the new inverter.

5. Connect all of the cables to the inverter.

6. Reconnect the line voltage, and (if being used) the external 24 V supply or the voltage for the digital outputs of the inverter.

7. Attach the operator panel to the inverter.

8. Transfer the settings from the operator panel to the inverter, e.g. via menu "EXTRAS" - "FROM BOP" in the BOP-2.

9. Wait until the transfer is complete.

   The inverter signals faults after the download. Ignore these faults, as they will be automatically acknowledged by the following steps.

10. Switch off the inverter power supply.

11. Wait until all LEDs on the inverter are dark.

12. Switch on the inverter power supply again (power on reset).

13. Perform a **reduced** acceptance test, see the section Reduced acceptance test after component replacement (Page 266).

You have replaced the inverter and transferred the safety function settings from the operator panel to the new inverter.

7.3.3 Replacing a converter without data backup

If the settings have not been backed up, after replacing the inverter, you must recommission the drive.

Procedure

To replace the inverter, proceed as follows:

1. Disconnect the line voltage to the inverter and (if installed) the external 24 V supply or the voltage for the digital outputs of the inverter.

2. Remove the connecting cables of the inverter.

3. Remove the defective inverter.

4. Install the new inverter.

5. Connect all of the cables to the inverter.

6. Reconnect the line voltage, and (if being used) the external 24 V supply or the voltage for the digital outputs of the inverter.

7. Recommission the drive.

Inverter commissioning has been completed after it has been commissioned.

7.4 Reduced acceptance test after component replacement

After a component has been replaced or the firmware updated, a reduced acceptance test of the safety functions must be performed.

Table 7- 1   Reduced acceptance test after component replacement

Measure	Acceptance test	Documentation
Replacing the Control Unit or the inverter with an identical type	An acceptance test for the safety functions is not required. Only check the motor's direction of rotation.	• Supplement inverter data • Log the new checksum • Countersignature
Replacing a Power Module with an identical type		Supplement the hardware version in the inverter data.
Replacing the motor with an identical pole pair number		No change.
Replacing the gearbox with an identical ratio		
Replacing the Safe Brake Relay	Check the SBC function.	Supplement the hardware version in the inverter data.
Replacing the safety-related peripherals (e.g. Emergency Stop switch).	Check the control of the safety functions affected by the components that have been replaced.	No change.
Inverter firmware update.	An acceptance test for the safety functions is not required. Check as to whether the firmware update was successful and the inverter functions as expected.	• Supplement firmware version in the inverter data • Log the new checksum • Countersignature

See also Section: Acceptance tests for the safety functions (Page 156).

System properties 8

8.1 Probability of failure of the safety functions (PFH value)

The specified probability of failure values apply under the following preconditions:

- The service life of the inverter has not expired.
- The test interval has not expired.

Service life

You may not operate inverters with integrated safety functions for longer than 20 years. The 20 years starts when the device is delivered. The service life cannot be extended. This is the case even if a service department checks the inverter – or in the meantime, the inverter was decommissioned.

Test interval

You must test the safety-related circuits of the inverter at least once every year. This process is called "forced dormant error detection" or "test stop".

Information on the procedure can be found in Section: Regularly testing the safety functions (Page 161).

Probability of failure

Table 8- 1   Probability of failure of the safety functions

Safety function	PFH, PFH$_D$ [1]	PFD [2]
STO, SBC [3], SS1, SLS, SDI, SSM	5×10^{-8} 1/h	5×10^{-3}

[1] PFH, PFH$_D$: Probability of dangerous failures per hour.

PFH according to IEC 61800-5-2, PFH$_D$ according to IEC 62061.

[2] PFD: For a low demand rate of the safety function: Mean probability of dangerous failure when the safety function is demanded according to IEC 61508.

[3] Including Safe Brake Relay

The machine manufacturer must specify a probability of failure in the form of a PFH value for every safety function of a machine.

The integrated inverter safety functions are only ever part of a complete machine safety function. A complete safety function comprises the following components, for example:

- A dual-channel sensor for detecting an open protective door.

- A central fail-safe controller for processing the sensor signal further.

- An inverter for safely stopping (SS1) a motor if a protective door is opened.

IEC 62061 explains how to calculate the PFH_D value for the complete safety function from the PFH_D values of the components used for the safety function.

We provide a free tool in the Internet to calculate the PFH_D value of a complete machine: Safety Evaluation Tool (www.siemens.com/safety-evaluation-tool).

Application examples for the probability of failure PFH and PFD are available in the Internet: Application example (http://support.automation.siemens.com/WW/view/en/76254308).

8.2 Response times

Response times after selection

When selecting the Safe Torque Off (STO) function, the motor is safely in a no-torque condition after the response time. If, at the instant that STO is selected, the motor is stationary, then after the response time, the motor is also in a safe state.

For all other functions, which are active after selection, the relationship between the response time and safe state of the motor is not always clear:

- SS1 of the basic functions: The motor is only in a safe state after the safety-related timer has expired and at standstill. In practice, after selection, the response time in comparison to the safety-related timer can be neglected.

- SS1 of the extended functions: The motor is only in a safe state when at standstill. When SS1 is selected, the inverter brakes the motor after the response time. Although the inverter monitors braking, the time until the motor comes to a standstill depends on the application itself, and from a non-safety-related parameter. Consequentially, in practice the response time after selection is not relevant.

- SLS and SDI: The motor is only in a safe state with the feedback signal "SLS is active" or "SDI is active". The time from selecting the function until the motor reaches a safe state depends on the application itself, and from a non-safety-related parameter. Consequentially, in practice the response time after selection is not relevant.

After selection, the response time is only relevant for the application for the STO function and is only specified for STO.

Response times of the STO function after selection.

The response times depend on the following conditions:

- Safety function setting
  - Basic function
  - Extended function
- PROFIBUS or PROFINET
- Selected via safety input or PROFIsafe

The response times in the tables below apply from the point at which the safety input signal changes or the PROFIsafe telegram is received.

The "worst case values" in the tables mean the following:

Worst case for a fault-free inverter:	The response time is less than or equal to the specified value. The response time is valid for fault causes outside the inverter itself, e.g.: • Incorrect setpoint input from the higher-level control system • Speed has violated the limit value
Worst case for an inverter fault:	The response time is less than or equal to the specified value. The response time is valid for fault causes inside the inverter itself, e.g.: • Fault/error in a switch-off signal path • Microprocessor error

Response times of the STO function when selected via PROFIsafe

Table 8- 2   Response times of the STO basic function

	Worst case for a fault-free inverter	Worst case for an inverter fault
PROFIBUS	14 ms	
PROFINET	14 ms + bus cycle time	

Table 8- 3   Response times of the STO extended function

	Worst case for a fault-free inverter	Worst case for an inverter fault
PROFIBUS	54 ms	56 ms
PROFINET	54 ms + bus cycle time	56 ms + bus cycle time

Bus cycle time: Time for a cyclic data exchange via PROFINET.

Response times of the STO function when selected via a safety input

Table 8- 4   STO response times

	Worst case for a fault-free inverter	Worst case for an inverter fault
STO basic function	4 ms + t_E [1]	6 ms + t_E [1]
STO extended function	50 ms + t_E [1]	52 ms + t_E [1]
[1]	When debounce time > 0: t_E = debounce time + 3 ms If debounce time = 0: t_E = 4 ms Depending on how you set the STO safety function, you can find a description of the debounce time in one of the following sections: • STO as a basic function: Setting the filter for safety inputs (Page 94). • STO as an extended function: Setting the filter for safety inputs (Page 113).	

Response time after PROFIsafe communication interruption

If the PROFIsafe telegram does not appear before the end of the PROFIsafe monitoring time F_WD_Time, the inverter responds as follows:

- The inverter signals one of the following faults:
  – Fault F01611 (basic functions have been enabled)
  – Message C01711 (extended functions have been enabled)

  The inverter receives monitoring time F_WD_Time from the fail-safe controller (F-CPU). See also the section Configuring PROFIBUS communication with telegram 30 via GSD (Page 78).

- The inverter selects the STO function.

Response times when limit values are violated

Table 8- 5   Time until the response is initiated

Function	Response	Worst case for a fault-free drive system	Worst case when a fault exists
SS1	STOP A	67 ms [2]	113 ms [2]
SLS	STOP A or STOP B		
SDI	STOP A or STOP B		
[2]	If you switch on the motor when a safety function is active, the inverter detects a limit value violation at the earliest after the "delay time actual value acquisition" has expired, also refer to Section: Setting encoderless actual value sensing (Page 109).		

Signal change into the "Status SSM"

Function	Response	Worst case for a fault-free drive system	Worst case when a fault exists
SSM	Signal change into the "Status SSM"	67 ms [3]	113 ms [3]
[3]	If you switch on the motor when a safety function is active, the inverter signals the correct status at the earliest after the "Delay time actual value acquisition" has expired, also refer to Section: Setting encoderless actual value sensing (Page 109).		

8.3 Certification

Certifications

The safety functions of the inverter fulfill the following requirements:

- Category 3 and Performance Level (PL) d according to EN ISO 13849-1:2006
- Safety integrity level 2 (SIL 2) to IEC 61508
- EC declaration of conformity

EC type-examination certificate and manufacturer declaration

The safety functions integrated in the drive are certified by a test institute for each of the firmware versions that have been released. With the EC type-examination certificate, the test institute confirms that the safety functions comply with the requirements as laid down in EN ISO 13849-1 and IEC 61508.

We provide a manufacturer's declaration for the transition period from releasing a firmware version up to the test institute issuing an EC type-examination certificate. The manufacturer declaration confirms that the safety functions are in conformance with the appropriate standards.

Procedure

Proceed as follows, to load the certificates relevant for Safety Integrated from the Internet:

1. In the Internet, open the following page: Certificates
   (http://support.automation.siemens.com/WW/view/en/36426537/134200)

2. Filter according to Certificate type "Functional safety/machine safety".

3. Select the certificate according to the inverter order number.
   – There is an EC type-examination certificate and a manufacturer declaration for each inverter family.
   – Each certificate includes lists with the associated firmware and hardware.
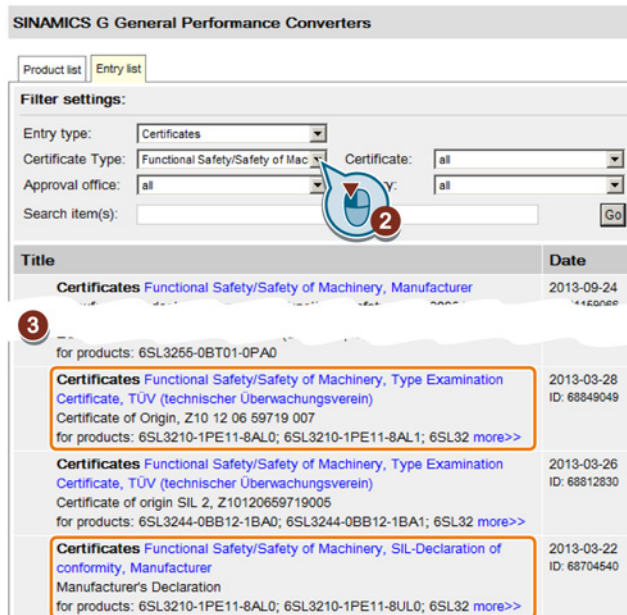
You have loaded certificates relevant for Safety Integrated from the Internet.

EC Declaration of Conformity

According to Annex IV of the machinery directive, drives equipped with Safety Integrated are defined as "Logic units for safety functions" and therefore as a safety component. The machinery directive specifies that safety components should be handled just like machines. As a consequence, safety components require a CE marking.

As machine builder, you must provide documentation that you create for the CE marking of the machine, together with the EC Declaration of Conformity for the products that have been installed.

The current EC Declarations of Conformity for the inverter are available in the Internet:

EC Declaration of Conformity
(http://support.automation.siemens.com/WW/view/en/67385845)

8.4 Safe Brake Relay

Technical data of the Safe Brake Relay

Technical data	Property
Supply voltage	20.4 to 28.8 V DC We recommend that you use a power supply with a minimum rated voltage of 26 V in order to compensate for voltage drops along the brake cable.
Current drawn at 24 V DC	0.05 A + the current drawn by the motor brake
Maximum current	2 A
Conductor cross section, max.	2.5 mm^2
Dimensions (W x H x D)	69 mm x 63 mm x 33 mm
Weight	approx. 0.17 kg

Appendix A

A.1 Examples of acceptance tests

For the acceptance test, check whether the safety functions in the inverter have been set correctly. The following acceptance tests are examples which demonstrate the basic procedure. They are not suitable for every possible setting of the inverter.

Recommendations for the acceptance test

- Perform the acceptance test with the maximum possible velocity and acceleration to test the expected maximum braking distances and braking times.

- The trace function in the STARTER PC tool can simplify the acceptance test in certain applications: for example, if a drive in the machine is difficult to access. Therefore, we recommend that you use the trace function for some acceptance tests.

- If you have recorded a trace for an acceptance test, you have to proceed as follows:

    - When you save the trace, enter the storage location in the acceptance report.

    - If you print the trace, append the printout to the acceptance report.

- If you can carry out the acceptance test without the trace function, there is no need to use this tool.

- Alarm A01697:

    These alarms are issued following each system startup and are not critical for acceptance.

After the acceptance test of the inverter's safety functions, you must also check whether the safety-related functions in the machine or system are functioning correctly. See also Acceptance test (Page 156).

Acceptance support by the STARTER application

The "Safety Acceptance Test" application guides you semi-automatically through the acceptance test of the safety functions. The application logs its settings as an Excel file.

Application acceptance test (http://support.automation.siemens.com/WW/view/en/73102423).

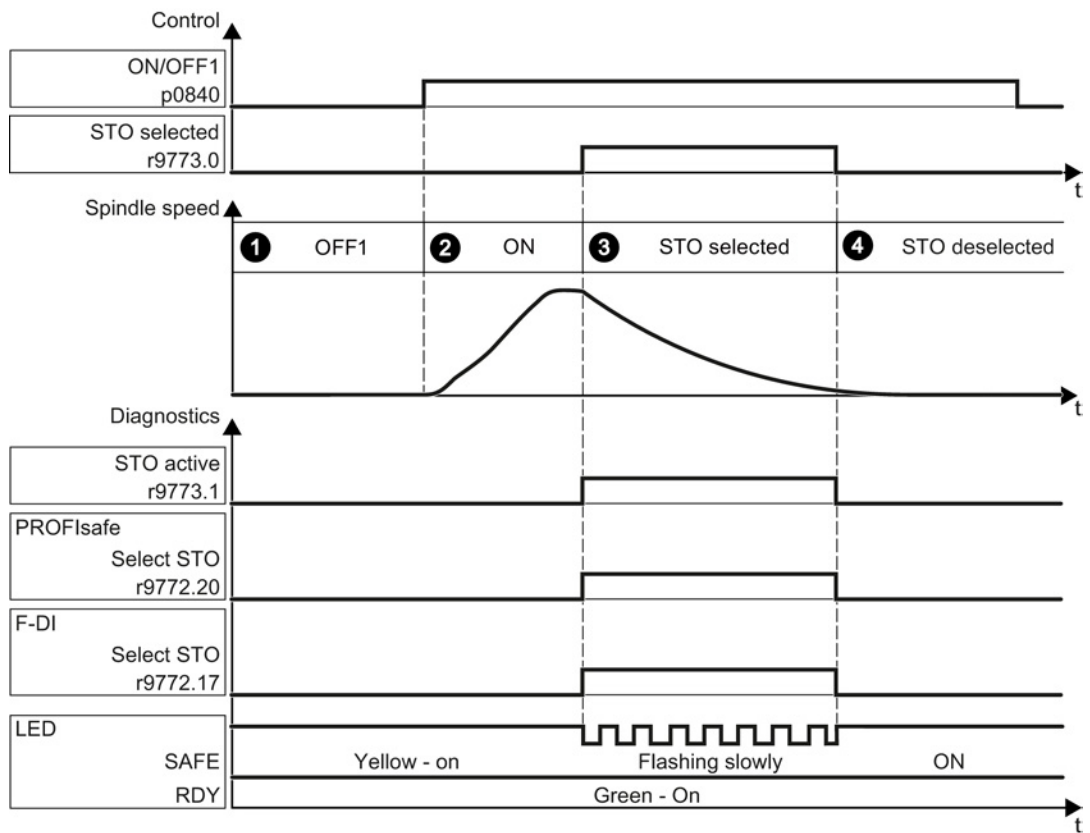## A.1.1 Acceptance test STO (basic functions)

Figure A-1   Acceptance test for STO (basic functions)

Procedure

To perform an acceptance test of the STO function as part of the basic functions, proceed as follows:

		Status
1.	**The inverter is ready**	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• STO is not active (r9773.1 = 0).	
2.	**Switch on motor**	
	2.1. Enter a speed setpoint ≠ 0.	
	2.2. Switch on the motor (ON command).	
	2.3. Check that the correct motor is running.	
3.	**Select STO**	
	3.1. Select STO while the motor is running *Test each configured activation, e.g. via digital inputs and PROFIsafe.*	
	3.2. Check the following:	
	When controlled by PROFIsafe / For control via terminal	
	• The inverter signals the following: "STO selection via PROFIsafe" (r9772.20 = 1) • The inverter signals the following: "STO Selection via terminal" (r9772.17 = 1)	
	• If a mechanical brake is not available, the motor coasts down. A mechanical brake brakes the motor and holds it to ensure that it remains at a standstill.	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• The inverter signals the following: "STO is selected" (r9773.0 = 1). "STO is active" (r9773.1 = 1).	
4.	**Deselect STO**	
	4.1. Deselect STO.	
	4.2. Check the following:	
	• STO is not active (r9773.1 = 0).	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	

You have performed the acceptance test of the STO function.

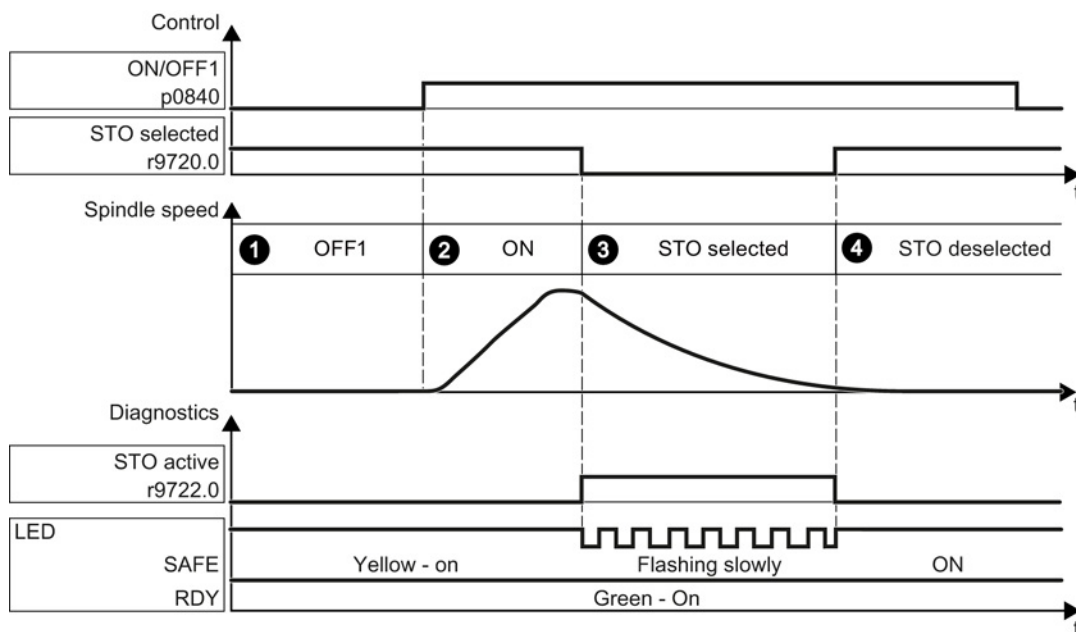## A.1.2 Acceptance test STO (extended functions)

Figure A-2   Acceptance test for STO (Extended functions)

Procedure

To perform an acceptance test of the STO function as part of the extended functions, proceed as follows:

		Status
1.	**The inverter is ready**	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• STO is not active (r9722.0 = 0).	
2.	**Switch on motor**	
	2.1. Enter a speed setpoint ≠ 0.	
	2.2. Switch on the motor (ON command).	
	2.3. Check that the correct motor is running.	
3.	**Select STO**	
	3.1. Select STO while the motor is running.	
	3.2. Check the following:	
	• If a mechanical brake is not available, the motor coasts down. A mechanical brake brakes the motor and holds it to ensure that it remains at a standstill.	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• The inverter signals the following: "STO is active" (r9722.0 = 1).	
4.	**Deselect STO**	
	4.1. Deselect STO.	
	4.2. Check the following:	
	• STO is not active (r9722.0 = 0).	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	

You have performed the acceptance test of the STO function.

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A.1.3   SS1 acceptance test (basic functions)
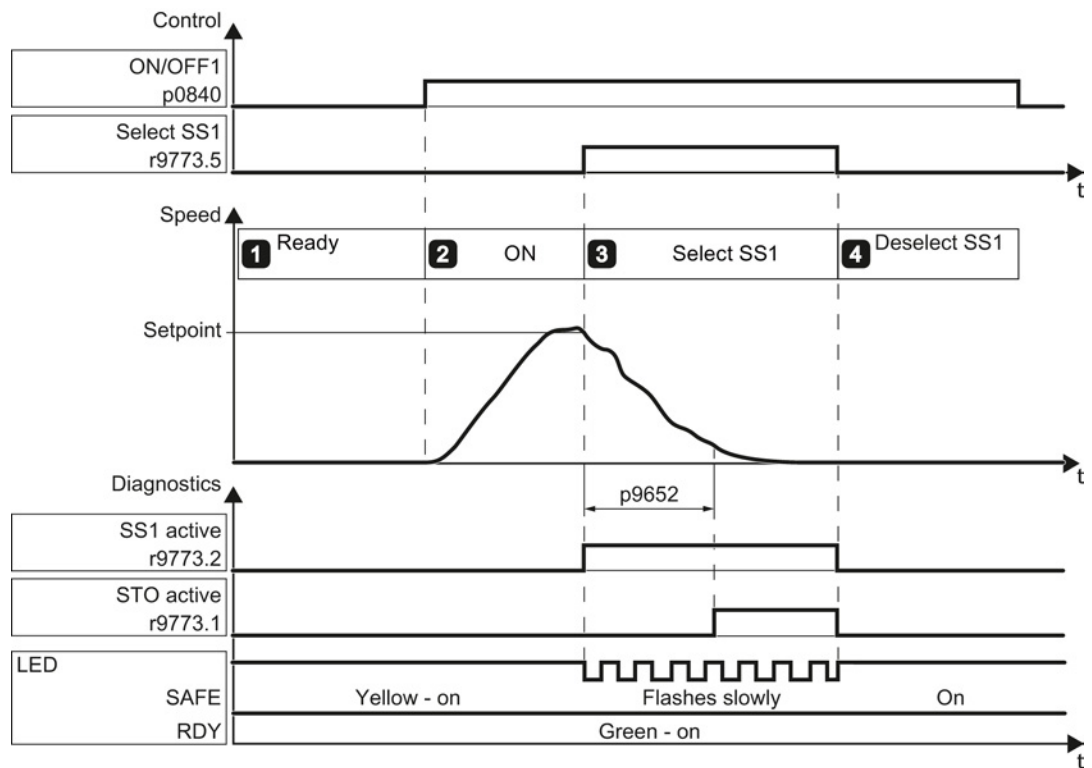

Figure A-3   SS1 acceptance test for basic functions

Procedure

To perform the acceptance test of the SS1 function, proceed as follows:

			Status
1.	**The inverter is ready**		
	Check the following:		
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).		
	• SS1 is not active (r9773.6 = 0).		
2.	**Switch on motor**		
	2.1.	Enter a speed setpoint ≠ 0.	
	2.2.	Switch on the motor (ON command).	
	2.3.	Check that the correct motor is running.	
3.	**Select SS1**		
	3.1.	Select SS1 while the motor is switched on. *Test each configured activation, e.g. via digital inputs and PROFIsafe.*	
	3.2.	In your machine, check the following:	
		• The motor brakes on the OFF3 ramp.	
		• SS1 is active (r9773.6 = 1).	
		• After the p9652 time has expired, the inverter signals: "STO is active" (r9773.1 = 1).	
4.	**Deselect SS1**		
	4.1.	Deselect SS1.	
	4.2.	Check the following:	
		• SS1 is not active (r9773.6 = 0).	
		• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	

You have completed the acceptance test of the SS1 function.

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A.1.4   SS1 acceptance test (extended functions)

The two diagrams show the recommended steps to take during the acceptance test. The behavior of the drive differs according to the settings you have made for SS1:

- Diagram 1: After SS1 has been selected, the inverter monitors the speed using braking ramp monitoring.

- Diagram 2: After SS1 has been selected, the inverter monitors the speed using the acceleration monitoring.
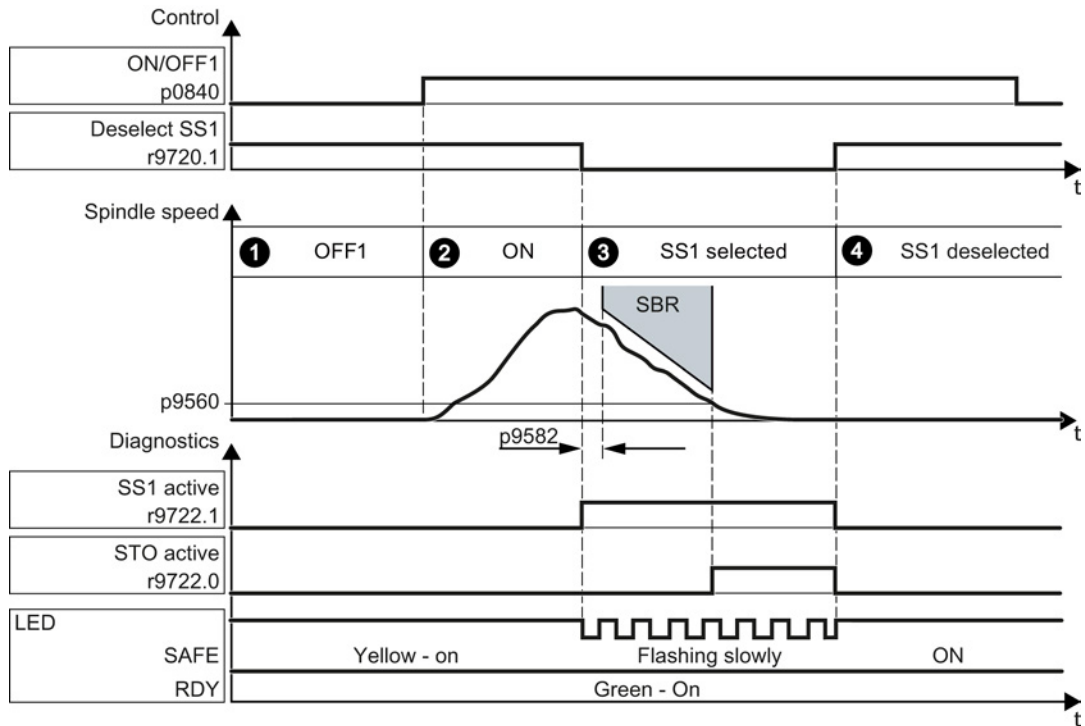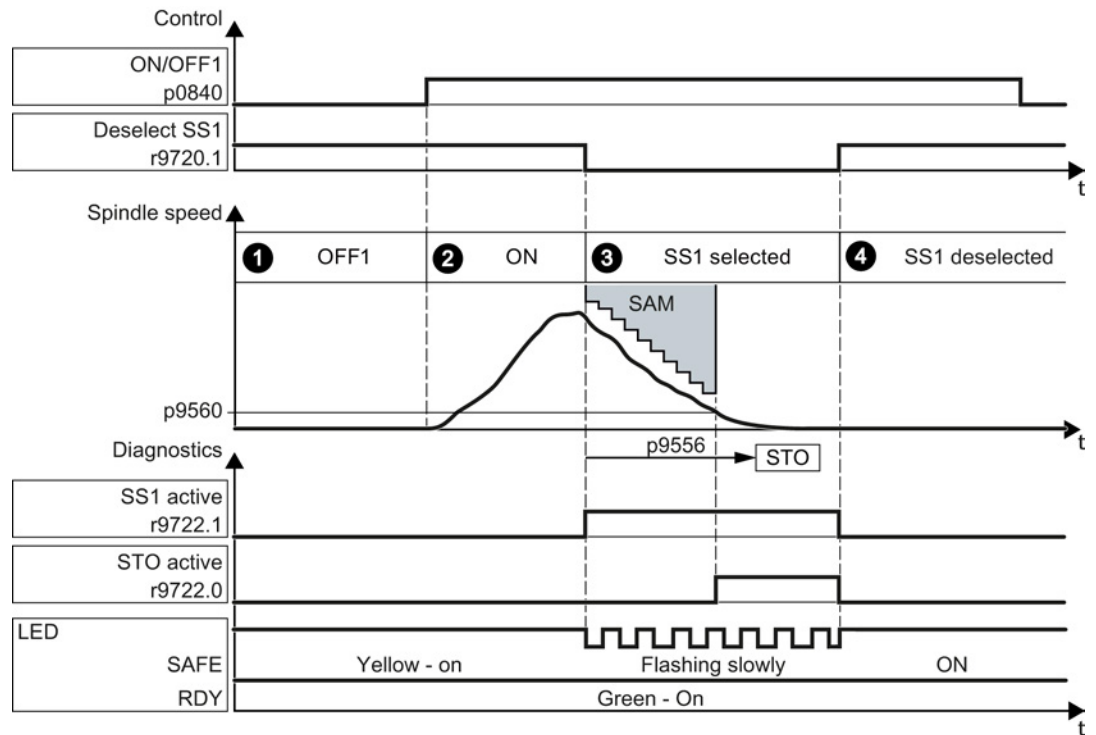

Figure A-4   Diagram 1 - acceptance test SS1 with braking ramp monitoring

Figure A-5   Diagram 2 - acceptance test for SS1 with acceleration monitoring

Procedure

To perform the acceptance test of the SS1 function, proceed as follows:

		Status
1.	**The inverter is ready**	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• SS1 is not active (r9722.1 = 0).	
	Go online with the STARTER and configure the following trace: • Trigger on variable - bit pattern (r9720.1 = 0) • Record the following values: r9714[0], r9714[1], r9722 Display the bits r9722.0/.1 • Select the time interval and pretrigger so you can recognize the selection of SS1 and the transition into the subsequent STO state. • Start the trace.	
2.	**Switch on motor**	
2.1.	Enter a speed setpoint ≠ 0.	
2.2.	Switch on the motor (ON command).	
2.3.	Check that the correct motor is running.	
3.	**Select SS1**	
3.1.	Select SS1 while the motor is switched on. *Test each configured activation, e.g. via digital inputs and PROFIsafe.*	
3.2.	Check: The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
3.3.	Analyze the trace.	
	• SS1 is active after selecting SS1 (r9722.1 = 1).	
	• The motor brakes on the OFF3 ramp.	
	• STO becomes active if the velocity drops below the shutdown velocity p9560 (r9722.0 = 1).	
	• The recorded curves of r9714[0] and r9714[1] are approximately parallel.	
4.	**Deselect SS1**	
4.1.	Deselect SS1.	
4.2.	Check the following:	
	• SS1 is not active (r9722.1 = 0).	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	

You have completed the acceptance test of the SS1 function.

Example of a trace
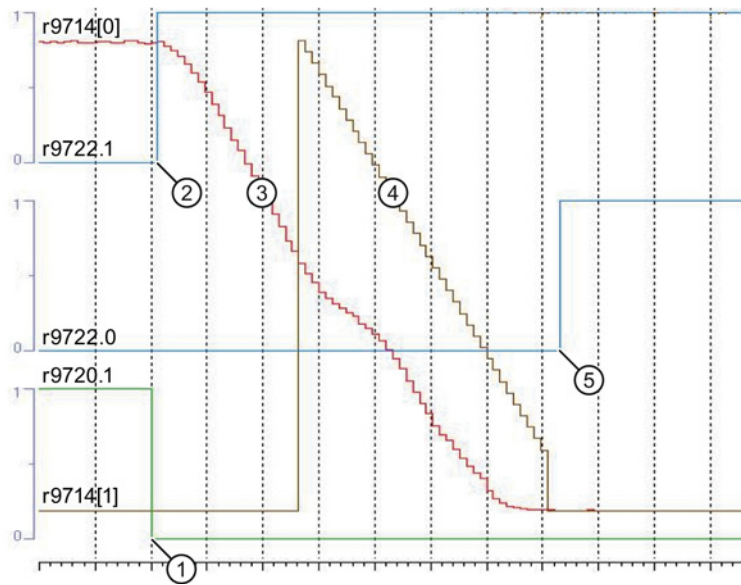
① SS1 is selected

② SS1 is active

③ Speed: The motor brakes on the OFF3 ramp.

④ Monitoring the speed when braking
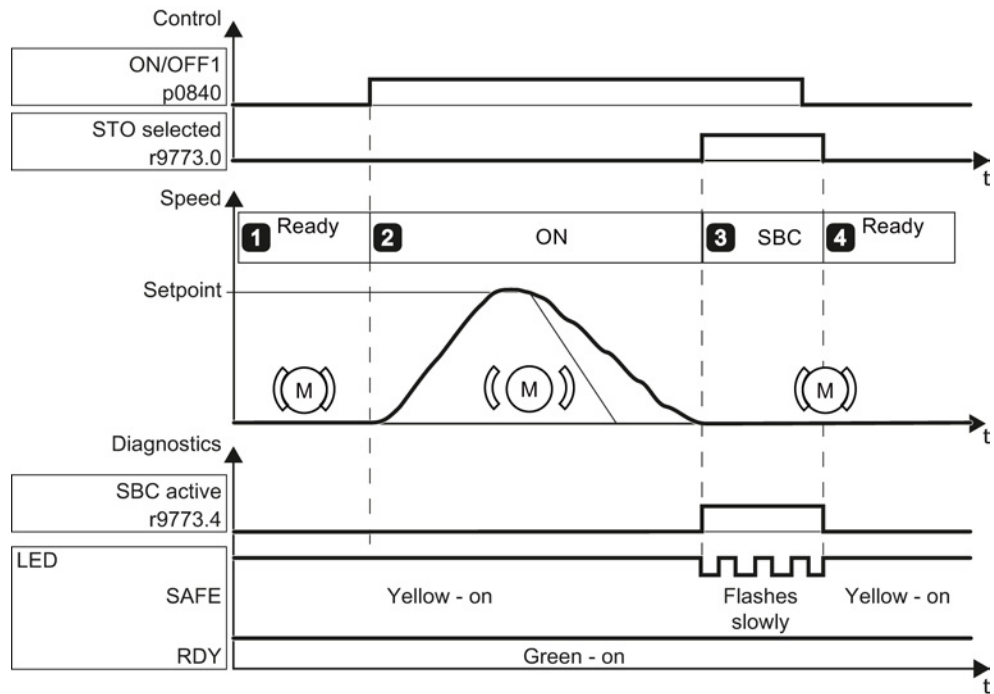
⑤ STO is active

A.1.5 SBC acceptance test

Figure A-6   Acceptance test for SBC

Procedure

To perform the acceptance test of the SBC function, proceed as follows:

		Status
1.	**The inverter is ready**	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• SBC is not active (r9773.4 = 0).	
2.	**Switch on motor**	
	2.1. Enter a speed setpoint ≠ 0.	
	2.2. Switch on the motor (ON command).	
	2.3. Check that the correct motor is running.	
	2.4. Enter a speed setpoint = 0.	
3.	**Select SBC**	
	3.1. Select the STO function or the SS1 function.	
	3.2. Check: The inverter signals "SBC is active" (r9773.4 = 1).	
4.	**inverter is ready**	
	4.1. Deselect STO.	
	4.2. Check the following:	
	• The inverter signals "SBC is not active" (r9773.4 = 0).	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	

You have performed the acceptance test of the SBC function.

A.1.6   Acceptance test SLS

The two diagrams show the recommended steps to take during the acceptance test. The behavior of the drive differs according to the settings you have made for SLS :

- Diagram 1: If the speed is excessively high, the drive responds with a STOP A.
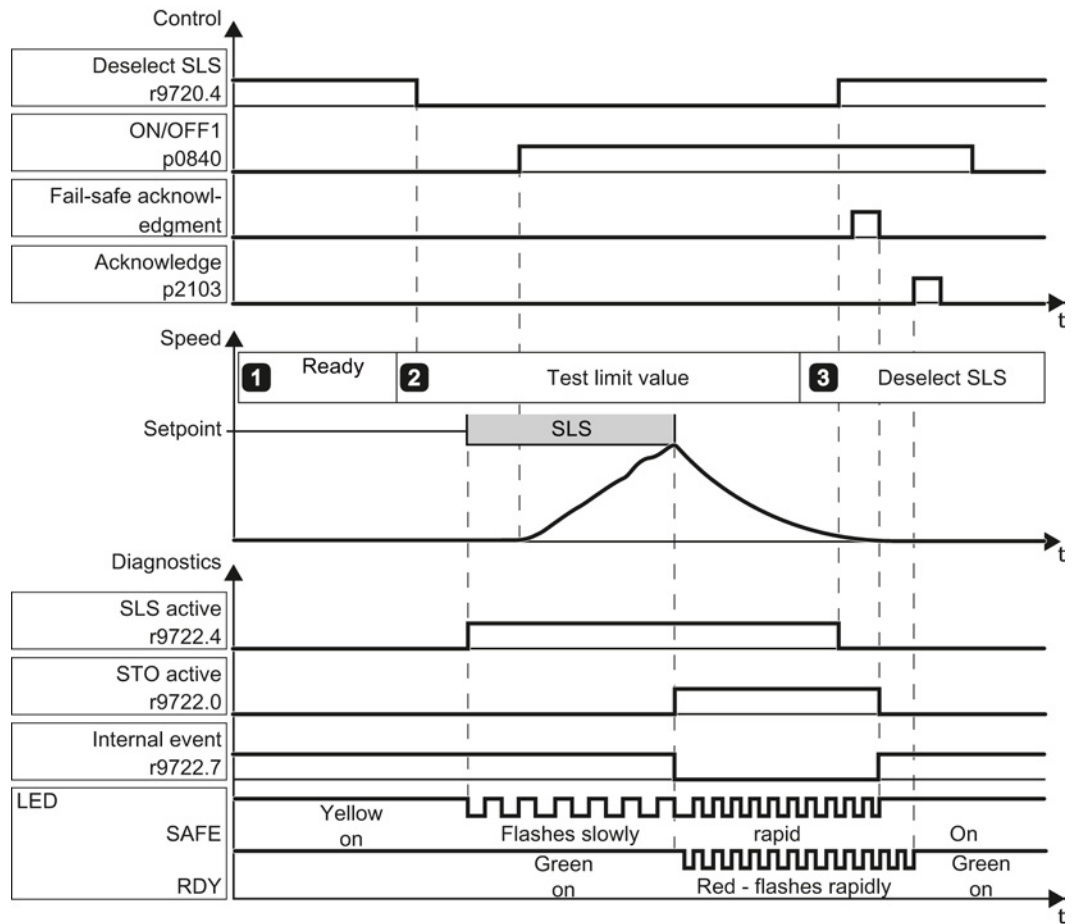- Diagram 2: If the speed is excessively high, the drive responds with a STOP B.

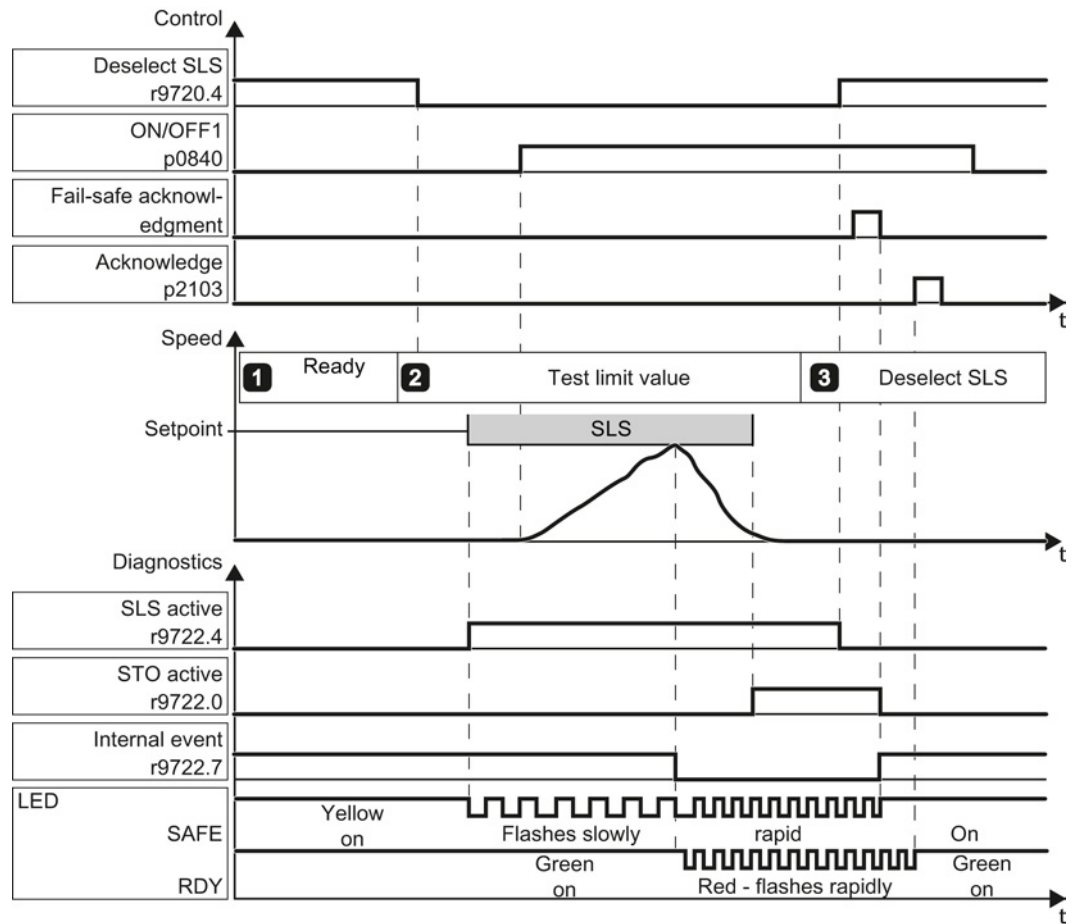Figure A-7   Diagram 1 - acceptance test for SLS with stop reaction STOP A

Figure A-8   Diagram 2 - acceptance test SLS with stop reaction STOP B

Procedure

To perform the acceptance test of the SLS function, proceed as follows:

		Status
If you are using multiple SLS levels, repeat the test for each of the SLS levels.		
1.	**The inverter is ready**	
	Check the following:	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• SLS is not active (r9722.4 = 0).	
	Go online with the STARTER and configure the following trace: • Trigger on variable - bit pattern (r9722.7 = 0) • Record the following values: r9714[0], r9714[1], r9722 Display the bits r9722.0/.4/.7/.9/.10 • Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses.	
2.	**Switch on motor**	
2.1.	Enter a speed setpoint > SLS level.	
2.2.	Select SLS with the SLS level to be tested.	
2.3.	Activate the acceptance mode: 	
	WARNING **Machine motion hazard** In the following test, speed limitation of the SLS function is deactivated. The increased motor speed can lead to material damage or physical injury. • For this test, secure dangerous machine parts using barriers, for example.	
2.4.	Switch on the motor within 5 seconds after selecting SLS (ON command). *If you wait longer than 5 seconds for the ON command, then STO is activated. In this case, deselect SLS and then select it again.*	

				Status
	2.5.	Check that the correct motor is running.		
		The following tests depend on how you have set the SLS function during commissioning:		
		First diagram:	*Second diagram:*	
		The inverter responds with STOP A in the event of a limit violation.	*The inverter responds with STOP B in the event of a limit violation.*	
	2.6.	The inverter signals the following: • C01714 and C30714 (safe velocity limit exceeded) • C01700 and C30700 (STOP A initiated)	The inverter signals the following: • C01714 and C30714 (safe velocity limit exceeded) • C01701 and C30701 (STOP B initiated) • C01700 and C30700 (STOP A initiated)	
	2.7.	Analyze the trace.		
		• After SLS is selected, the inverter signals "SLS is active" (r9722.4 = 1).		
		• The inverter signals the selected SLS level (r9722.9 and r9722.10).		
		• If r9714[0] exceeds the active SLS limit, the inverter signals an internal event (r9722.7 = 0).		
		STOP A in the event of a limit value violation	*STOP B in the event of a limit value violation*	
		• If r9714[0] exceeds the active SLS limit, the motor coasts down to a standstill (r9722.0 = 1).	• If r9714[0] exceeds the active SLS limit, the motor brakes on the OFF3 ramp (r9722.1 = 1).	
			• After braking, STO is active (r9722.0 = 1).	
3.	**Deselect SLS**			
	3.1.	Deselect SLS.		
	3.2.	Check: SLS is not active (r9722.4 = 0).		
	3.3.	Acknowledge the messages for the safety functions.		

☐   You have performed the acceptance test of the SLS function.

Example of a trace (STOP B in the event of a limit violation)
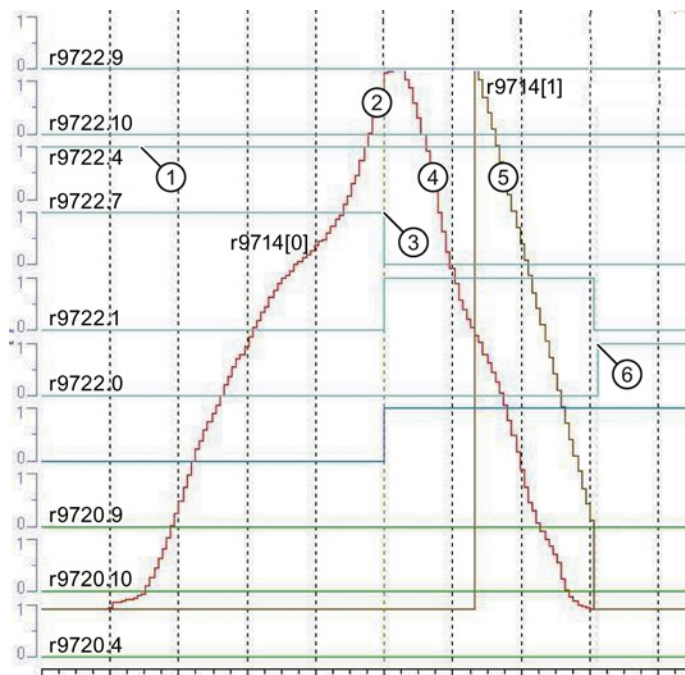
① SLS is active

② Speed: The motor accelerates to the active SLS level

③ The speed exceeds the active SLS level

④ Speed: STOP B is active - the motor brakes on the OFF3 ramp

⑤ Monitoring the speed when braking

⑥ STO as a consequence of STOP B being active

A.1.7 SSM acceptance test

The two diagrams show the recommended steps to take during the acceptance test. It differs depending on the settings you have made for SSM:

● Diagram 1: The "speed below limit value" checkback signal remains active when the motor is switched off.

● Diagram 2: The "speed below limit value" checkback signal becomes inactive when the motor is switched off.

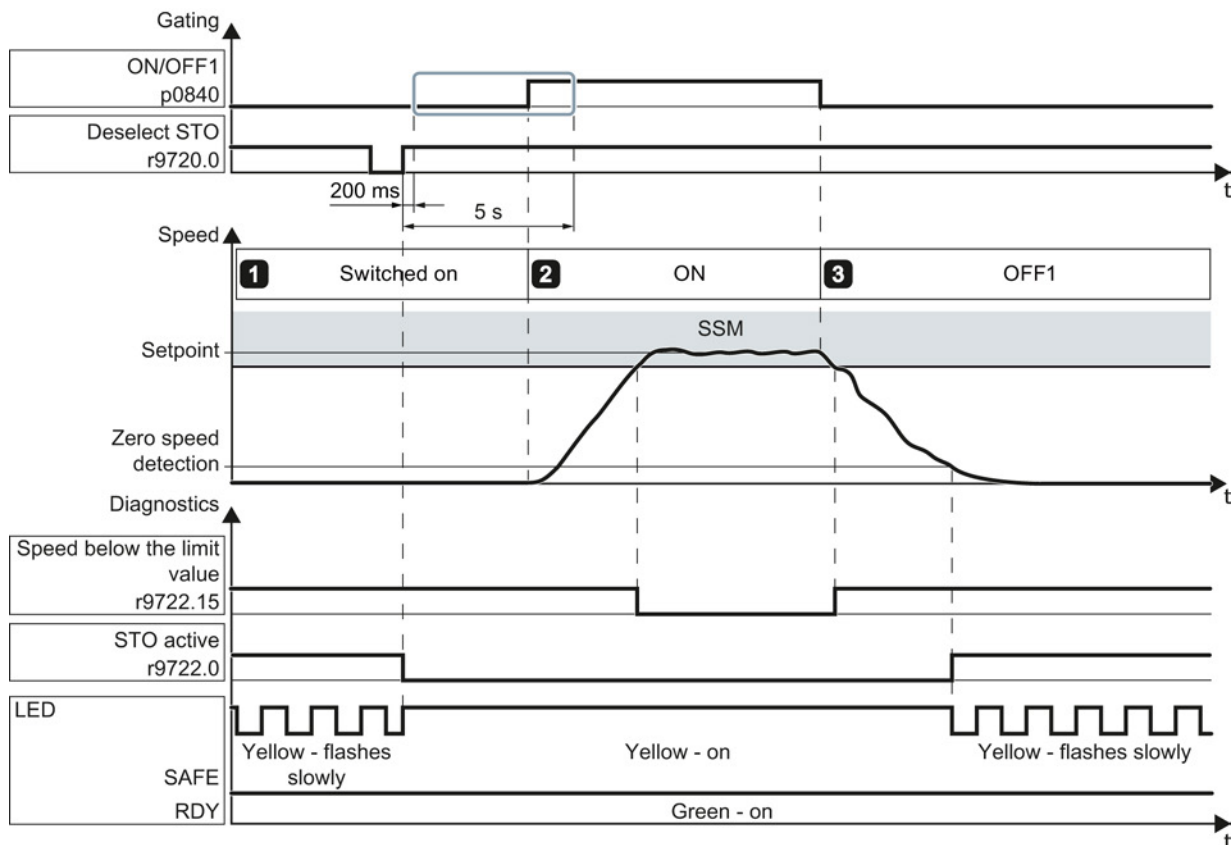The diagrams show the setting "SSM without hysteresis" as an example.

Figure A-9   Diagram 1 - acceptance test SSM with active feedback signal when the motor is switched off
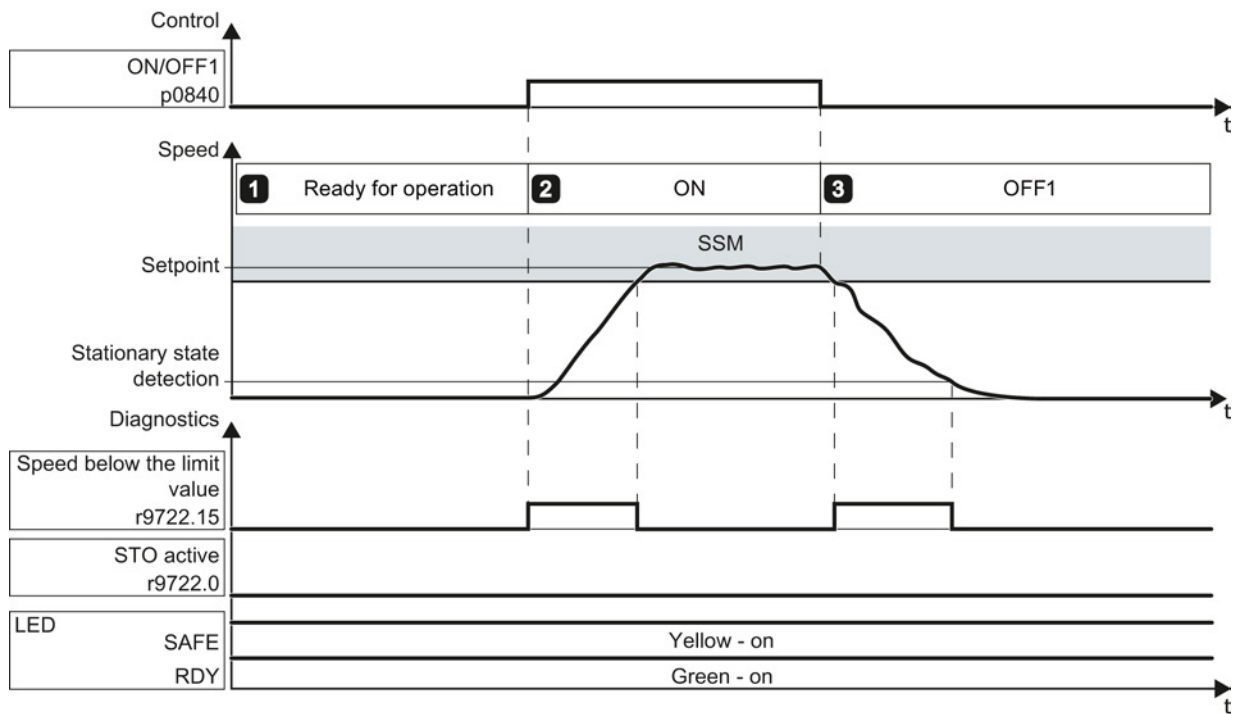
Figure A-10   Diagram 2 - acceptance test SSM with inactive feedback signal when the motor is switched off
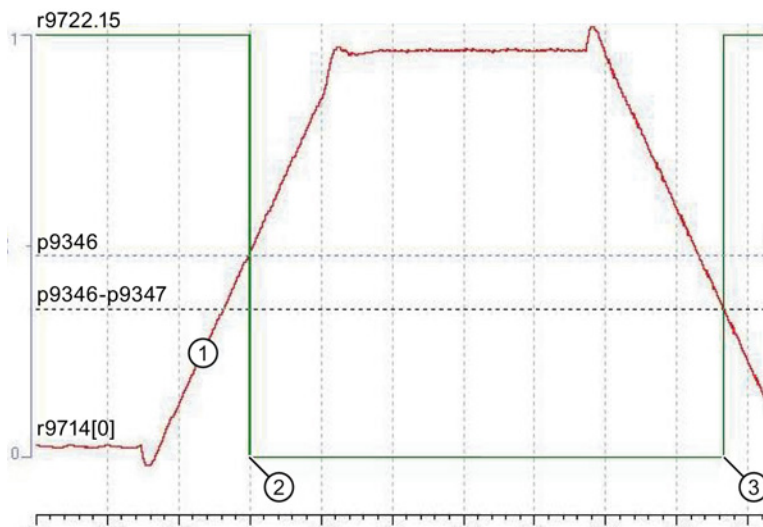
Procedure

To perform the acceptance test of the SSM function, proceed as follows:

			Status
1.	**The inverter is ready**		
	• Check: The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).		
	Go online with the STARTER and configure the following trace: • Trigger on variable - bit pattern (r9722.15 = 0) • Record the following values: r0899, r9714[0], r9722 Display the following bits: – r0899.11 – r9722.15 • Select the time interval and pretrigger so you can recognize when the level exceeds the SSM limit and subsequently falls below it again.		
2.	**Switch on motor**		
	2.1.	Specify a speed setpoint which is above the SSM limit.	
	2.2.	*The following procedure depends on how you have set the SSM function during commissioning:*	
		Upper diagram: *The "speed below limit value" checkback signal remains active when the motor is switched off.*	*Lower diagram:* *The "speed below limit value" checkback signal becomes inactive when the motor is switched off.*
		2.2.1. Select STO.	Switch on the motor (ON command).
		2.2.2. Deselect STO again.	
		2.2.3. Switch on motor within 5 s of deselecting STO (ON command).	
	2.3.	Check that the correct motor is running.	
	2.4.	Wait until the motor speed reaches the setpoint.	
3.	**Switch off the motor**		
	3.1.	Switch off the motor (OFF1 command).	
	3.2.	Analyze the trace: • If r9714[0] > velocity limit p9346, r9722.15 = 0 applies.	
		SSM without hysteresis: • If r9714[0] < velocity limit p9546, r9722.15 = 1 applies.	*SSM with hysteresis:* • If r9714[0] < velocity limit p9546 - hysteresis p9547, r9722.15 = 1 applies.
		The "speed below limit value" checkback signal remains active when the motor is switched off: • If the motor is switched off (r0899.11 = 0), then r9722.15 = 1 applies.	*The "speed below limit value" checkback signal becomes inactive when the motor is switched off:* • If the motor is switched off (r0899.11 = 0), then r9722.15 = 0 applies.

You have completed the acceptance test of the SSM function.

Example of a trace

① Speed: The motor accelerates

② Speed above the limit value

③ Speed below the limit value

A.1.8   Acceptance test SDI

The acceptance test for SDI+ and SDI- is separately described in the following. If you use the SDI function in both directions of rotation, you must carry out both acceptance tests.

SDI can be set with the STOP A and STOP B stop responses. The following diagrams only show the case with the stop response STOP A. The different response of the drive, depending on the stop response set is described in the following tables.

Acceptance test for SDI positive

The two diagrams show the recommended steps to take during the acceptance test. The acceptance test differs depending on how you have set SDI:

- Diagram 1: The "SDI active" feedback signal remains active when the motor is switched off.

- Diagram 2: The "SDI active" feedback signal becomes inactive when the motor is switched off.
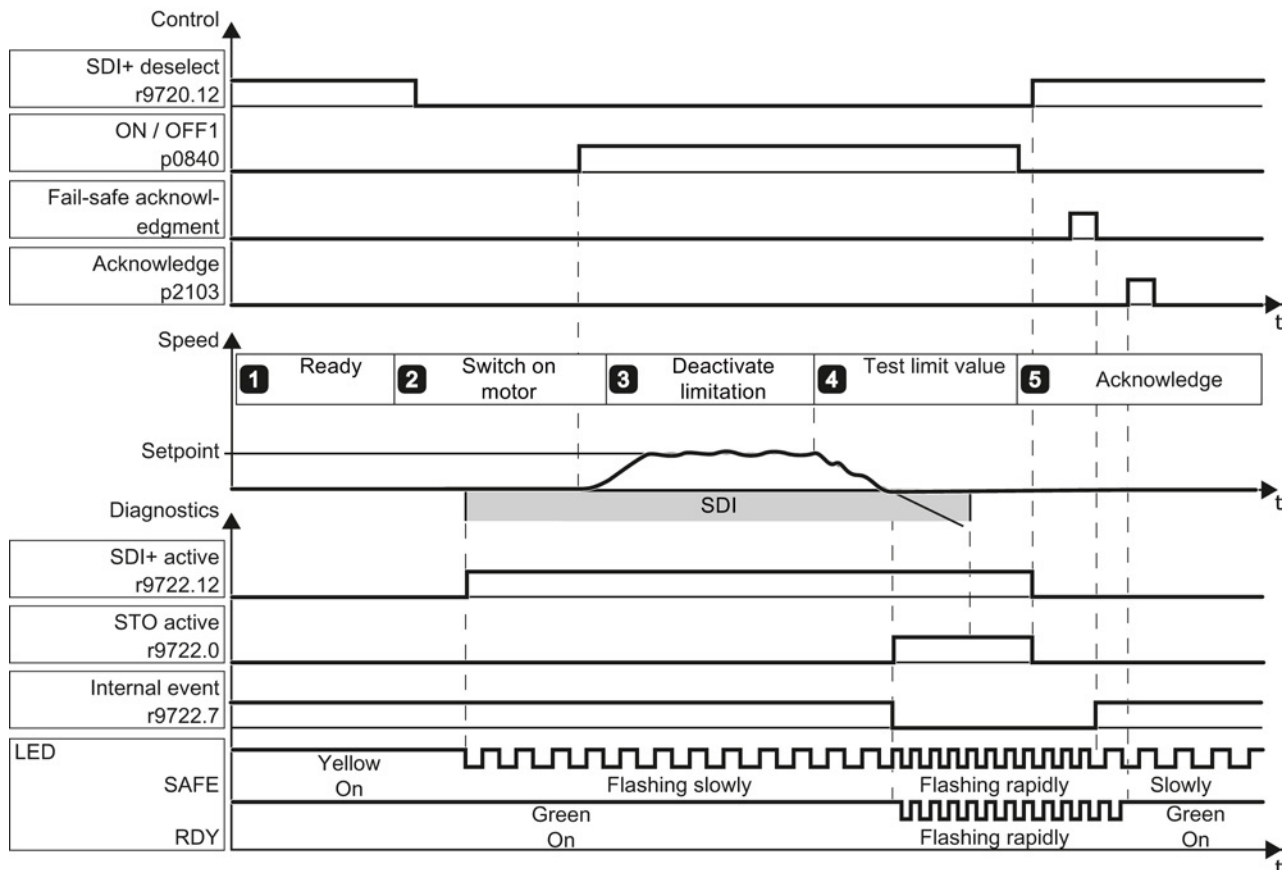

Figure A-11   Diagram 1 - acceptance for SDI+, "SDI active" remains active when the motor is switched off
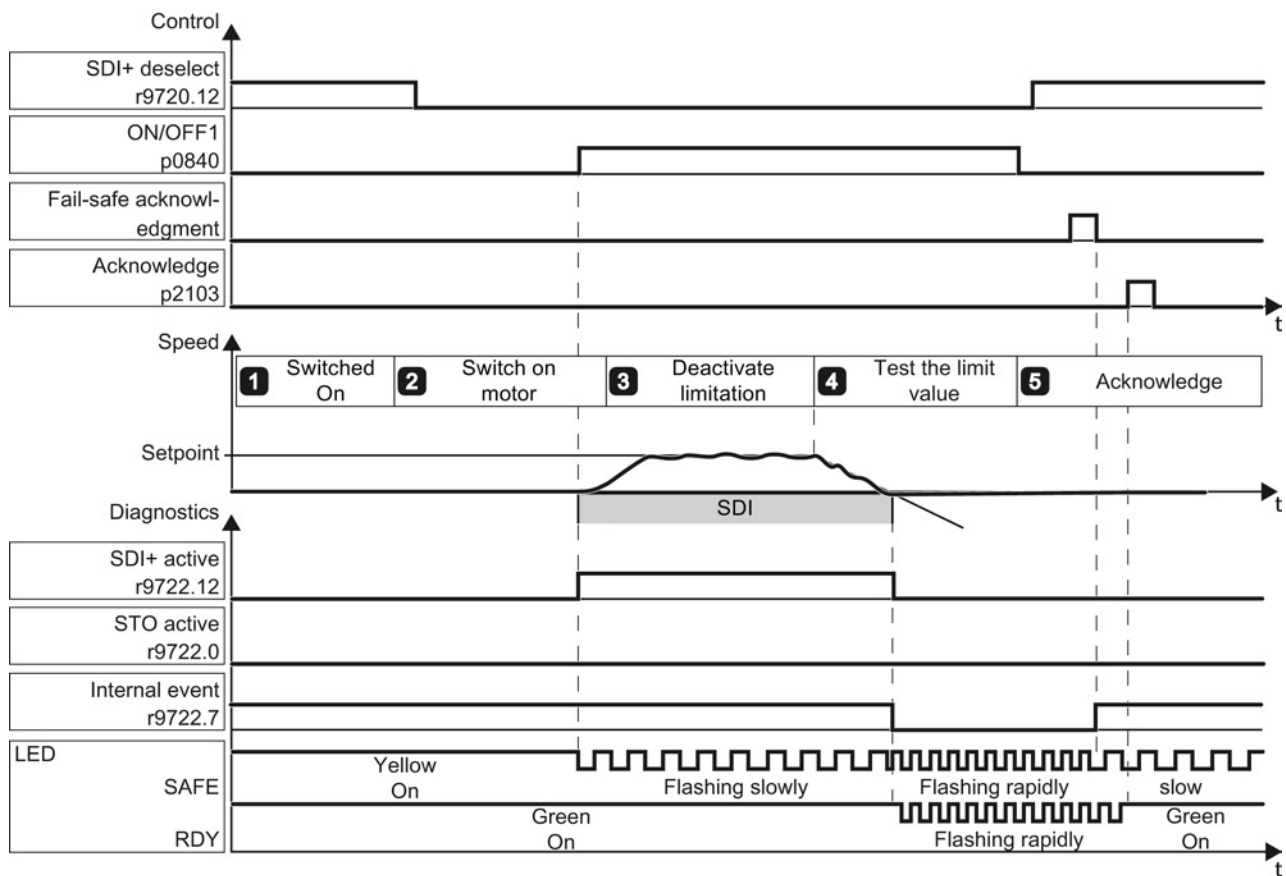
Figure A-12   Diagram 2 - acceptance for SDI+, "SDI active" becomes inactive when the motor is switched off

Procedure

To perform the acceptance test of the SDI function for the positive direction of rotation, proceed as follows:

		Status
1.	**The inverter is ready**	
	Check the following:	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	• SDI+ is not active (r9722.12 = 0).	
	Go online with the STARTER and configure the following trace:	
	• Trigger on variable - bit pattern (r9722.7 = 0).	
	• Record the following values: r9713[0], r9722 Display the bits r9722.0/.1/.7/.12	
	• Select the time interval and pretrigger so you can recognize when the SDI tolerance has been exceeded and the subsequent drive responses.	
2.	**Switch on motor**	
	2.1.	Enter a positive speed setpoint.	
	2.2.	Select SDI+ so that only positive speeds are permitted.	
	2.3.	*The next steps depend on how you have set the SDI function during commissioning:*	

Note: within row 2.3 there is a nested table:

First diagram:	Second diagram:
The "SDI active" feedback signal remains active when the motor is switched off.	*The "SDI active" feedback signal becomes inactive when the motor is switched off.*
Switch on motor within 5 seconds after deselecting SDI (ON command). *If you wait longer than 5 seconds for the ON command, then STO is activated. In this case, deselect SDI and then select it again.*	Switch on the motor (ON command).

		Status
	2.4.	Check that the correct motor is rotating in the expected direction.	
3.	**Deactivate the setpoint limitation for the acceptance test**	
	Activate the Acceptance mode:	

				Status
4.	**Test the set limit value**			
	4.1.	Enter a negative speed setpoint.		
	4.2.	*The following test depends on how you have set the SDI function during commissioning:*		

		STOP A in the event of a limit value violation
		
		• The inverter signals the following:
		  – C01716 and C30716 (tolerance for safe direction of motion exceeded)
		  – C01700 and C30700 (STOP A initiated)
			STOP B in the event of a limit value violation
			
			• The inverter signals the following:
			  – C01716 and C30716 (tolerance for safe direction of motion exceeded)
			  – C01701 and C30701 (STOP B initiated)
			  – C01700 and C30700 (STOP A initiated)	

	4.3.	Analyze the trace:		
		• When SDI+ is selected, the inverter signals: SDI+ is active (r9722.12 = 1).		
		• If r9713[0] > SDI tolerance, then the inverter signals an internal event (r9722.7 = 0).		
		STOP A in the event of a limit value violation • The motor coasts down to a standstill (r9722.0 = 1).	*STOP B in the event of a limit value violation* • The inverter brakes the motor on the OFF3 ramp (r9722.1 = 1).	
			• After braking, STO is active (r9722.0 = 1).	
5.	**Acknowledge fault**			
	5.1.	Deselect SDI+.		
	5.2.	Check: SDI+ is not active (r9722.12 = 0).		
	5.3.	Acknowledge the messages for the safety functions.		

☐ You have completed the acceptance test of the SDI function for the positive direction of rotation.

Acceptance test for SDI negative

The two diagrams show the recommended steps to take during the acceptance test. The acceptance test differs depending on how you have set SDI:

- Diagram 1: The "SDI active" feedback signal remains active when the motor is switched off.

- Diagram 2: The "SDI active" feedback signal becomes inactive when the motor is switched off.
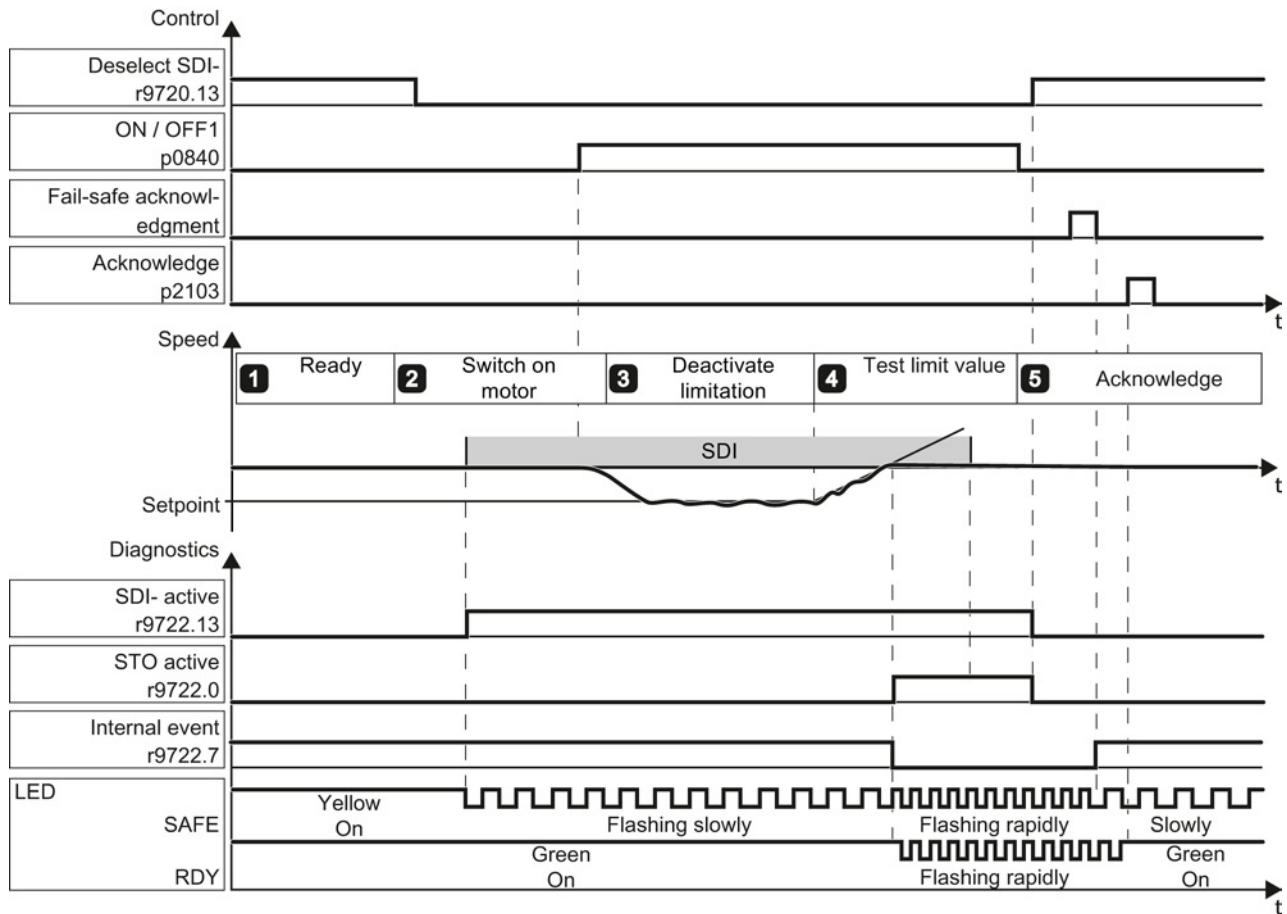
Figure A-13   Diagram 1 - acceptance for SDI-, "SDI active" remains active when the motor is switched off
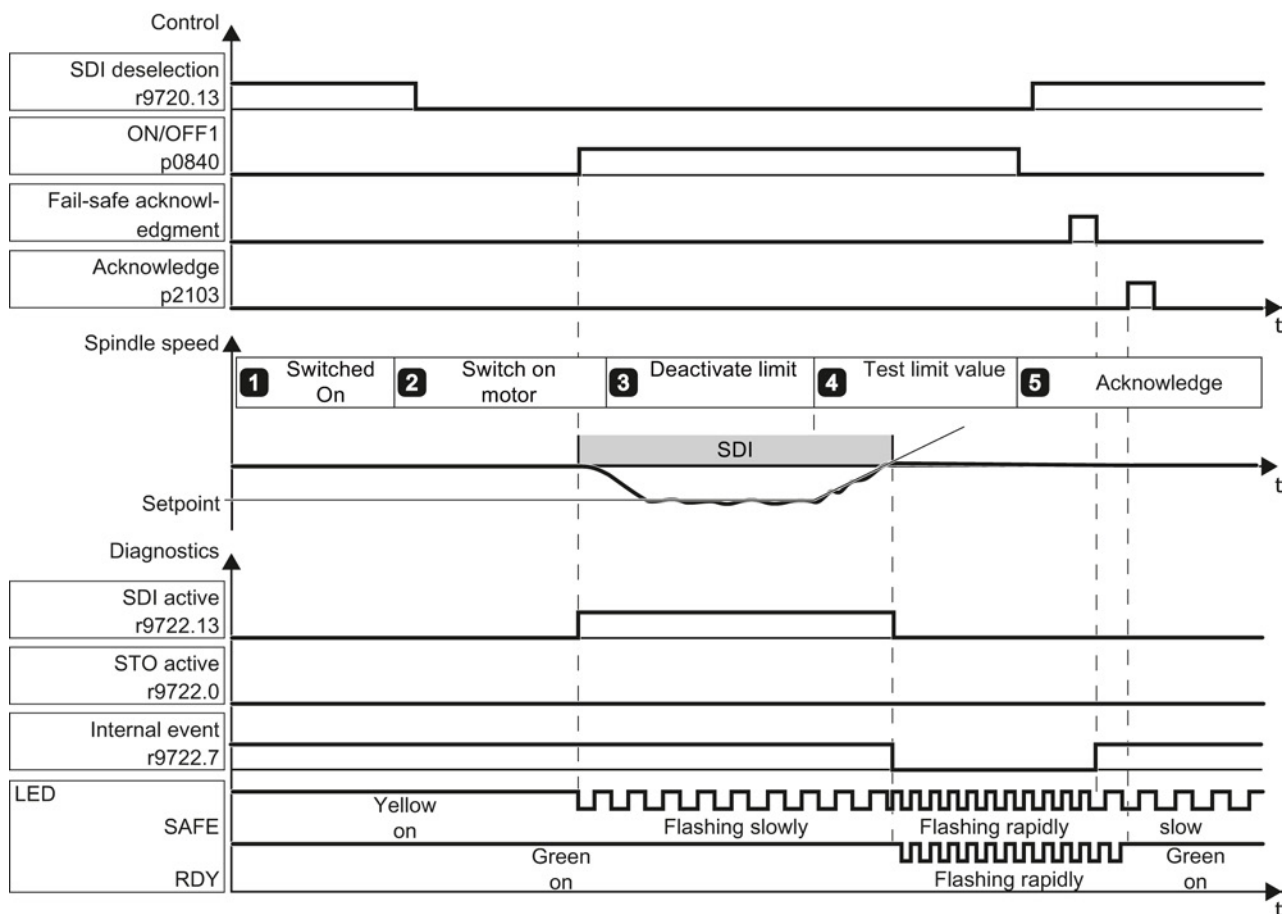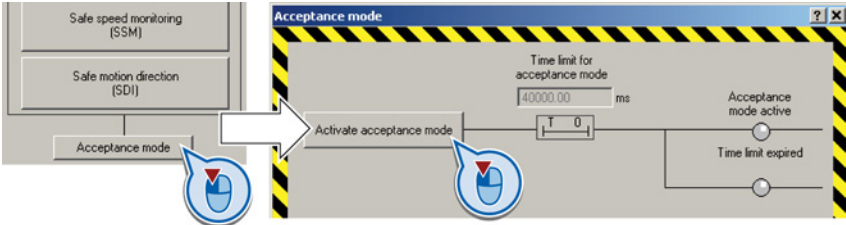
Figure A-14   Diagram 2 - acceptance for SDI-, "SDI active" becomes inactive when the motor is switched off

Procedure

To perform the acceptance test of the SDI function for the negative direction of rotation, proceed as follows:

		Status
1.	**The inverter is ready**	
	Check the following:	
	• SDI- is not active (r9722.13 = 0).	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
	Go online with the STARTER and configure the following trace:	
	• Trigger on variable - bit pattern (r9722.7 = 0).	
	• Record the following values: r9713[0], r9722	
	Display the bits r9722.0/.1/.7/.13	
	• Select the time interval and pretrigger so you can recognize when the SDI tolerance has been exceeded and the subsequent drive responses.	
2.	**Switch on motor**	
2.1.	Enter a negative speed setpoint.	
2.2.	Select SDI- so that only negative speeds are permitted.	
2.3.	*The next steps depend on what settings you made for SDI during commissioning:*	

	First diagram:	*Second diagram:*	
	The "SDI active" feedback signal remains active when the motor is switched off.	*The "SDI active" feedback signal becomes inactive when the motor is switched off.*	
	Switch on motor within 5 seconds after deselecting SDI (ON command). *If you wait longer than 5 seconds for the ON command, then STO is activated. In this case, deselect SDI and then select it again.*	Switch on the motor (ON command).	

			Status
2.4.	Check that the correct motor is rotating in the expected direction.		
3.	**Deactivate the setpoint limitation for the acceptance test**		
	Activate the Acceptance mode:		

				Status
4.	**Test the set limit value**			
	4.1.	Enter a positive speed setpoint.		
	4.2.	*The following test depends on how you have set the SDI function during commissioning:*		
		STOP A in the event of a limit value violation	*STOP B in the event of a limit value violation*	
		The inverter signals the following: • C01716 and C30716 (tolerance for safe direction of motion exceeded) • C01700 and C30700 (STOP A initiated)	The inverter signals the following: • C01716 and C30716 (tolerance for safe direction of motion exceeded) • C01701 and C30701 (STOP B initiated) • C01700 and C30700 (STOP A initiated)	
	4.3.	Analyze the trace		
		• When SDI- is activated, the inverter signals: SDI- is active (r9722.13 = 1).		
		• If r9713[0] > SDI tolerance, then the inverter signals an internal event (r9722.7 = 0).		
		STOP A in the event of a limit value violation	*STOP B in the event of a limit value violation*	
		• The motor coasts down to a standstill (r9722.0 = 1).	• The inverter brakes the motor on the OFF3 ramp (r9722.1 = 1).	
			• After braking, STO is active (r9722.0 = 1).	
5.	**Acknowledge fault**			
	5.1.	Deselect SDI-.		
	5.2.	Check: SDI- is not active (r9722.13 = 0).		
	5.3.	Acknowledge the messages for the safety functions.		

You have completed the acceptance test of the SDI function for the negative direction of rotation.

Example of a trace (STOP B in the event of a limit violation)
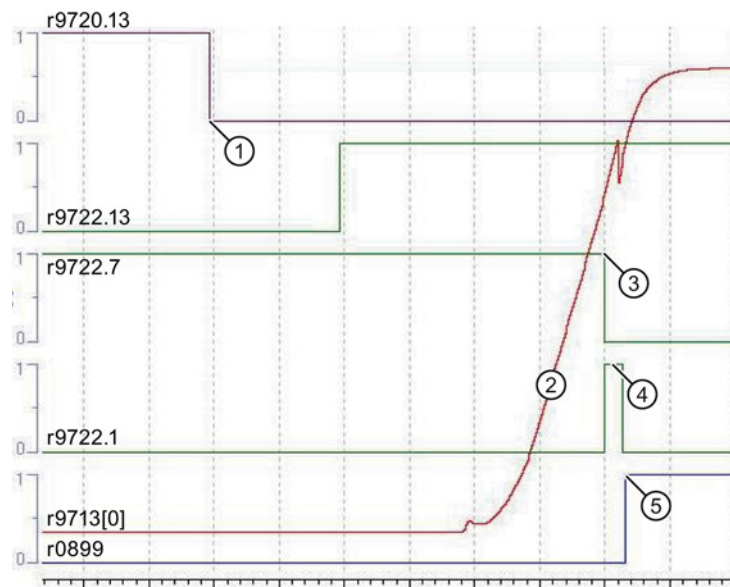
① SDI is selected

② Position actual value: The motor starts to rotate

③ The position actual value of the drive deviates from the permissible tolerance

④ STOP B is active - the motor brakes on the OFF3 ramp

⑤ STO as a consequence of STOP B being active

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A.1.9 Acceptance test for F-DI status in PROFIsafe telegram 900
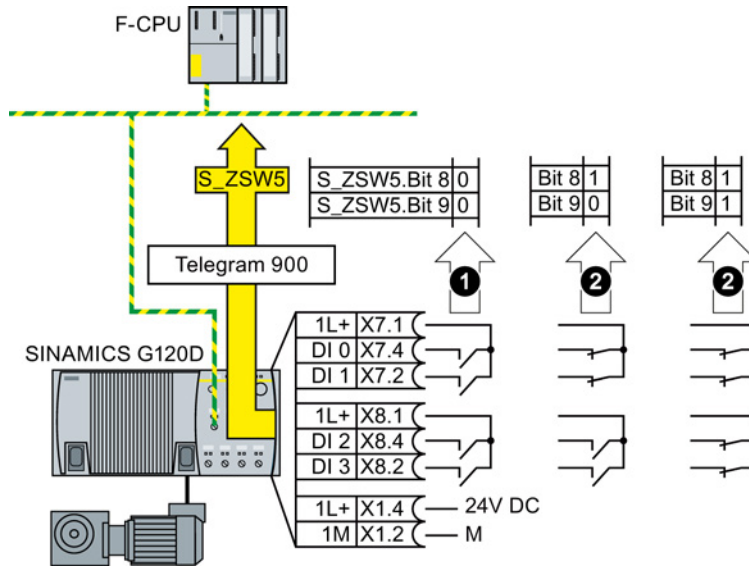
Figure A-15   Acceptance test for the status of the safety inputs using the example of a SINAMICS G120D

Procedure

To perform the acceptance test of the F-DI status, proceed as follows:

		Status
-	**The inverter is ready**	
	• The inverter signals neither faults nor alarms of the safety functions (r0945[0…7], r2122[0…7]).	
1.	**Check the "Low" status of the safety input**	
1.1.	Switch the signal of the safety input to be tested to low.	
1.2.	In the F-CPU, check whether in status word S_ZSW5 the corresponding bit has the value 0.	
2.	**Check the "High" status of the safety input**	
2.1.	Switch the signal of the safety input to be tested to high.	
2.2.	In the F-CPU, check whether in status word S_ZSW5 the corresponding bit has the value 1.	

You have completed the acceptance test for the F-DI status.

A.2 Documentation for acceptance

A.2.1 Creating logs with the settings of the safety functions

STARTER creates a log of the settings of the safety functions, which you can use for your machine documentation.

Procedure

Proceed as follows to create the acceptance documentation for the drive using STARTER:

1. In STARTER, select "Create acceptance documentation":
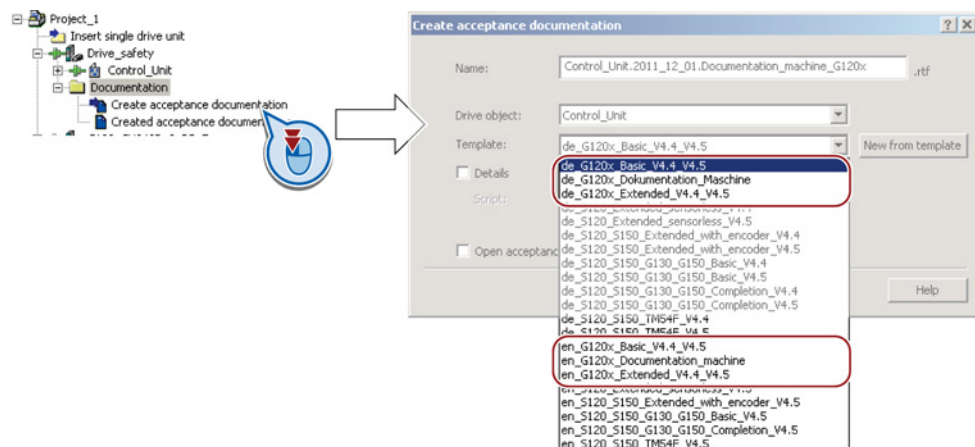
STARTER has templates in German and English.

2. Select the suitable template and create a report for each drive of your machine or system:

   – Template for the machine documentation:

   de_G120x_Dokumentation_Maschine: German template.

   en_G120x_Documentation_machine: English template.

   – Report of the settings for the basic functions, from firmware version V4.4 onwards:

   de_G120x_Basicc_V4.4…: German report.

   en_G120x_Basic_V4.4…: English report.

   – Report of the settings for the extended functions, from firmware version V4.4 onwards:

   Protokoll_de_G120x_Extended_V4.4…: German report.

   Protocol_en_G120x_Extended_V4.4…: English report.

3. You load the created reports for archiving and the machine documentation for further processing:
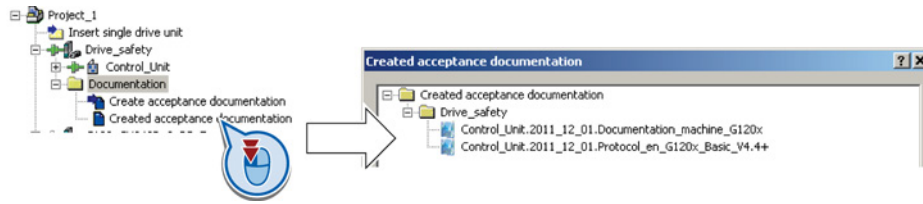
4. Archive the protocols and the machine documentation.

You have generated the documents to accept the safety functions.

You can find the logs and the machine documentation in the following sections.

A.2.2 Example of machine documentation

Machine or system description

Designation	…
Type	…
Serial number	…
Manufacturer	…
End user	…
Block diagram of the machine and/or plant: … … … … … … …	

Inverter data

Table A- 1   Hardware version of the safety-related inverter

Labeling the drive	Order number and hardware version of the inverter
…	…
…	…

Function table

Table A- 2   Active safety functions depending on the operating mode and safety equipment

Operating mode	Safety equipment	Drive	Selected safety function	Checked
…	…	…	…	
…	…	…	…	
Example:				
Production	*Protective door closed*	*Conveyor belt*	*---*	*---*
	Protective door open	*Conveyor belt*	*SS1 (braking in 2 seconds)*	
	Emergency Stop button pressed	*Conveyor belt*	*STO*	
Setting up	*Protective door closed*	*Conveyor belt*	*---*	*---*
	Protective door open	*Conveyor belt*	*SLS level 1 (300 rpm)*	
	Emergency Stop button pressed	*Conveyor belt*	*STO*	

Logging the settings

File name of the log:	
…	
…	

Data backup

Data	Storage medium			Holding area
	Archiving type	Designation	Date	
Log of the settings	…	…	…	…
Acceptance tests	…	…	…	…
STARTER traces	…	…	…	…
PLC program	…	…	…	…
Circuit diagrams	…	…	…	…

Countersignatures

Commissioning engineer

This confirms that the tests and checks have been carried out properly.

Date	Name	Company/dept.	Signature
…	…	…	…

Machine manufacturer

This confirms that the settings documented above are correct.

Date	Name	Company/dept.	Signature
…	…	…	…

A.2.3 Log the settings for the basic functions, firmware V4.4 ... V4.7

Drive = <pDO-NAME_v>

Table A- 3   Firmware version

Name	Number	Value
Control Unit firmware version	r18	<r18_v>
SI version, safety functions integrated in the drive (processor 1)	r9770	<r9770_v>

Table A- 4   Monitoring cycle

Name	Number	Value
SI monitoring clock cycle (processor 1)	r9780	<r9780_v>

Table A- 5   Checksums

Name	Number	Value
SI module identifier, Control Unit	r9670	<r9670_v>
SI module identifier, Power Module	r9672	<r9672_v>
SI reference checksum SI parameters (processor 1)	p9799	<p9799_v>
SI reference checksum SI parameters (processor 2)	p9899	<p9899_v>

Table A- 6   Settings of the safety functions

Name		Number	Value
SI enable, functions integrated in the drive		p9601	<p9601_v>
Only for the CU250S-2 Control Unit	SI enable safe brake control	p9602	<p9602_v>
SI PROFIsafe address		p9610	<p9610_v>
F-DI switch over discrepancy time		p9650	<p9650_v>
SI STO debounce time		p9651	<p9651_v>
Only for the CU250S-2 Control Unit	SI Safe Stop 1 delay time	p9652	<p9652_v>
SI forced dormant error detection timer		p9659	<p9659_v>

Table A- 7   Safety logbook

Name	Number	Value
SI checksum to check changes	r9781[0]	<r9781[0]_v>
SI checksum to check changes	r9781[1]	<r9781[1]_v>
SI change control time stamp	r9782[0]	<r9782[0]_v>
SI change control time stamp	r9782[1]	<r9782[1]_v>

A.2.4 Log the settings for the extended functions, firmware V4.4 ... V4.7

Drive = <pDO-NAME_v>

Table A- 8 Firmware version

Name	Number	Value
Control Unit firmware version	r18	<r18_v>
SI motion, version safe motion monitoring functions	r9590	<r9590_v>
SI Version safety functions integrated in the drive	r9770	<r9770_v>

Table A- 9 Monitoring cycle

Name	Number	Value
SI monitoring clock cycle	r9780	<r9780_v>

Table A- 10 Checksums

Name	Number	Value
SI Motion reference checksum SI parameters (processor 2)	p9399[0]	<p9399[0]_v>
	p9399[1]	<p9399[1]_v>
SI module identifier, Control Unit	r9670	<r9670_v>
SI module identifier, Power Module	r9672	<r9672_v>
SI reference checksum SI parameters (processor 1)	p9799	<p9799_v>
SI Motion reference checksum SI parameters (processor 1)	p9729[0]	<p9729[0]_v>
	p9729[1]	<p9729[1]_v>
	p9729[2]	<p9729[2]_v>
SI reference checksum SI parameters (processor 2)	p9899	<p9899_v>

Table A- 11 Safety functions

Name	Number	Value
SI motion, enable safety-related functions	p9501	<p9501_v>
SI Motion function specification	p9506	<p9506_v>
SI Motion function configuration	p9507	<p9507_v>
SI Motion response during pulse suppression	p9509	<p9509_v>
SI motion, gearbox, motor/load, denominator	p9521	<p9521_v>
SI motion, gearbox, motor/load, numerator	p9522	<p9522_v>
SI Motion SLS limit values, limit value SLS1	p9531[0]	<p9531[0]_v>
SI Motion SLS limit values, limit value SLS2	p9531[1]	<p9531[1]_v>
SI Motion SLS limit values, limit value SLS3	p9531[2]	<p9531[2]_v>
SI Motion SLS limit values, limit value SLS4	p9531[3]	<p9531[3]_v>
SI Motion SLS speed setpoint limiting	p9533	<p9533_v>
SI motion, actual value comparison tolerance (crosswise)	p9542	<p9542_v>

Name		Number	Value
SI Motion SSM filter time		p9545	<p9545_v>
SI Motion SSM speed limit		p9546	<p9546_v>
SI Motion SSM speed hysteresis		p9547	<p9547_v>
SI Motion SAM actual speed tolerance		p9548	<p9548_v>
SI Motion SLS changeover delay time		p9551	<p9551_v>
SI Motion pulse suppression delay time		p9556	<p9556_v>
SI Motion acceptance test mode time limit		p9558	<p9558_v>
SI Motion forced dormant error detection timer		p9559	<p9559_v>
SI Motion pulse suppression shutdown velocity		p9560	<p9560_v>
SI Motion SLS-specific stop response, limit value SLS1		p9563[0]	<p9563[0]_v>
SI Motion SLS-specific stop response, limit value SLS2		p9563[1]	<p9563[1]_v>
SI Motion SLS-specific stop response, limit value SLS3		p9563[2]	<p9563[2]_v>
SI Motion SLS-specific stop response, limit value SLS4		p9563[3]	<p9563[3]_v>
SI Motion SDI tolerance		p9564	<p9564_v>
SI Motion SDI delay time		p9565	<p9565_v>
SI Motion SDI stop response		p9566	<p9566_v>
SI Motion SAM speed limit		p9568	<p9568_v>
SI Motion acceptance test mode		p9570	<p9570_v>
SI Motion braking ramp reference value		p9581	<p9581_v>
SI Motion braking ramp delay time		p9582	<p9582_v>
SI Motion braking ramp monitoring time		p9583	<p9583_v>
From firmware V4.5	SI Motion fault tolerance actual value acquisition encoderless	p9585	<p9585_v>
SI Motion delay time of the evaluation encoderless		p9586	<p9586_v>
SI Motion encoderless actual value acquisition filter time		p9587	<p9587_v>
SI Motion actual value acquisition encoderless minimum current		p9588	<p9588_v>
SI Motion voltage tolerance acceleration		p9589	<p9589_v>
SI enable, functions integrated in the drive		p9601	<p9601_v>
Only for the CU250S-2 Control Unit	Enable safe brake control	p9602	<p9602_v>
SI PROFIsafe address		p9610	<p9610_v>
F-DI switch over discrepancy time		p9650	<p9650_v>
SI STO debounce time		p9651	<p9651_v>
Only for the CU250S-2 Control Unit	Safe Stop 1 delay time	p9652	<p9652_v>
SI forced dormant error detection timer		p9659	<p9659_v>
F-DI switch over discrepancy time		p10002	<p10002_v>
SI acknowledgment internal event F-DI		p10006	<p10006_v>
SI digital inputs debounce time		p10017	<p10017_v>
SI STO input terminal		p10022	<p10022_v>
SI SS1 input terminal		p10023	<p10023_v>
SI SLS input terminal		p10026	<p10026_v>
SI SDI positive input terminal		p10030	<p10030_v>
SI SDI negative input terminal		p10031	<p10031_v>

Name	Number	Value
SI F-DI monitoring status	r10049	<r10049_v>
SI PROFIsafe F-DI transfer	p10050	<p10050_v>

Table A- 12   Fail-safe output in SINAMICS G120D with CU240/250D-2 DP/PN F and in SINAMICS G120 with CU250S-2

Name	Number	Value
SI wait time for test stop at DO	p10001	<p10001_v>
SI forced dormant error detection timer	p10003	<p10003_v>
SI forced dormant error detection F-DO signal source	p10007	<p10007_v>
SI safe state signal selection	p10039	< p10039_v>
SI F-DO 0 signal sources	p10042[0]	<p10042[0]_v>
	p10042[1]	<p10042[1]_v>
	p10042[2]	<p10042[2]_v>
	p10042[3]	<p10042[3]_v>
	p10042[4]	<p10042[4]_v>
	p10042[5]	<p10042[5]_v>
SI F-DO feedback signal input activation	p10046	<p10046_v>
SI F-DO test stop mode	p10047	<p10047_v>

Table A- 13   Safety logbook

Name	Number	Value
SI checksum to check changes	r9781[0]	<r9781[0]_v>
SI checksum to check changes	r9781[1]	<r9781[1]_v>
SI change control time stamp	r9782[0]	<r9782[0]_v>
SI change control time stamp	r9782[1]	<r9782[1]_v>

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A.3 Standards and specifications

A.3.1 General information

A.3.1.1 Aims

Manufacturers and operating companies of equipment, machines, and products are responsible for ensuring the required level of safety. This means that plants, machines, and other equipment must be designed to be as safe as possible in accordance with the current state of the art. For this purpose, companies describe in the various standards the current state of the art covering all aspects relevant to safety. If it can be justifiably assumed that all of the relevant standards are complied with, this ensures that state-of-the-art technology has been utilized and, in turn, a plant builder or a manufacturer of a machine or a piece of equipment has fulfilled his appropriate responsibility.

Safety systems are designed to minimize potential hazards for both people and the environment by means of suitable technical equipment, without restricting industrial production and the use of machines more than is necessary. The protection of man and environment must be assigned equal importance in all countries based on internationally harmonized rules and regulations. This is also intended to avoid competitive advantages or disadvantages due to different safety requirements in different countries.

There are different concepts and requirements in the various regions and countries of the world when it comes to ensuring the appropriate degree of safety. The legislation and the requirements of how and when proof is to be given and whether there is an adequate level of safety are just as different as the assignment of responsibilities.

The most important thing for manufacturers of machines and companies that set up plants and systems is that the legislation and regulations in the country where the machine or plant is being operated apply. For example, the control system for a machine that is to be used in the US must fulfill local US requirements even if the machine manufacturer (OEM) is based in the European Economic Area (EEA).

A.3.1.2 Functional safety

Safety, from the perspective of the object to be protected, cannot be split-up. The causes of hazards and, in turn, the technical measures to avoid them can vary significantly. This is why a differentiation is made between different types of safety (e.g. by specifying the cause of possible hazards). "Functional safety" is involved if safety depends on the correct function.

To ensure the functional safety of a machine or plant, the safety-related parts of the protection and control devices must function correctly. In addition, the systems must behave in such a way that either the plant remains in a safe state or it is brought into a safe state if a fault occurs. In this case, it is necessary to use specially qualified technology that fulfills the requirements described in the associated Standards. The requirements to implement functional safety are based on the following basic goals:

• Avoiding systematic faults

• Controlling random faults or failures

Benchmarks for establishing whether or not a sufficient level of functional safety has been achieved include the probability of hazardous failures, the fault tolerance, and the quality that is to be ensured by avoiding systematic faults. This is expressed in the standards using specific classification. In IEC/EN 61508, IEC/EN 62061 "Safety Integrity Level" (SIL) and EN ISO 13849-1 "Category" and "Performance Level" (PL).

A.3.2   Safety of machinery in Europe

The EU Directives that apply to the implementation of products are based on Article 95 of the EU contract, which regulates the free exchange of goods. These are based on a new global concept ("new approach", "global approach"):

- EU Directives only specify general safety goals and define basic safety requirements.

- Technical details can be defined by means of standards by Standards Associations that have the appropriate mandate from the commission of the European Parliament and Council (CEN, CENELEC). These standards are harmonized in line with a specific directive and listed in the official journal of the commission of the European Parliament and Council. Legislation does not specify that certain standards have to be observed. When the harmonized Standards are observed, it can be assumed that the safety requirements and specifications of the Directives involved have been fulfilled.

- EU Directives specify that the Member States must mutually recognize domestic regulations.

The EU Directives are equal. This means that if several Directives apply for a specific piece of equipment or device, the requirements of all of the relevant Directives apply (e.g. for a machine with electrical equipment, the Machinery Directive and the Low-Voltage Directive apply).

A.3.2.1   Machinery Directive

The basic safety and health requirements specified in Annex I of the Directive must be fulfilled for the safety of machines.

The protective goals must be implemented responsibly to ensure compliance with the Directive.

Manufacturers of a machine must verify that their machine complies with the basic requirements. This verification is facilitated by means of harmonized standards.

A.3.2.2   Harmonized European Standards

The two Standards Organizations CEN (Comité Européen de Normalisation) and CENELEC (Comité Européen de Normalisation Électrotechnique), mandated by the EU Commission, drew-up harmonized European standards in order to precisely specify the requirements of the EC directives for a specific product. These standards (EN standards) are published in the official journal of the commission of the European Parliament and Council and must be included without revision in domestic standards. They are designed to fulfill basic health and safety requirements as well as the protective goals specified in Annex I of the Machinery Directive.

When the harmonized standards are observed, it is "automatically assumed" that the Directive is fulfilled. As such, manufacturers can assume that they have observed the safety aspects of the Directive under the assumption that these are also covered in this standard. However, not every European Standard is harmonized in this sense. Key here is the listing in the official journal of the commission of the European Parliament and Council.

The European Safety of Machines standard is hierarchically structured. It is divided into:

- A standards (basic standards)

- B standards (group standards)

- C standards (product standards)

Type A standards/basic standards

A standards include basic terminology and definitions relating to all types of machine. This includes EN ISO 12100 (previously EN 292-1) "Safety of Machines, Basic Terminology, General Design Principles".

A standards are aimed primarily at the bodies responsible for setting the B and C standards. The measures specified here for minimizing risk, however, may also be useful for manufacturers if no applicable C standards have been defined.

Type B standards/group standards

B standards cover all safety-related standards for various different machine types. B standards are aimed primarily at the bodies responsible for setting C standards. They can also be useful for manufacturers during the machine design and construction phases, however, if no applicable C standards have been defined.

A further sub-division has been made for B standards:

- Type B1 standards for higher-level safety aspects (e.g. ergonomic principles, safety clearances from sources of danger, minimum clearances to prevent parts of the body from being crushed).

- Type B2 standards for protective safety devices are defined for different machine types (e.g. EMERGENCY STOP devices, two-hand operating circuits, interlocking elements, contactless protective devices, safety-related parts of controls).

Type C standards/product standards

C standards are product-specific standards (e.g. for machine tools, woodworking machines, elevators, packaging machines, printing machines etc.). Product standards cover machine-specific requirements. The requirements can, under certain circumstances, deviate from the basic and group standards. Type C/product standards have the highest priority for machine manufacturers who can assume that it fulfills the basic requirements of Annex I of the Machinery Directive (automatic presumption of compliance). If no product standard has been defined for a particular machine, type B standards can be applied when the machine is constructed.

A complete list of the standards specified and the mandated draft standards are available on the Internet at the following address:

http://www.newapproach.org/

Recommendation: Due to the rapid pace of technical development and the associated changes in machine concepts, the standards (and C standards in particular) should be checked to ensure that they are up to date. Please note that the application of a particular standard may not be mandatory provided that all the safety requirements of the applicable EU directives are fulfilled.

A.3.2.3 Standards for implementing safety-related controllers

If the functional safety of a machine depends on various control functions, the controller must be implemented in such a way that the probability of safety functions failing in a dangerous fashion is sufficiently minimized. EN ISO 13849-1 (formerly EN 954-1) and IEC61508 define principles for implementing safety-related machine controllers which, when properly applied, ensure that all the safety requirements of the EC Machinery Directive are fulfilled. These standards ensure that the relevant safety requirements of the Machinery Directive are fulfilled.

Any architectures All SIL 1-3 (from PL b)	Defined architectures, restricted maximum PL for electronics
EN 62061 Safety of Machinery Functional safety - safety-related electrical, electronic and programmable electronic control systems	EN ISO 13849 Safety of Machinery Safety-related parts of control systems
Sector Standard EN 62061 for the area of machines below EN 61508	For deviations from the defined architectures, reference to EN 61508
Universal use for electrical, electronic and programmable electronic systems that execute safety functions or guarantee functional safety	
EN 61508 Functional safety, safety-related electrical/electronic/programmable electronic control systems (Part 0 to 7)	

Figure A-16   Standards for implementing safety-related controllers

The application areas of EN ISO 13849-1, EN 62061, and EN 61508 are very similar. To help users make an appropriate decision, the IEC and ISO associations have specified the application areas of both standards in a joint table in the introduction to the standards. EN ISO 13849-1 or EN 62061 should be applied depending on the technology (mechanics, hydraulics, pneumatics, electrics, electronics, programmable electronics), risk classification and architecture.

	Systems for executing safety-related control functions	EN ISO 13849-1	EN 62061
A	Non-electrical (e.g. hydraulic, pneumatic)	X	Not covered
B	Electromechanical (e.g. relay and/or basic electronics)	Restricted to the designated architectures (see comment 1) and max. up to PL = e	All architectures and max. up to SIL 3
C	Complex electronics (e.g. programmable electronics)	Restricted to the designated architectures (see comment 1) and max. up to PL = d	All architectures and max. up to SIL 3
D	A standards combined with B standards	Restricted to the designated architectures (see comment 1) and max. up to PL = e	X See comment 3
E	C standards combined with B standards	Restricted to the designated architectures (see comment 1) and max. up to PL = d	All architectures and max. up to SIL 3
F	C standards combined with A standards or C standards combined with A standards and B standards	X See comment 2	X See comment 3
"X" indicates that the point is covered by this standard. Comment 1: Designated architectures are described in Annex B of EN ISO 13849-1 and provide a simplified basis for the quantification. Comment 2: For complex electronics: Using designated architectures in compliance with EN ISO 13849-1 up to PL = d or every architecture in compliance with EN 62061. Comment 3: For non-electrical systems: Use components that comply with EN ISO 13849-1 as sub-systems.			

A.3.2.4 DIN EN ISO 13849-1 (replaces EN 954-1)

A qualitative analysis according to DIN EN 13849-1 is not sufficient for modern control systems due to their technology. Among other things, DIN EN ISO 13849-1 does not take into account time behavior (e.g. test interval and/or cyclic test, lifetime). This results in the probabilistic approach in DIN EN ISO 13849-1 (probability of failure per unit time).

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DIN EN ISO 13849-1 is based on the known categories of EN 954-1. It now also takes into account complete safety functions and all the devices required to execute these. With DIN EN ISO 13849-1, safety functions are investigated from a quantitative perspective going beyond the qualitative basis of EN 954-1. Performance levels (PL), which are based on the categories, are used. The following safety-related characteristic quantities are required for devices/equipment:

- Category (structural requirement)

- PL: Performance level

- $MTTF_d$: Mean time to dangerous failure

- DC: Diagnostic coverage

- CCF:
  Common cause failure

The standard describes how the performance level (PL) is calculated for safety-related components of the controller on the basis of designated architectures. For deviations from this, DIN EN ISO 13849-1 refers to IEC 61508.

When combining several safety-related parts to form a complete system, the standard explains how to determine the resulting PL.

Note

DIN EN ISO 13849-1 and machinery directive

Since May 2007, DIN EN ISO 13849-1 has been harmonized as part of the Machinery Directive.

A.3.2.5 EN 62061

EN 62061 (identical to IEC 62061) is a sector-specific standard subordinate to IEC/EN 61508. It describes the implementation of safety-related electrical machine control systems and looks at the complete life cycle, from the conceptual phase to decommissioning. The standard is based on the quantitative and qualitative analyses of safety functions,

whereby it systematically applies a top-down approach to implementing complex control systems (known as "functional decomposition"). The safety functions derived from the risk analysis are sub-divided into sub-safety functions, which are then assigned to real devices, sub-systems, and sub-system elements. Both the hardware and software are covered. EN 62061 also describes the requirements placed on implementing application programs.

A safety-related control systems comprises different sub-systems. From a safety perspective, the sub-systems are described in terms of the SIL claim limit and PFH_D characteristic quantities.

Programmable electronic devices (e.g. PLCs or variable-speed drives) must fulfill IEC 61508. They can then be integrated in the controller as sub-systems. The following safety-related characteristic quantities must be specified by the manufacturers of these devices.

Safety-related characteristic quantities for subsystems:

- SIL CL: SIL claim limit

- PFH_D:
  Probability of dangerous failures per hour

- T1:
  Lifetime

Simple sub-systems (e.g. sensors and actuators) in electromechanical components can, in turn, comprise sub-system elements (devices) interconnected in different ways with the characteristic quantities required for determining the relevant PFH_D value of the sub-system.

Safety-related characteristic quantities for subsystem elements (devices):

- λ:
  Failure rate

- B10 value: For elements that are subject to wear

- T1:
  Lifetime

For electromechanical devices, a manufacturer specifies a failure rate λ with reference to the number of operating cycles. The failure rate per unit time and the lifetime must be determined using the switching frequency for the particular application.

Parameters for the sub-system, which comprises sub-system elements, that must be defined during the design phase:

- T2:
  Diagnostic test interval

- β:
  Susceptibility to common cause failure

- DC:
  Diagnostic coverage

The PFH_D value of the safety-related controller is determined by adding the individual PFH_D values for subsystems.

The user has the following options when setting up a safety-related controller:

- Use devices and sub-systems that already comply with EN ISO 13849-1, IEC/EN 61508, or IEC/EN 62061. The standard provides information specifying how qualified devices can be integrated when safety functions are implemented.

- Develop own subsystems:

  – Programmable, electronic systems and complex systems: Application of IEC 61508 or IEC 61800-5-2.

  – Simple devices and subsystems: Application of EN 62061.

EN 62061 does not include information about non-electric systems. The standard provides detailed information on implementing safety-related electrical, electronic, and programmable electronic control systems. DIN EN ISO 13849-1 must be applied for non-electric systems.

Note

Function examples

Details of simple sub-systems that have been implemented and integrated are now available as "functional examples".

Note

EN 62061 and machinery directive

IEC 62061 has been ratified as EN 62061 in Europe and harmonized as part of the Machinery Directive.

A.3.2.6   Series of standards IEC 61508 (VDE 0803)

This series of standards describes the current state of the art.

IEC 61508 is not harmonized in line with any EU directives, which means that an automatic presumption of conformity for fulfilling the protective requirements of a directive is not implied. The manufacturer of a safety-related product, however, can also use IEC 61508 to fulfill basic requirements of European directives in accordance with the latest conceptual design, for example, in the following cases:

- If no harmonized standard exists for the application in question. In this particular case, the manufacturer may use IEC 61508. although no presumption of conformity exists here.

- A harmonized European standard (e.g. EN 62061, EN ISO 13849, EN 60204-1) references IEC 61508. This ensures that the appropriate requirements of the directives are fulfilled ("standard that is also applicable"). When manufacturers apply IEC 61508 properly and responsibly in accordance with this reference, they can use the presumption of conformity of the referencing standard.

IEC 61508 covers all the aspects that must be taken into account when E/E/PES systems (electrical, electronic, and programmable electronic system) are used in order to execute safety functions and/or to ensure the appropriate level of functional safety. Other hazards (e.g. electric shock) are not part of the standard, similar to DIN ISO 13849.

IEC 61508 has recently been declared the "International Basic Safety Publication", which makes it a framework for other sector-specific standards (e.g. EN 62061). As a result, this standard is now accepted worldwide, particularly in North America and in the automotive industry. Today, many regulatory bodies already stipulate it (e.g. as a basis for NRTL listing).

Another recent development with respect to IEC 61508 is its system approach, which extends the technical requirements to include the entire safety installation from the sensor to the actuator, the quantification of the probability of hazardous failure due to random hardware failures, and the creation of documentation covering all phases of the safety-related lifecycle of the E/E/PES.

A.3.2.7 Risk analysis/assessment

Risks are intrinsic in machines due to their design and functionality. For this reason, the Machinery Directive requires that a risk assessment be performed for each machine and, if necessary, the level of risk reduced until the residual risk is less than the tolerable risk. To assess these risks, the following standards must be applied:

- EN ISO 12100 "Safety of Machinery - basic terminology, general principles for design"

- EN ISO 13849-1 (successor to EN 954-1) "Safety-related parts of control systems"

EN ISO 12100-1 focuses on the risks to be analyzed and the design principles for minimizing risk.

The risk assessment is a procedure that allows hazards resulting from machines to be systematically investigated. Where necessary, the risk assessment is followed by a risk reduction procedure. When the procedure is repeated, this is known as an iterative process. This can help eliminate hazards (as far as this is possible) and can act as a basis for implementing suitable protective measures.

The risk assessment involves the following:

- Risk analysis

    - Determines the limits of the machine (EN ISO 12100)

    - Identification of hazards (EN ISO 12100)

    - Estimating the level of risk (EN 1050 Paragraph 7)

- Risk evaluation

As part of the iterative process to achieve the required level of safety, a risk assessment is carried out after the risk estimation. A decision must be made here as to whether the residual risk needs to be reduced. If the risk is to be further reduced, suitable protective measures must be selected and applied. The risk assessment must then be repeated.
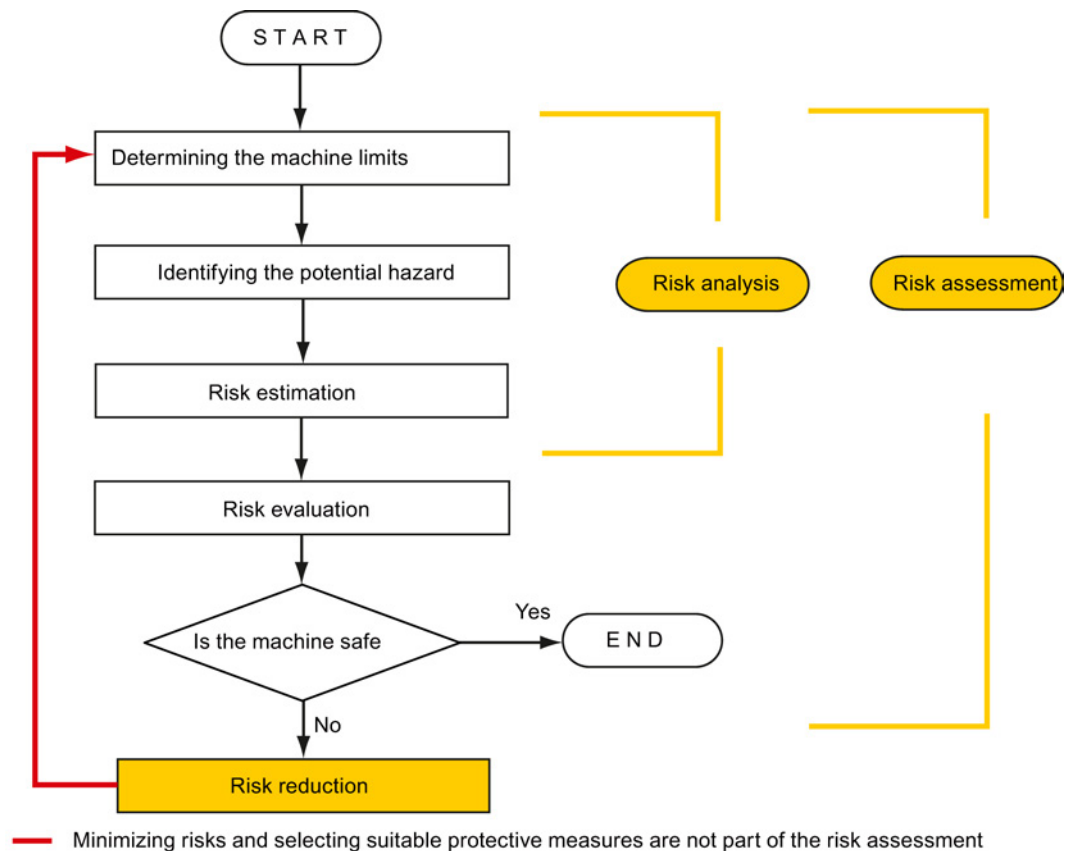
Figure A-17   Iterative process for achieving safety

Risks must be reduced by designing and implementing the machine accordingly (e.g. by means of controllers or protective measures suitable for the safety-related functions).

If the protective measures involve the use of interlocking or control functions, these must be designed according to EN ISO 13849-1. For electrical and electronic controllers, EN 62061 can be used as an alternative to EN ISO 13849-1. Electronic controllers and bus systems must also comply with IEC 61508.

A.3.2.8   Risk reduction

Risk reduction measures for a machine can be implemented by means of safety-related control functions in addition to structural measures. To implement these control functions, special requirements must be taken into account, graded according to the magnitude of the risk. These are described in EN ISO 13849-1 or, in the case of electrical controllers (particularly programmable electronics), in EN 61508 or EN 62061. The requirements regarding safety-related controller components are graded according to the magnitude of the risk and the level to which the risk needs to be reduced.

EN ISO 13849-1 defines a risk flow chart that instead of categories results in hierarchically graduated Performance Levels (PL).

IEC/EN 62061 uses "Safety Integrity Level" (SIL) for classification purposes. This is a quantified measure of the safety-related performance of a controller. The required SIL is also determined in accordance with the risk assessment principle according to ISO 12100 (EN

1050). Annex A of the standard describes a method for determining the required Safety Integrity Level (SIL).

Regardless of which standard is applied, steps must be taken to ensure that all the machine controller components required for executing the safety-related functions fulfill these requirements.

A.3.2.9 Residual risk

In today's technologically advanced world, the concept of safety is relative. The ability to ensure safety to the extent that risk is ruled out in all circumstances – "zero-risk guarantee" – is practically impossible. The residual risk is the risk that remains once all the relevant protective measures have been implemented in accordance with the latest state of the art.

Residual risks must be clearly referred to in the machine/plant documentation (user information according to EN ISO 12100).

A.3.3 Machine safety in the USA

A key difference between the USA and Europe in the legal requirements regarding safety at work is that, in the USA, no legislation exists regarding machinery safety that is applicable in all of the states and that defines the responsibility of the manufacturer/supplier. A general requirement exists stating that employers must ensure a safe workplace.

A.3.3.1 Minimum requirements of the OSHA

The Occupational Safety and Health Act (OSHA) from 1970 regulates the requirement that employers must offer a safe place of work. The core requirements of OSHA are specified in Section 5 "Duties".

The requirements of the OSH Act are managed by the "Occupational Safety and Health Administration" (also known as OSHA). OSHA employs regional inspectors who check whether or not workplaces comply with the applicable regulations.

The OSHA regulations are described in OSHA 29 CFR 1910.xxx ("OSHA Regulations (29 CFR) PART 1910 Occupational Safety and Health"). (CFR: Code of Federal Regulations.)

http://www.osha.gov

The application of standards is regulated in 29 CFR 1910.5 "Applicability of standards". The concept is similar to that used in Europe. Product-specific standards have priority over general standards insofar as they cover the relevant aspects. Once the standards are fulfilled, employers can assume that they have fulfilled the core requirements of the OSH Act with respect to the aspects covered by the standards.

In conjunction with certain applications, OSHA requires that all electrical equipment and devices that are used to protect workers be authorized by an OSHA-certified, "Nationally Recognized Testing Laboratory" (NRTL) for the specific application.

In addition to the OSHA regulations, the current standards defined by organizations such as NFPA and ANSI must be carefully observed and the extensive product liability legislation that exists in the US taken into account. Due to the product liability legislation, it is in the interests of manufacturing and operating companies that they carefully maintain the applicable regulations and are "forced" to fulfill the requirement to use state-of-the-art technology.

Third-party insurance companies generally demand that their customers fulfill the applicable standards of the standards organizations. Self-insured companies are not initially subject to this requirement but, in the event of an accident, they must provide verification that they have applied generally-recognized safety principles.

A.3.3.2 NRTL listing

To protect employees, all electrical equipment used in the USA must be certified for the planned application by a "Nationally Recognized Testing Laboratory" (NRTL) certified by the OSHA. NRTLs are authorized to certify equipment and material by means of listing, labeling, or similar. Domestic standards (e.g. NFPA 79) and international standards (e.g. IEC/EN 61508 for E/E/PES systems) are the basis for testing.

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A.3.3.3 NFPA 79

Standard NFPA 79 (Electrical Standard for Industrial Machinery) applies to electrical equipment on industrial machines with rated voltages of less than 600 V. A group of machines that operate together in a coordinated fashion is also considered to be one machine.

For programmable electronics and communication buses, NFPA 79 states as a basic requirement that these must be listed if they are to be used to implement and execute safety-related functions. If this requirement is fulfilled, then electronic controls and communication buses can also be used for Emergency Stop functions, Stop Categories 0 and 1 (refer to NFPA 79 9.2.5.4.1.4). Just the same as EN 60204-1, NFPA 79 no longer specifies that the electrical energy must be disconnected by electromechanical means for emergency stop functions.

The core requirements regarding programmable electronics and communication buses are: system requirements (see NFPA 79 9.4.3)

1. Control systems that contain software-based controllers must:

   – In the event of a single fault
   (a) Initiate that the system switches to a safe shutdown mode
   (b) Prevent the system from restarting until the fault has been rectified
   (c) Prevent an unexpected restart

   – Offer the same level of protection as hard-wired controllers

   – Be implemented in accordance with a recognized standard that defines the requirements for such systems.

2. IEC 61508, IEC 62061, ISO 13849-1, ISO 13849-2 and IEC 61800-5-2 are specified as suitable standards in a note.

Underwriter Laboratories Inc. (UL) has defined a special category for "Programmable Safety Controllers" for implementing this requirement (code NRGF). This category covers control devices that contain software and are designed for use in safety-related functions.

A precise description of the category and a list of devices that fulfill this requirement can be found on the Internet at the following address:

http://www.ul.com → Online Certifications Directory → UL Category code/Guide information → search for category "NRGF"

TUV Rheinland of North America, Inc. is also an NRTL for these applications.

A.3.3.4 ANSI B11

ANSI B11 standards are joint standards developed by associations such as the Association for Manufacturing Technology (AMT) and the Robotic Industries Association (RIA).

The hazards of a machine are evaluated by means of a risk analysis/assessment. The risk analysis is an important requirement in accordance with NFPA 79, ANSI/RIA 15.06, ANSI B11.TR-3 and SEMI S10 (semiconductors). The documented findings of a risk analysis can be used to select a suitable safety system based on the safety class of the application in question.

A.3.4 Machine safety in Japan

The situation in Japan is different from that in Europe and the US. Legislation such as that prescribed in Europe does not exist. Similarly, product liability does not play such an important role as it does in the US.

Instead of legal requirements to apply standards have been defined, an administrative recommendation to apply JIS (Japanese Industrial Standard) is in place: Japan bases its approach on the European concept and uses basic standards as national standards (see table).

Table A- 14   Japanese standards

ISO/IEC number	JIS number	Comment
ISO12100	JIS B 9700	earlier designation TR B 0008 and TR B 0009
ISO14121- 1 / EN1050	JIS B 9702	
ISO13849-1	JIS B 9705-1	
ISO13849-2	JIS B 9705-1	
IEC 60204-1	JIS B 9960-1	Without annex F or route map of the European foreword
IEC 61508-0 to -7	JIS C 0508	
IEC 62061		JIS number not yet assigned

A.3.5 Equipment regulations

In addition to the requirements of the guidelines and standards, company-specific requirements must be taken into account. Large corporations in particular (e.g. automobile manufacturers) make stringent demands regarding automation components, which are often listed in their own equipment specifications.

Safety-related issues (e.g. operating modes, operator actions with access to hazardous areas, EMERGENCY STOP concepts, etc.) should be clarified with customers early on so that they can be integrated in the risk assessment/risk reduction process.

A.3.6 Other safety-related issues

A.3.6.1 Additional references

- Safety Integrated: The Safety System for Industry (5th Edition and supplement), order no. 6ZB5 000-0AA01-0BA1

- Safety Integrated - Terms and Standards - Machine Safety Terminology (Edition 04/2007), order no. E86060-T1813-A101-A1

A.3.6.2 Information sheets issued by the Employer's Liability Insurance Association

Safety-related measures to be implemented cannot always be derived from directives, standards, or regulations. In this case, supplementary information and explanations are required.

Some regulatory bodies issue publications on an extremely wide range of subjects.

Note

These publications are in German. In some instances, they are also available in English and French.

Information sheets covering the following areas are available, for example:

- Process monitoring in production environments

- Axes subject to gravitational force

- Roller pressing machines

- Lathes and turning centers - purchasing/selling

These information sheets issued by specialist committees can be obtained by all interested parties (e.g. to provide support in factories, or when regulations or safety-related measures for plants and machines are defined). These information sheets provide support for the fields of machinery construction, production systems, and steel construction.

You can download the information sheets from the following Internet address (website is in German, although some of the sheets are available in English):

Employer's Liability Insurance Association (www.bghm.de)

First select the area "Arbeitsschützer", followed by the menu item "Praxishilfen" and finally "DGUV-Informationen".

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A.4   Manuals and technical support

A.4.1   Manuals for your inverter

Table A- 15   Manuals for your inverter

Information depth	Manual	Contents	Available languages	Download or order number
++	**Getting Started Guide** for the following inverters: • SINAMICS G120 with Control Units CU230P-2; CU240B-2; CU240E-2 • SINAMICS G120 with CU250S-2 Control Unit • SINAMICS G120C • SINAMICS G120D • SINAMICS G110M	Install the inverter and rotate the motor.	English, German, Italian, French, Spanish, Chinese	Download manuals (http://support.automation.siemens.com/WW/view/en/22339653/133300) **SINAMICS Manual Collection** Documentation on DVD, order number 6SL3097-4CA00-0YG0
+++	**Operating instructions** for the following inverters: • SINAMICS G120 with the Control Units CU240B-2; CU240E-2 • SINAMICS G120 with the Control Unit CU250S-2 • SINAMICS G120C • SINAMICS G120D with the Control Unit CU240D-2 • SINAMICS G120D with the Control Unit CU250D-2 • SINAMICS G110M • SIMATIC ET 200pro FC-2	Installing, commissioning and maintaining the inverter.		
+++	**Function Manual for Safety Integrated**	(this manual)	English, German, Chinese	
+++	**Fieldbus Function Manual** for the SINAMICS G120, G120C and G120D inverters	Configuring fieldbuses.		

Information depth	Manual	Contents	Available languages	Download or order number
+++	**List Manual** for the following inverters: • SINAMICS G120 with the Control Units CU240B-2; CU240E-2 • SINAMICS G120 with the Control Unit CU250S-2 • SINAMICS G120C • SINAMICS G120D with the Control Units CU240D-2, CU250D-2 • SINAMICS G110M • SIMATIC ET 200pro FC-2	Complete list of all parameters, alarms and faults. Graphic function diagrams.		
+	**Getting Started Guide** for the following SINAMICS G120 Power Modules: • PM240, PM250 and PM260 • PM240-2	Installing the Power Module	English	
+	**Installation Instructions** for reactors, filters and braking resistors	Installing components		
+++	**Hardware Installation Manual** for the following SINAMICS G120 Power Modules: • PM240 • PM240-2 • PM250 • PM260	Installing power modules, reactors and filters. Maintaining power modules.	English, German	
+++	**Operating Instructions** for the following Operator Panels: • BOP-2 • IOP	Operating operator panels, installing door assembly for IOP		
+++	**Operating Instructions** SIMATIC ET 200pro Distributed I/O System	Installing, commissioning and troubleshooting the distributed I/O system ET 200pro and F-Switch.	English, German, Italian, French, Spanish, Chinese, Russian	Download SIMATIC (http://support.automation.siemens.com/WW/view/en/19737445/133300)
+++	**Manual** SIMATIC ET 200pro motor starter	Installing, commissioning and troubleshooting ET 200pro motor starters and the F-RSM module.	English, French, German	

A.4.2 Configuring support

Table A- 16   Support when configuring and selecting the inverter

Manual or tool	Contents	Available languages	Download or order number
Catalog D 31	Ordering data and technical information for the standard SINAMICS G inverters	English, German, Italian, French, Spanish	Everything about SINAMICS G120 (www.siemens.en/sinamics-g120)
Online catalog (Industry Mall)	Ordering data and technical information for all SIEMENS products	English, German	
SIZER	The overall configuration tool for SINAMICS, MICROMASTER and DYNAVERT T drives, motor starters, as well as SINUMERIK, SIMOTION controls and SIMATIC Technology	English, German, Italian, French	You obtain SIZER on a DVD (Order number: 6SL3070-0AA00-0AG0) and in the Internet: Download SIZER (http://support.automation.siemens.com/WW/view/en/10804987/130000)

The TÜV-approved "Safety Evaluation Tool" for the standards IEC 62061 and ISO 13849-1 helps you to evaluate the safety functions of your machine. This online tool provides you with a standards-compliant report that can be integrated in the documentation as proof of safety:

Safety Evaluation Tool (www.siemens.com/safety-evaluation-tool).

A.4.3   Product Support

You can find additional information on the product and more in the Internet under: Product support (http://www.siemens.com/automation/service&support).

In addition to our documentation, under this address we offer our complete knowledge base online: You can find the following information:

- Actual product information (Update), FAQ (frequently asked questions), downloads.

- The Newsletter contains the latest information on the products you use.

- The Knowledge Manager (Intelligent Search) helps you find the documents you need.

- Users and specialists from around the world share their experience and knowledge in the Forum.

- You can find your local representative for Automation & Drives via our contact database under "Contact & Partner".

- Information about local service, repair, spare parts and much more can be found under "Services".

A.5 Mistakes and improvements

If you come across any mistakes when reading this manual or if you have any suggestions for how it can be improved, then please send your suggestions to the following address or by E-mail:

Siemens AG
Drive Technologies
Motion Control Systems
Postfach 3180
91050 Erlangen, Germany

E-mail (mailto:docu.motioncontrol@siemens.com)

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Further information

SINAMICS inverters:
www.siemens.com/sinamics

Safety Integrated:
www.siemens.com/safety-integrated

Subject to change without prior notice

Scan the QR code for additional informati- on.

www.siemens.com drives