SINAMICS G120

SINAMICS G120C frequency converters

SINAMICS G120D frequency converters with the Control Units CU240D-2 and CU250D-2

SINAMICS G120 frequency converter with the Control Units CU240E-2

Safety Integrated Funtction Manual · 08/2012

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SINAMICS G120 Safety Integrated Function Manual, SINAMICS G120 and G120C

Function Manual

Edition 08/2012, Firmware V4.5

08/2012, FW V4.5

A5E03052391B AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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

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

⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the relevant information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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A5E03052391B AC
℗ 08/2012 Technical data subject to change

Change history

Essential changes with respect to the manual, Edition 01/2011

New functions in firmware V4.5	In Chapter
Fail-safe digital output of the SINAMICS G120D converter with the CU240D-2 and CU250D-2 Control Units	Evaluating via F-DO (Page 50)

Revised descriptions	In Chapter
The instructions on the CU240S and CU240D Control Units have been removed. Information on these Control Units can be found in the manual: Function Manual: SINAMICS G120, SINAMICS G120D, SIMATIC ET200S FC, SIMATIC ET200pro FC (http://support.automation.siemens.com/WW/view/en/52614603).	Description (Page 13)
An introduction into the functionality of the safety functions has been added.	Description (Page 13)
The commissioning instructions combines the "Basic functions" and "Extended Functions".	Commissioning (Page 65)
The descriptions of the selection and deselection of the functions and the interaction between the various functions are combined in this Chapter.	Operation (Page 155)
A description has been added as to how the acceptance documents are created using the STARTER PC-based tool. The recommended acceptance tests have been revised.	Acceptance tests for the safety functions (Page 126)
Information about the service life of the converter with integrated safety technology and for the test interval have been added.	System properties (Page 219)

Corrections		In Chapter
Response time of STO (Extended Safety)		System properties (Page 219)
Typical: 50 ms (not 34 ms)	Worst-case scenario: 54 ms (not 44 ms)	

Table of contents

Introduction 1

1.1 About this manual

Who requires this manual and why?

This manual is aimed primarily at machine and plant manufacturers, commissioning engineers, and service personnel. The manual describes the integrated safety functions of the SINAMICS G120 (G120, G120C and G120D) converter family, and puts the target groups addressed in a position to correctly parameterize and commission the integrated safety functions of the converter.

What is described in this manual?

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

- Activating the safety functions via fail-safe digital inputs or PROFIsafe.
- Commissioning the safety functions.
- Performing diagnostics for 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 converter functions. An overview of the documentation available and the associated applications is provided in the sectionManuals for your inverter (Page 242).

1.2 Guide through this manual

Chapter	In this chapter, you will find answers to the following questions:
Description (Page 13)	• What safety functions does my converter have? • How do the safety functions basically work? • In which applications are the safety functions of my converter not permitted?
Interfaces (Page 33)	• How many fail-safe inputs does my converter have? • How do I have to wire up the fail-safe inputs of my converter? • What do I have to observe if the wiring extends beyond the control cabinet? • How do I configure the communication of my converter via PROFIsafe? • How are the control words and status words assigned in PROFIsafe?
Commissioning (Page 65)	• What approach to commissioning should I take? • What tool do I need for commissioning? • How do I transfer the parameters of the safety functions to other converters? • How do I reset my converter to the factory setting? • How do I check the safety functions after commissioning? • What safety function settings must I document?
Operation (Page 155)	• How must I select and deselect the safety function? • How do the converter and motor respond when the safety function is active? • How do the safety functions mutually influence one another? • How do the converter and motor respond to faults when the safety function is active? • How do I acknowledge safety function faults?
Servicing and maintenance (Page 207)	• When do I have to recommission the safety functions of my converter after I have replaced defective components? • What do I have to check after making a replacement?
System events (Page 215)	• What is the meaning of the signal states of the LED on my converter? • What is the meaning of the alarms and faults, which are assigned to the safety functions?
System properties (Page 219)	• 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 converter? • According to which standards are the safety functions of my converter certified?
Appendix (Page 221)	• As machine manufacturer or company operating a machine, what standards and regulations must I observe? • Where can I find more information on my converter?

Description

2

2.1 About this chapter

Overview

In this Chapter, users using the system for the first-time should obtain a quick overview of the principle mode of operation of the safety functions.

The table at the beginning of this chapter compares all of the devices described in this manual with other drive products with integrated safety functions.

The description of the safety functions starts with the definition according to EN 61800-5-2 and simple examples for using the function.

You can identify whether your converter supports the respective function.

The description of the functions is simplified as far as possible to clearly show the essential properties and setting options.

2.2 Drive products with integrated safety functions

	Applications with fixed speed		Applications with variable speed							High-performance and motion control applications		
	SIMATIC ET 200S Motor starter	SIMATIC ET 200pro Motor starter	SIMATIC ET 200S FC	SIMATIC ET 200pro FC	SINAMICS G120C	SINAMICS G120	SINAMICS G120D	SINAMICS G130	SINAMICS G150	SINAMICS S110	SINAMICS S120	SINAMICS S150
Integrated safety functions according to IEC 61800-5-2												
STO Safe Torque Off	Yes		Yes		Yes			Yes		Yes		
SS1 Safe Stop 1	-	-	Yes		-	Yes		Yes		Yes		
SBC Safe Brake Control	-	-	-	-	-	-	-	Yes[4]		Yes[3]	Yes[3, 4]	Yes[4]
SBT Safe Brake Test	-	-	-	-	-	-	-	-	-	-	Yes[1]	-
SLS Safely-Limited Speed	-	-	Yes		-	Yes		-	-	Yes		
SSM Safe Speed Monitor	-	-	-	-	-	Yes		-	-	Yes		
SDI Safe Direction	-	-	-	-	-	Yes		-	-	Yes		
SOS Safe Operating Stop	-	-	-	-	-	-	-	-	-	Yes		
SS2 Safe Stop 2	-	-	-	-	-	-	-	-	-	Yes		
SCA Safe Cam	-	-	-	-	-	-	-	-	-	-	-	-
SLP Safely-Limited Position	-	-	-	-	-	-	-	-	-	-	Yes	-
Fail-safe interfaces												
PROFIBUS with PROFIsafe profile	Yes		Yes		Yes			Yes		Yes		
PROFINET with PROFIsafe profile	Yes		Yes		Yes			Yes		Yes		
Fail-safe inputs	Yes, with external components		Yes, with external components		Yes			Yes		Yes, external components required in certain cases		
Fail-safe outputs	-		-		-	-	Yes	-	-	Yes	Yes, when TM54F is used	
Certifications												
EN ISO 13849-1	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		-
NRTL listed	Yes		-		-			-		-	Yes[2]	-

Content of this manual

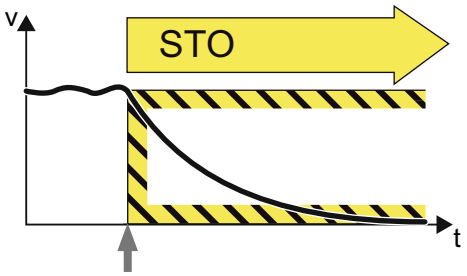
[1] With certified DCC application
[2] Only for SINAMICS S120 Booksize
[3] With Safe Brake Module
[4] For Chassis and Cabinet Modules with Safe Brake Adapter

Figure 2-1 Overview of products for drive technology with integrated safety functions

2.3 Safe Torque Off (STO)

Definition according to EN 61800-5-2:

"The STO function prevents energy from being supplied to the motor, which can generate a torque."



Examples of how the function can be used

Example	Solution option
When the Emergency Stop button is pressed, it is not permissible that a stationary motor undesirably starts.	• Wire the Emergency Stop button with a fail-safe input. • Select STO via the fail-safe input.
A central Emergency Stop button ensures that several drives cannot unintentionally start.	• Evaluating an Emergency Stop pushbutton in a central control. • Select STO via PROFIsafe.

Which converters support this function?

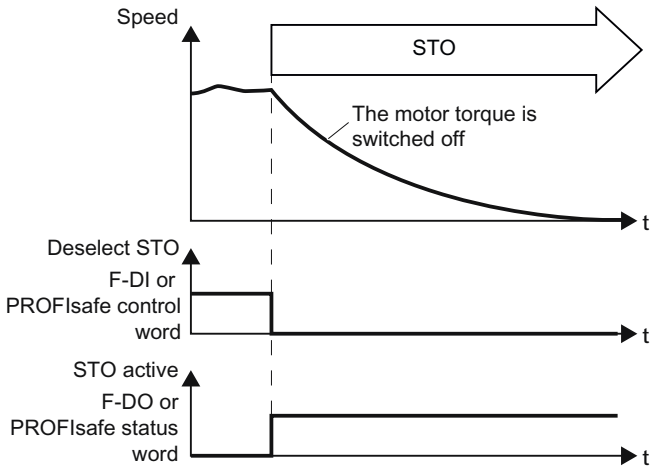
Table 2- 1 Converter with STO

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
with Control Unit	with Control Unit	G120C G120C DP G120C PN G120C CAN
CU240E-2 CU240E-2 DP CU240E-2 F CU240E-2 DP-F CU240E-2 PN CU240E-2 PN-F	CU240D-2 DP CU240D-2 DP-F CU240D-2 PN CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

How does STO function in detail?

The converter recognizes the selection ofSTO via a fail-safe input or via the safe communicationPROFIsafe.

The converter then safely switches off the torque of the connected motor.



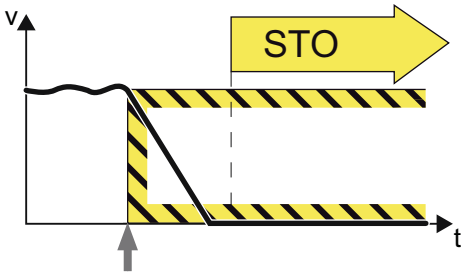
If no motor holding brake is present, the motor coasts to a standstill.

If you use a motor holding brake, the converter closes the brake immediately after selecting STO.

2.4 Safe Stop 1 (SS1)

Definition according to EN 61800-5-2:

"The SS1 function brakes the motor, monitors the magnitude of the motor deceleration within defined limits and initiates the STO function if the motor speed falls below a specified limit value."



Example of how the function can be used

Example	Solution option
It is only permissible to open a protective door if the motor torque has been switched off.	• Select SS1 in the converter using a fail-safe input or via PROFIsafe . • If the converter signals "STO active" viaPROFIsafe , release the protective door.

Which converters support this function?

Table 2- 2 Converters with SS1

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
with Control Unit	with Control Unit	---
CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

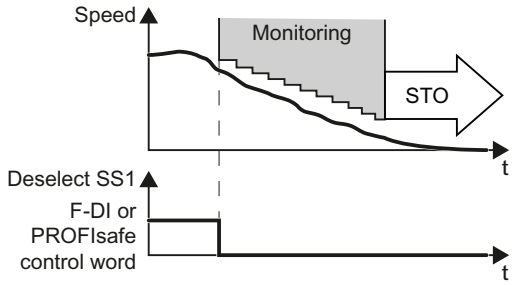
For these converters, an encoder to sense the motor speed is not required for the SS1 function.

How does SS1 function in detail?

Overview

SS1 brakes the motor and monitors the absolute speed.

If the motor speed is low enough, the converter safely switches off the motor torque using STO .



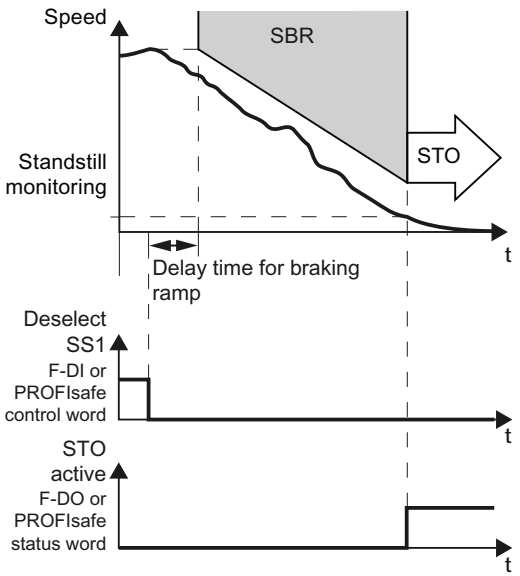
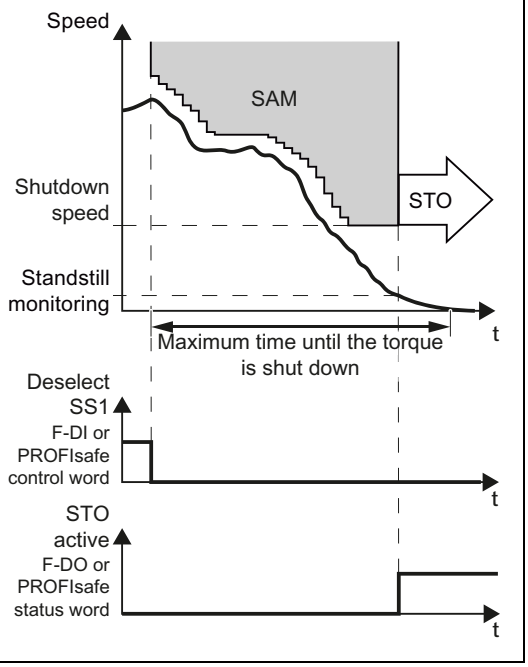
Select SS1

As soon as the converter identifies that SS1 has been selected via a fail-safe input or via safe communication PROFIsafe , the following happens:

- If the motor has already been switched off when selecting SS1 , then the converter safely switches off the motor torque (STO).
- If the motor is switched on when SS1 is selected, the converter brakes the motor with the OFF3 ramp-down time.

Monitoring modes

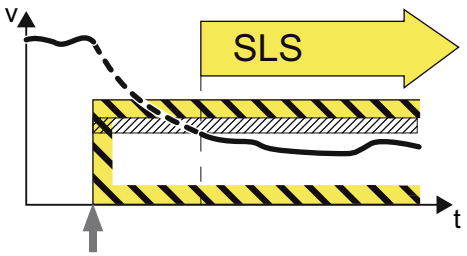
You can select between two different monitoring modes of the SS1function.

Braking ramp monitoring	Acceleration monitoring
	

Braking ramp monitoring	Acceleration monitoring
• Using the SBR (Safe Brake Ramp) function, the converter 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, which was present at the instant in time that SS1 was selected. • When the standstill monitoring threshold is fallen below, the converter safely switches off the motor torque (STO) .	• The converter monitors the motor speed using the function SAM (Safe Acceleration Monitor). • The converter prevents the motor from re-accelerating by continuously adjusting the monitoring threshold to the decreasing speed. • The converter reduces the monitoring threshold until the "Shutdown speed" has been reached. • The converter safely switches off the motor torque (STO), if one of the following conditions is fulfilled: – The converter detects that the motor is stationary. – The maximum time until the torque is switched off has expired.

2.5 Safely Limited Speed (SLS)

Definition according to EN 61800-5-2:
"The SLS function prevents the motor from exceeding the defined speed limit."



Examples of how the function can be used

Example	Solution option
After opening a protective door, the machine operator must enter the machine and in the hazardous zone, operate a horizontal conveyor belt running at a slow speed using a pushbutton.	• Select SLS in the converter using a fail-safe input or PROFIsafe . • The converter limits and monitors the speed of the horizontal conveyor.
A spindle drive, depending on the selection of the cutting tool, must not exceed a specific maximum speed.	• Select SLS and the corresponding SLS level in the converter via PROFIsafe.

Which converters support this function?

Table 2- 3

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
with Control Unit	with Control Unit	---
CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

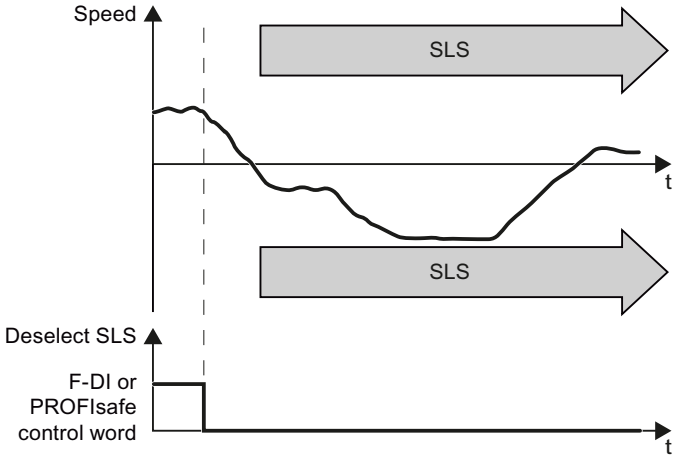
For these converters, an encoder to sense the motor speed is not required for the SLS function.

How does SLSfunction in detail?

Overview

SLS monitors the absolute value of the actual speed.

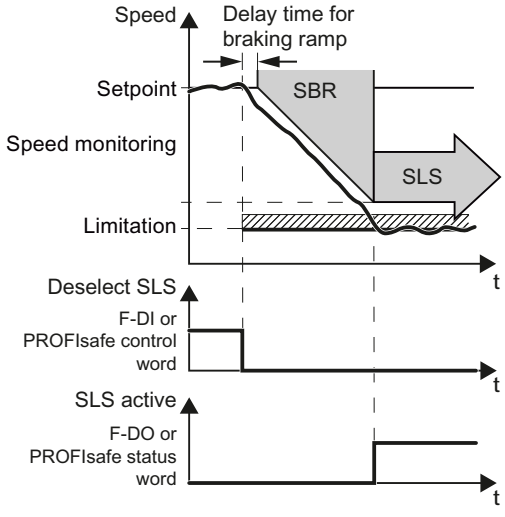
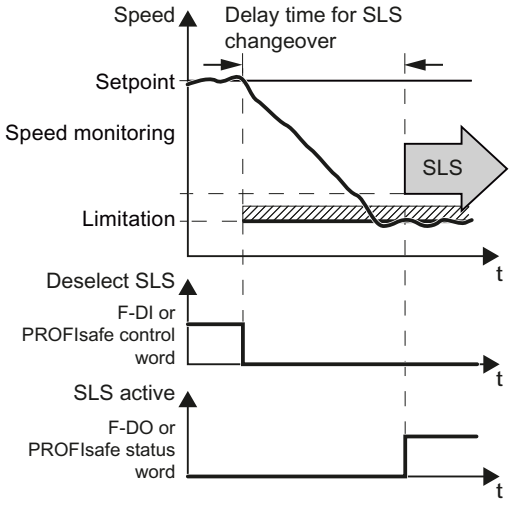
In addition, SLS limits the speed to values below the monitoring threshold.



Selecting SLS when the motor is switched on

As soon as the converter identifies that SLS has been selected via a fail-safe input or via safe communication PROFIsafe , the following happens:

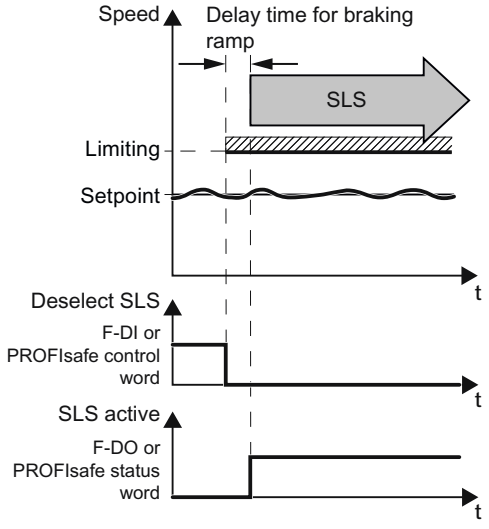
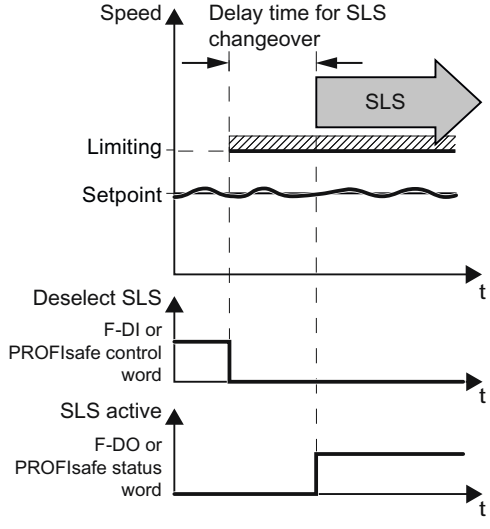
- The converter limits the speed to a value below the SLS monitoring and brakes the motor with the OFF3 ramp-down time.
- You can select whether the converter monitors motor braking using the SBR (Safe Brake Ramp) function or not.

With braking ramp monitoring	Without braking ramp monitoring
	

With braking ramp monitoring	Without braking ramp monitoring
• After the adjustable "delay time for the braking ramp", using the SBR (Safe Brake Ramp) function, the converter monitors whether the speed decreases. • The converter switches from SBR to SLS as soon as one of the following two conditions are fulfilled: – The SBRmonitoring 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 converter monitors the load speed after the "delay time for SLS changeover" has expired.
Benefits: • Already during braking, the converter 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 subfunction SBR 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 SLSlimit, then the drive responses follows:

With braking ramp monitoring	Without braking ramp monitoring
	
• The converter monitors the speed after the "delay time for the braking ramp".	The converter monitors the load speed after the adjustable "delay time for SLS changeover".

Deselecting SLS

If the higher-level control deselects SLS , then the converter deactivates limiting and monitoring.

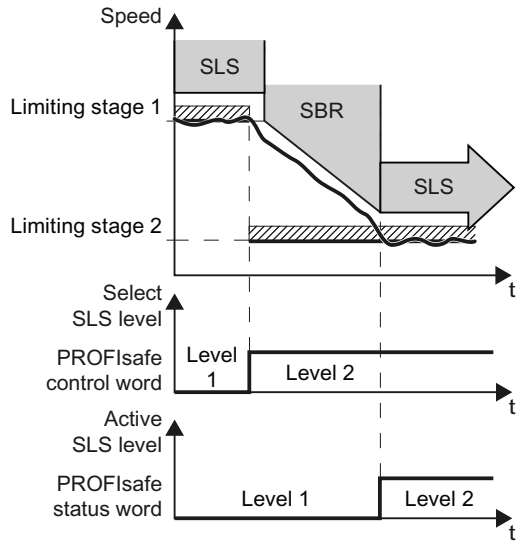
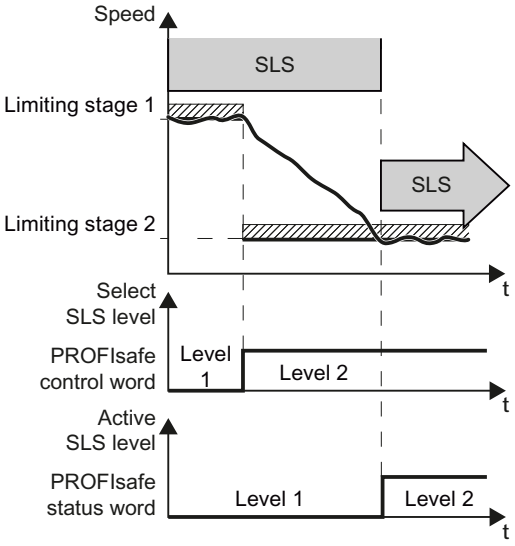
Changing over the monitoring thresholds

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

Note

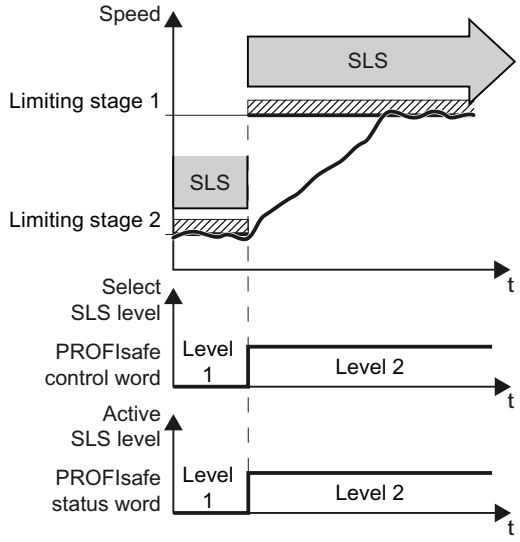
Switching over the speed levels is only possible via PROFIsafe .

Switching to a lower speed level

<table>
<tr><th>With braking ramp monitoring</th><th>Without braking ramp monitoring</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>• Once the "delay time for braking ramp" has elapsed, the converter monitors the motor speed using the function SBR (Safe Brake Ramp).
• The converter switches from SBR monitoring to SLS monitoring as soon as one of the two following conditions is fulfilled:
– The SBRmonitoring ramp has reached the value of the SLSmonitoring.
This case is shown in the diagram above.
– The load speed has decreased down to the value SLSmonitoring and the "delay time for braking ramp" has expired.</td><td>• The converter monitors the speed with the lower SLS level after the "delay time for SLS switchover" has expired.</td></tr>
</table>

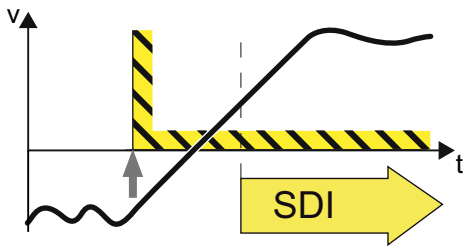
Switching to a higher speed level

If you switch over from a lower to a higher speed level, the converter immediately monitors the actual speed against the higher speed.



2.6 Safe Direction (SDI)

Definition according to EN 61800-5-2:
"The SDI function prevents the motor shaft moving in the wrong direction."



Examples of how the function can be used

Example	Solution option
A protective door must only be opened if a drive moves in the safe direction (away from the operator).	• Select SDI in the converter using a fail-safe input or PROFIsafe . • Enable the locking mechanism of the protective doors via the PROFIsafe status bit of the converter.
When replacing the pressure cylinders of the plates, the drive must only move in the safe direction of rotation.	• Select SDI in the converter using a fail-safe input or PROFIsafe . • In the converter, 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 start to move in one direction.	
When a crane trolley is at the operating limit switch then it may only start in the opposite direction.	

Which converters support this function?

Table 2- 4 Converters with SDI

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
with Control Unit	with Control Unit	---
CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

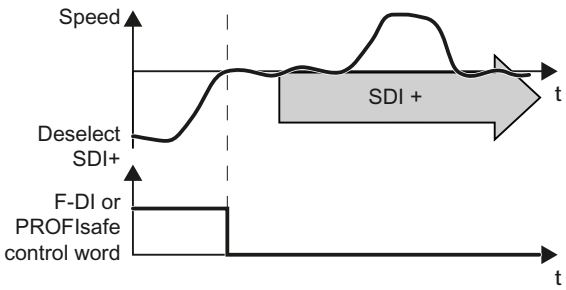
For these converters, an encoder to sense the motor speed is not required for the SDI function.

How does SDIfunction in detail?

Overview

SDI monitors the actual direction of rotation.

In addition, SDI limits the speed to values in the permissible direction.



Selecting and deselecting SDI

As soon as the converter has detected the selection of SDI+ or SDI- via a fail-safe input or via the safe communication PROFIsafe , the following happens:

- The converter is set in the factory, so that after selecting SDI, it limits the speed in the permitted direction of rotation.
- After the delay time has expired, the converter monitors the direction of rotation of the motor.
- If the higher-level control deselects SDI , then the converter deactivates limiting and monitoring.

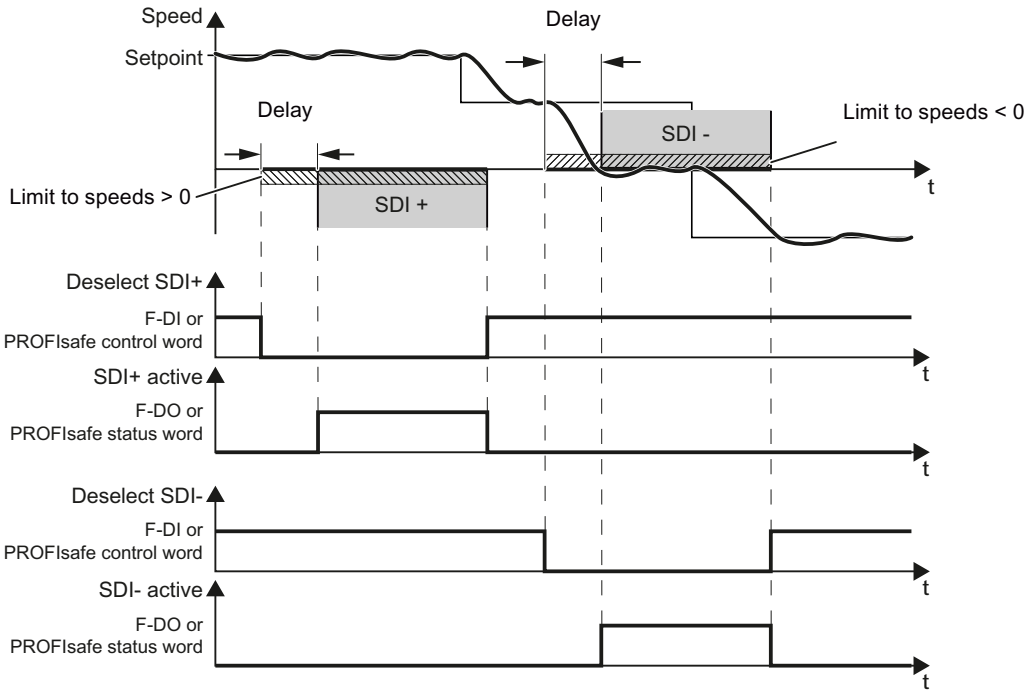


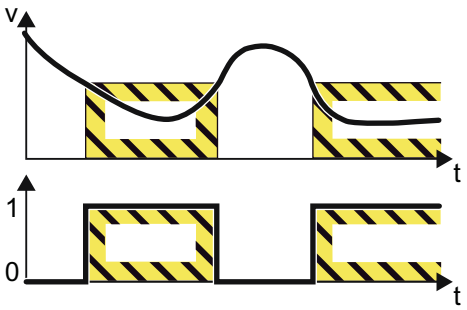
Figure 2-2 Time response of the safety function SDI (Safe Direction)

The converter tolerates brief and slight load movement in the monitored direction of rotation.

2.7 Safe Speed Monitor (SSM)

Definition according to EN 61800-5-2:

"The SSM function supplies a safe output signal, to indicate whether the motor speed lies below a defined limit."



Example of how the function can be used

Example	Solution option
A centrifuge may only filled below a certain minimum velocity.	• The converter safety monitors the centrifuge speed and enables the process to advance to the next step using the PROFIsafe status bit "Status SSM ".

Which converters support this function?

Table 2- 5 Converters with SSM

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
with Control Unit	with Control Unit	---
CU240E-2 DP-F CU240E-2 PN-F	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

For these converters, an encoder to sense the motor speed is not required for the SSM function.

How does SSMfunction in detail?

Preconditions

The safety function SSM cannot be selected or deselected using external control signals. SSM is active when you have set a monitoring velocity > 0 for SSM .

Evaluating the speed

The converter compares the load speed with the speed limit and signals if the limit value is fallen below to the high-level control.

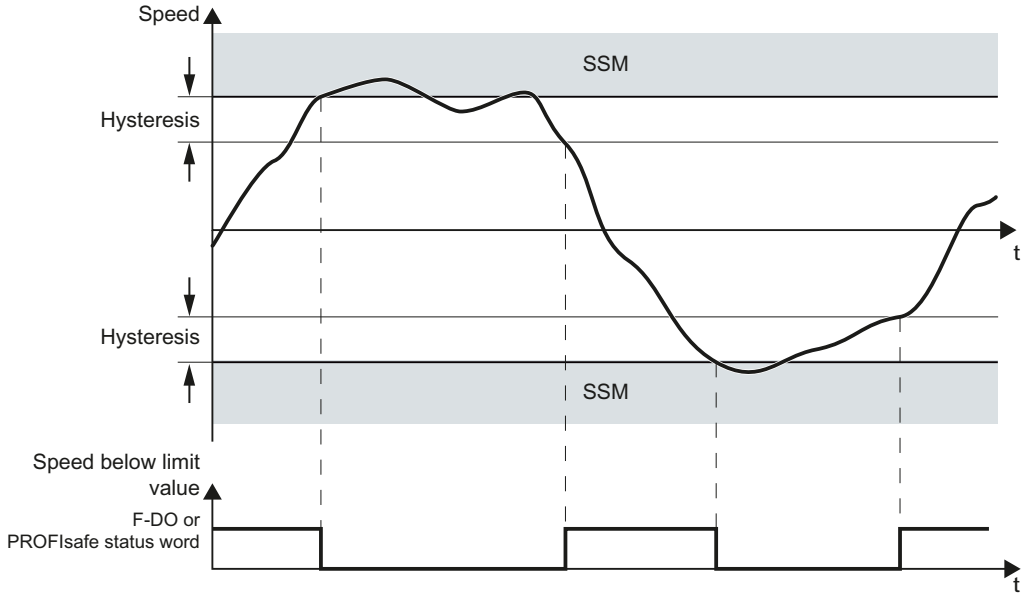


Figure 2-3 Time response of the safety function SSM (Safe Speed Monitor)

2.8 Preconditions and restrictions when used in an application

2.8.1 General conditions

Prerequisites for using fail-safe functions

1. The machine risk assessment, e.g. in compliance with DIN EN ISO 12100, "Safety of machinery - general design principles – Risk assessment and risk minimization", allows converter safety functions to be used in accordance with SIL 2 or PL d.
2. The closed-loop speed control of the converter must function properly. Each fail-safe drive train must be set up in such a way that all the operating procedures performed by the driven machine can be properly monitored and that the converter operates below its limit values (for current, temperature, voltage, etc.). The drive train comprises a converter, motor, brake and driven machine. The performance and parameters of the converter must be compatible with both the connected motor and the application in question.
3. Once the machine has been successfully commissioned, you must review the typical operating conditions and operate the machine close to the permissible limit values. The converter must not malfunction during this test.

Permissible control modes for using fail-safe functions

When the above-mentioned conditions are fulfilled, all of the fail-safe functions can be used for both V/f control and vector control.

Permissible motors for using fail-safe functions

When the above-mentioned conditions are fulfilled, all of the fail-safe functions can be used for induction motors from SIEMENS and other manufacturers.

Synchronous motors are not permitted.

2.8.2 Permissible and prohibited applications

The safety function STO may be used without any restrictions in all applications.

⚠WARNING

Suspended loads

If the motor can be accelerated by the mechanical system of the connected machine part after the motor has been switched off, it is not permissible to use safety functions SS1, SLS, SSM and SDI.

Whether or not a mechanical brake is installed is irrelevant here.

Examples:

1. For the hoisting gear of a crane, the suspended load can accelerate the motor as soon as the motor is switched off. In this case, encoderless safety functions SS1, SLS, SSM and SDI are not permissible.
   Even if the mechanical brake of the hoisting gear is applied after the motor has been switched off, this is of no significance regarding the fact that safety functions SS1, SLS, SSM and SDI are prohibited in this application.
2. A horizontal conveyor is always braked to a standstill due to friction as soon as the motor is switched off. In this case, encoderless safety functions SS1, SLS, SSM and SDI can be used without any restrictions.

⚠ WARNING

PM240 FSGX Power Module

In conjunction with the PM240 FSGX Power Module, only safety function STO of the basis functions is permitted. It is not permissible that you use the following safety functions in a converter equipped with the PM240 FSGX Power Module:

- STO of the extended functions
- SS1
- SLS
- SDI
- SSM

2.8.3 Impermissible functions

NOTICE

With some converter functions the motor speed fluctuates significantly. If a safety function is simultaneously active, then this can result in a malfunction of the safety function and the converter initiates a STOP F.

When one or several of the safety functions SS1, SLS, SSM or SDI are active or enabled, then you must not use the following converter functions:

- Motor identification
- Flying restart
- DC braking
- Compound braking

Further, if SS1, SLS, SSM or SDI is active, it is not permissible to switch over the closed-loop control of the motor, e.g. from closed-loop speed control to closed-loop torque control.

Interfaces

3

3.1 Overview of the interfaces

Depending on the design of converter, fail-safe digital inputs and outputs (F-DI, F-DO) or the safe bus communication PROFIsafe is available as interface of the safety functions.

Frequency converter		Interfaces		
		F-DI	F-DO	PROFIsafe
	SINAMICS G120C USS SINAMICS G120C CAN	1	0	No
	SINAMICS G120C DP SINAMICS G120C PN	1	0	Yes
	SINAMICS G120 with Control Unit …			
	CU240E-2	1	0	No
	CU240E-2 DP CU240E-2 PN	1	0	Yes
	CU240E-2 F	3	0	No
	CU240E-2 DP-F CU240E-2 PN-F	3	0	Yes
	SINAMICS G120D with Control Unit …			
	CU240D-2 DP CU240D-2 PN	1	0	Yes
	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	3	1	Yes

3.2 Activation via F-DI

3.2.1 Fail-safe inputs

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

Assignment of the fail-safe inputs

Table 3- 1 Converter (chassis units IP20) with only one fail-safe input

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

Table 3- 2 Converter (chassis units IP20) with several fail-safe inputs

SINAMICS G120 with Control Unit CU240E-2 F CU240E-2 DP-F CU240E-2 PN-F	Terminal strip	Digital input	Fail-safe 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 3- 3 Converter for cabinet-free installation (IP65) with only one fail-safe input

SINAMICS G120D with Control Unit CU240D-2 DP CU240D-2 PN	Connector.pin	Digital input	Fail-safe input
	X9.4	DI 4	F-DI 0
	X9.2	DI 5	

Table 3- 4 Converter for cabinet-free installation (IP65) with several fail-safe inputs

SINAMICS G120D with Control Unit CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	Connector.pin	Digital input	Fail-safe 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 a fail-safe input. The converter evaluates the signal on two separate signal paths.

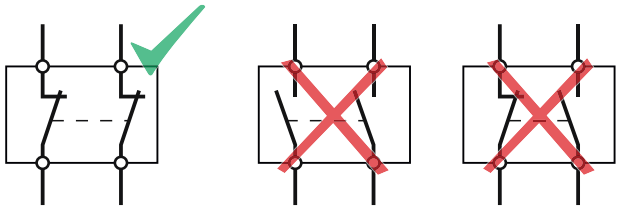
Connect devices

A fail-safe input is designed for the following devices:

- Direct connection of safety sensors, e.g. EMERGENCY STOP command devices or light curtains.
- Pre-processing safety relays, e.g. fail-safe controllers.

Permitted sensors and signals

The fail-safe input of the converter is designed for connecting sensors with two NC contacts.



Permitted sensors

If you interconnect pre-processing safety relays via two separate cables with the converter, the two transferred must always have the same signal state.

The converter expects the following signals at its fail-safe input:

- High signal: Fail-safe input is not active.
- Low signal: Fail-safe input is active.

Special measures for wiring of a fail-safe input

The converter evaluates deviations in the two signals of the fail-safe input. The converter thus detects, for example the following faults:

- Cable break
- Defective sensor

The converter cannot detect the following faults:

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

You have the following options to reduce the risk of damaged cables during operation of your machine or plant:

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

These special types of cable routing are normally required only if the cables are laid over larger distances, e.g. between remote control cabinets.

3.2.2 Wiring examples

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

3.2.2.1 Connecting sensors

Electromechanical sensor

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

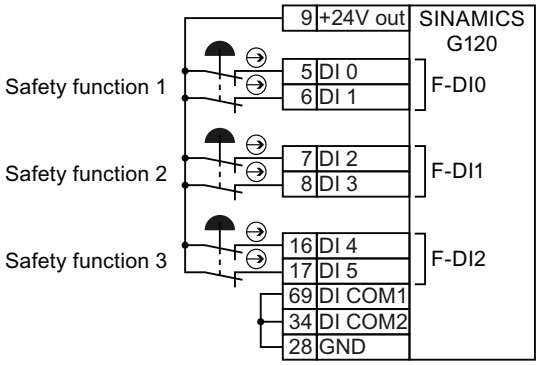


Figure 3-1 Connecting an electromechanical sensor to the converter power supply

External power supply

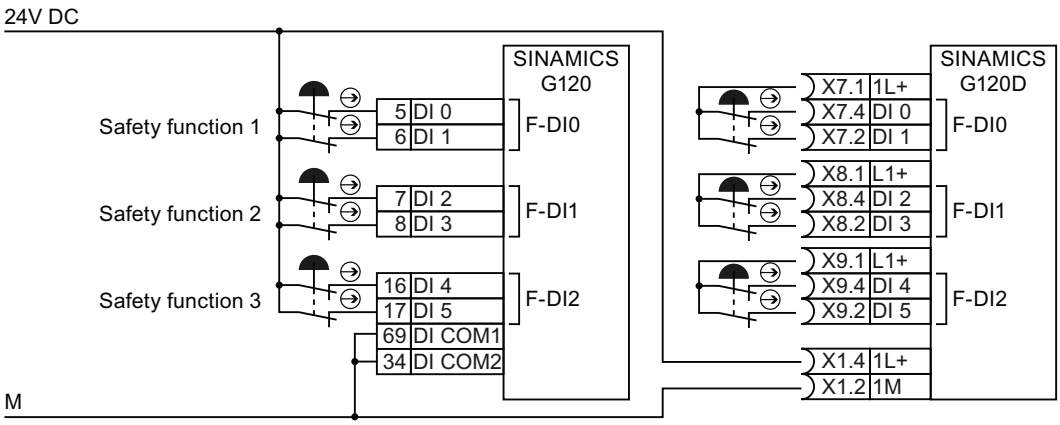


Figure 3-2 Connecting an electromechanical sensor to an external power supply

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 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 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.

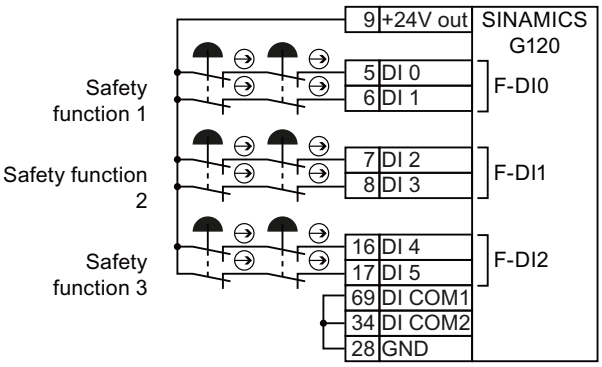


Figure 3-3 Connecting electromechanical sensors to the converter power supply in series

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.

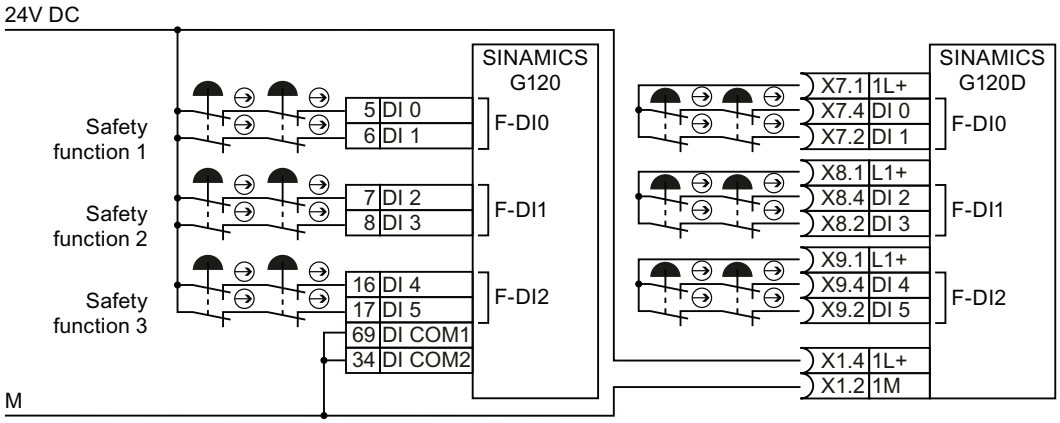


Figure 3-4 Connecting electromechanical sensors to an external power supply in series

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.

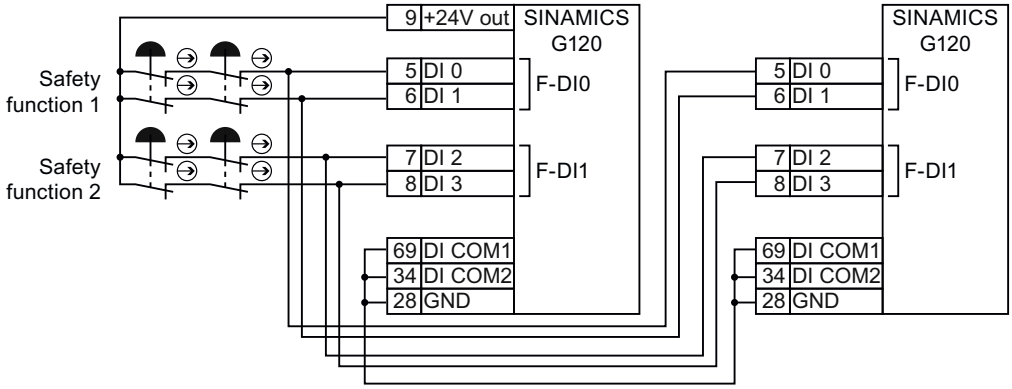


Figure 3-5 Simultaneous activation of several converters with converter power supply

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.

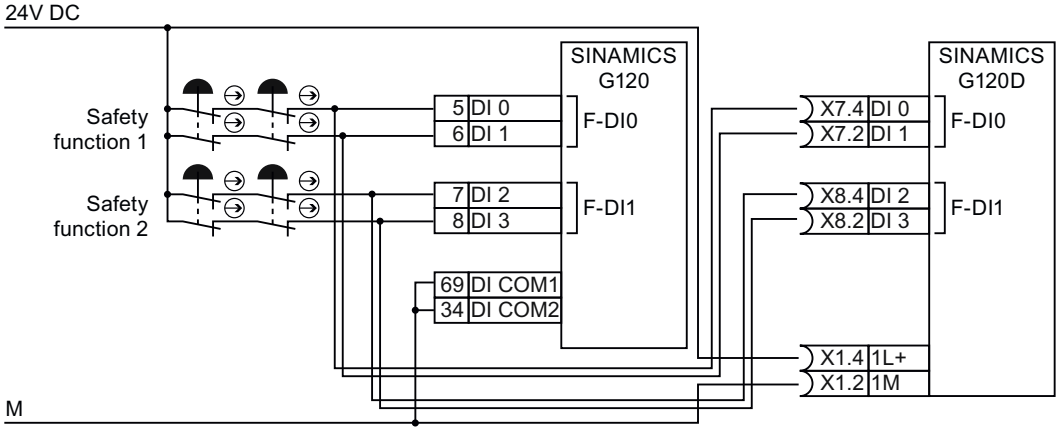


Figure 3-6 Simultaneous activation of several converters with external power supply

3.2.2.2 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 converter 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 set up and wired correctly does not contain any damaged wiring or cross circuits.

For this reason, you may interconnect a safety relay and converter in the same control cabinet by means of a single-channel wiring arrangement. The two terminals of the fail-safe input must be connected to each other on the converter.

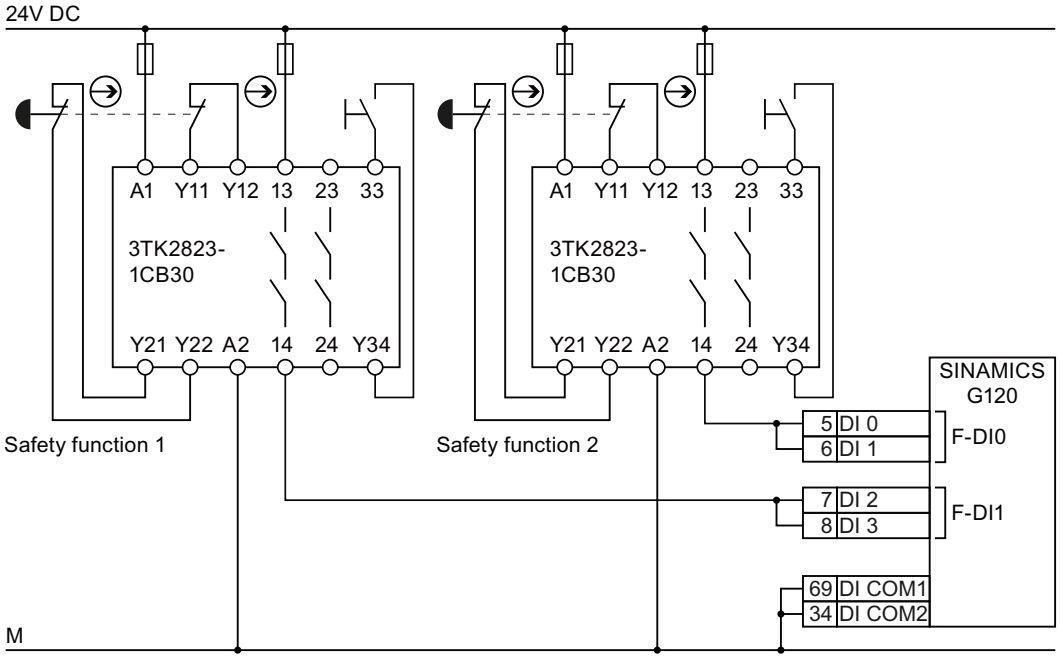


Figure 3-7 Interconnecting the converter and safety relay within the same control cabinet

Components in separate control cabinets

If the components are located in separate control cabinets, the wiring between the safety relay and fail-safe inputs on the converter 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.

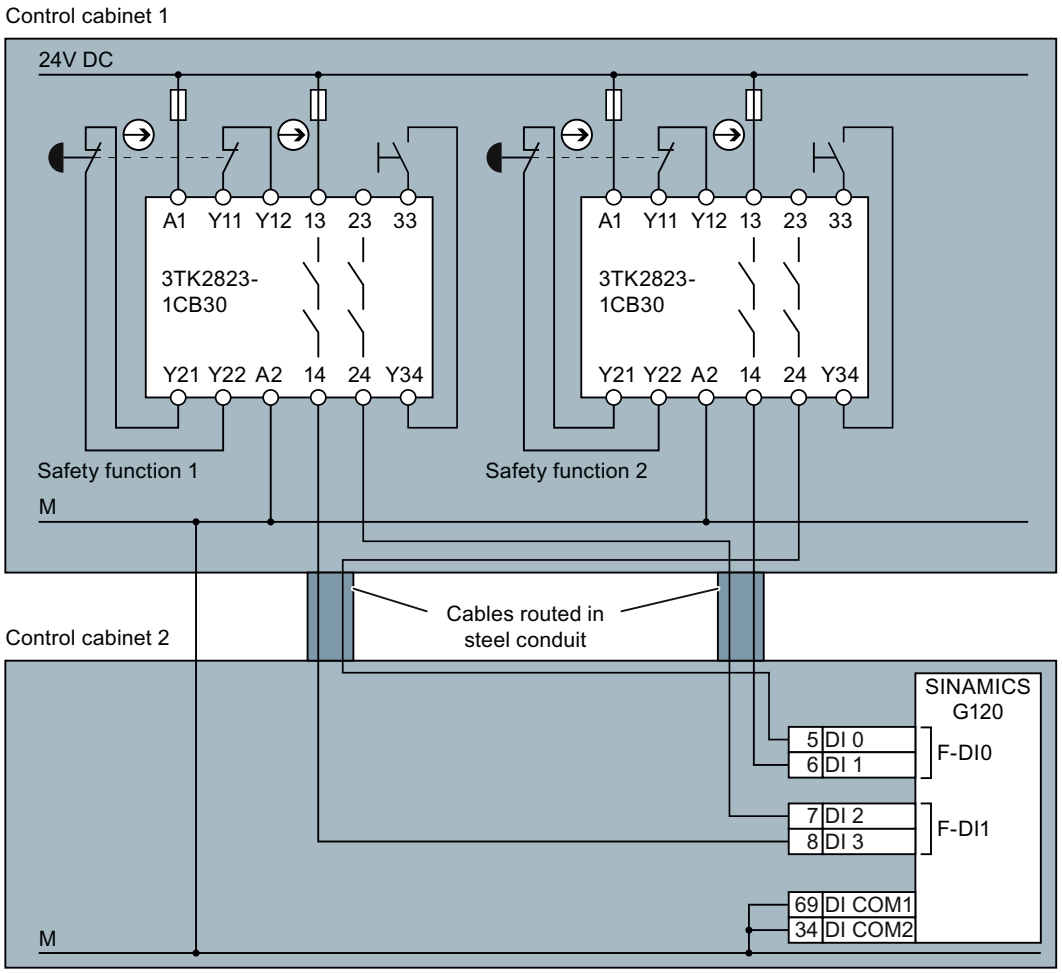


Figure 3-8 Interconnecting the converter and safety relay in separate control cabinets

3RK3 Modular Safety System

You can use both the fail-safe 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 converter.

The fail-safe 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 converter 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 set up and wired correctly does not contain any damaged wiring or cross circuits.

You may interconnect the Modular Safety System and converter within the same control cabinet by means of a single-channel wiring arrangement. The two terminals of the fail-safe input must be connected to each other on the converter.

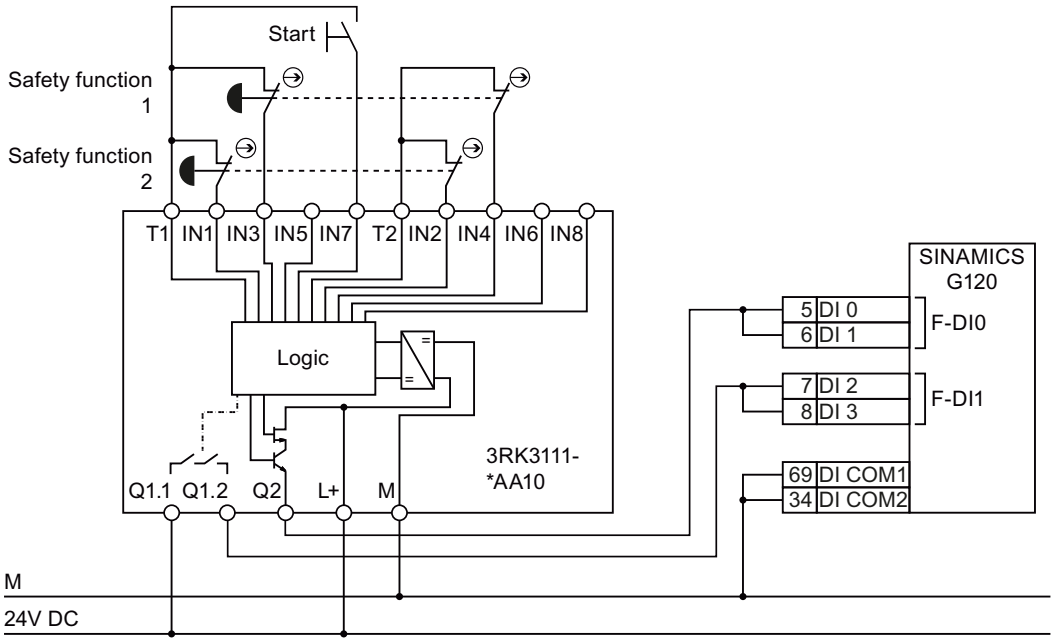


Figure 3-9 Interconnecting the converter and Modular Safety System within the same control cabinet

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 converter 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 fail-safe outputs of the 3RK3 central unit for transferring signals via two channels, converter discrepancy monitoring must be adapted to the different switching times of the electronic output and relay contact.

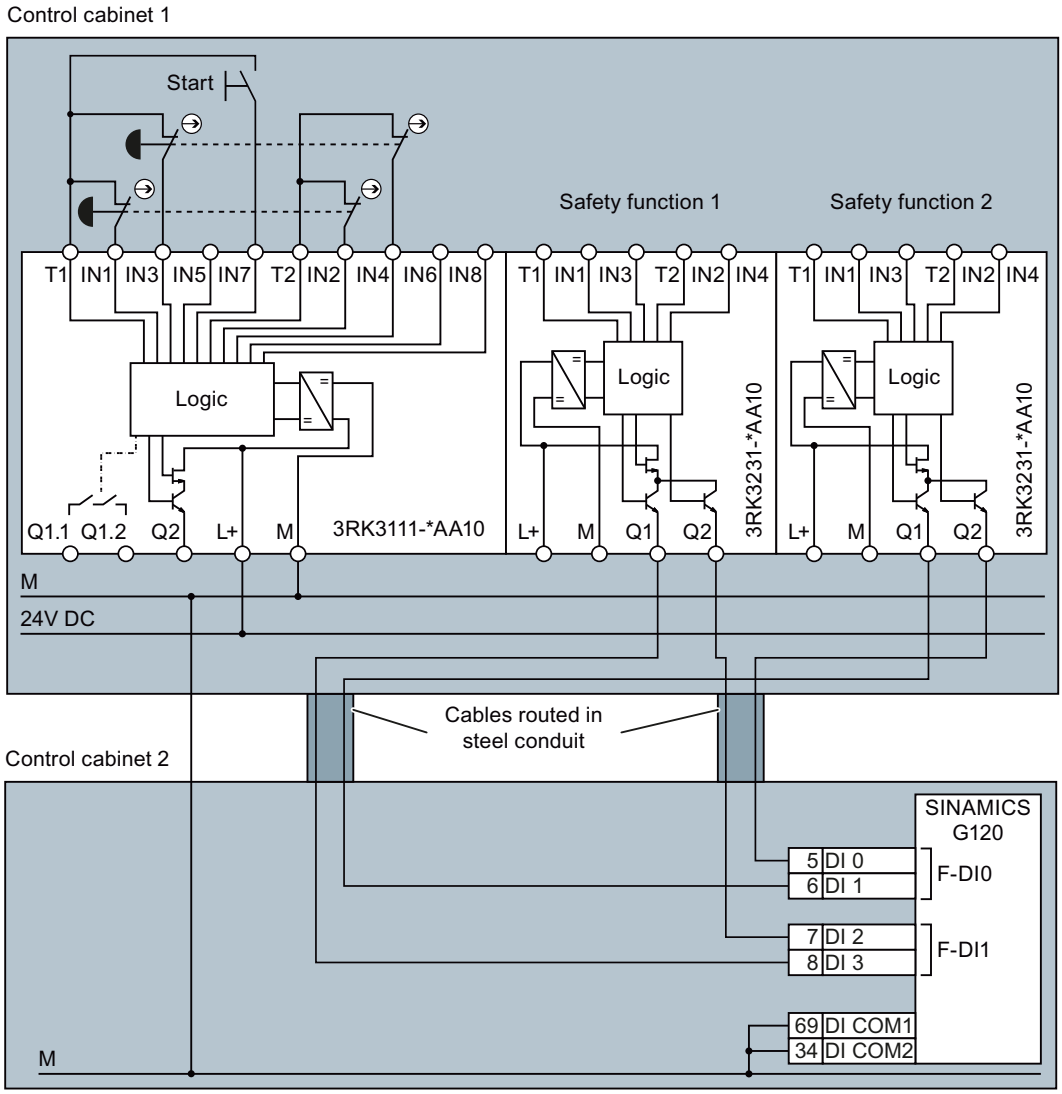


Figure 3-10 Interconnecting the converter and Modular Safety System in separate control cabinets

S7-300 I/O modules

Fail-safe outputs that switch to P potential are required for activating the fail-safe 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 converter 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 set up and wired correctly does not contain any damaged wiring or cross circuits.

You may interconnect the SM326 I/O module and converter within the same control cabinet by means of a single-channel wiring arrangement. The two terminals of the fail-safe input must be connected to each other on the converter.

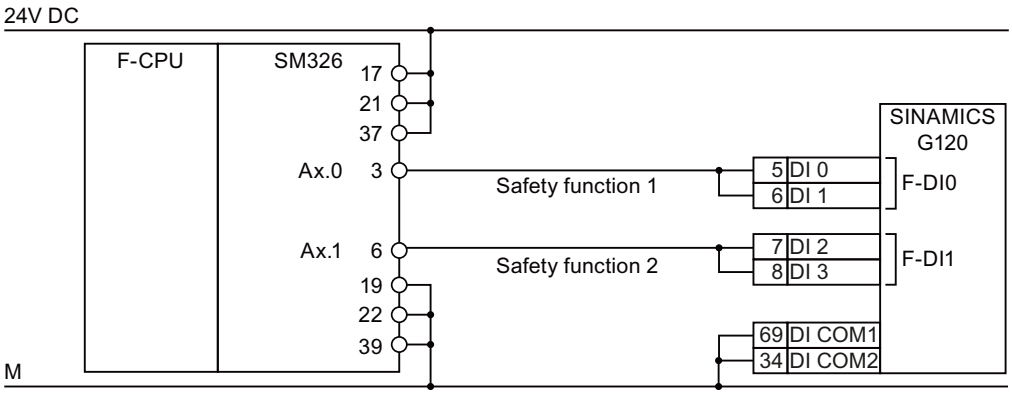


Figure 3-11 Interconnecting the converter and SM326 I/O module within the same control cabinet

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 converter 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.

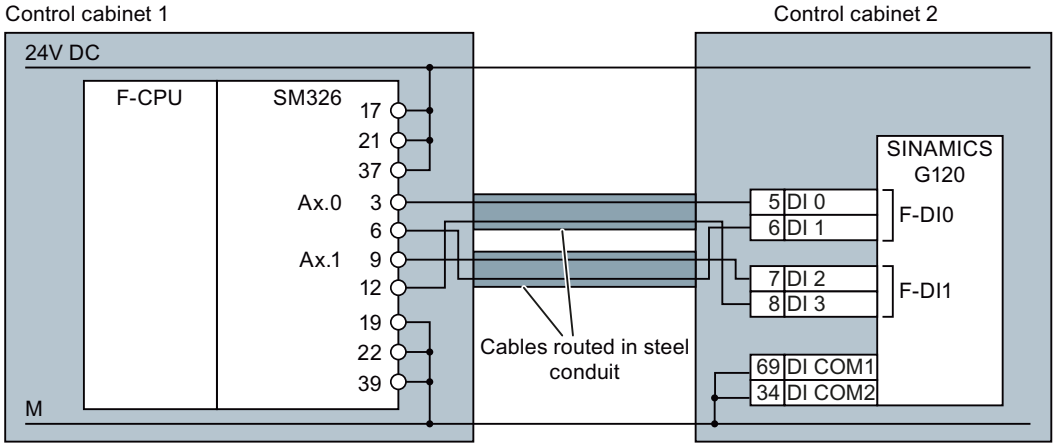


Figure 3-12 Interconnecting the converter and SM326 I/O module in separate control cabinets

ET 200 I/O modules

Fail-safe outputs that switch to P potential are required for activating the fail-safe 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 fail-safe relay module is activated via a fail-safe ET 200S output module.

The diagrams only show how the I/O modules and converter 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 set up and wired correctly does not contain any damaged wiring or cross circuits.

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

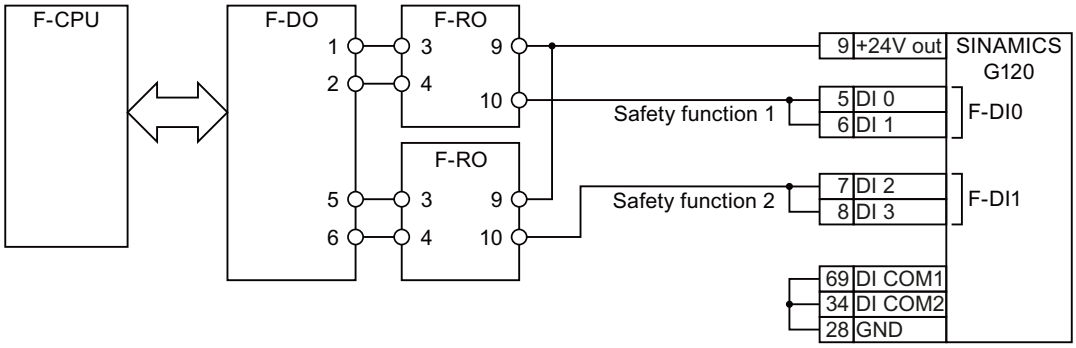


Figure 3-13 Interconnecting the converter and I/O modules within the same control cabinet

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 converter 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.

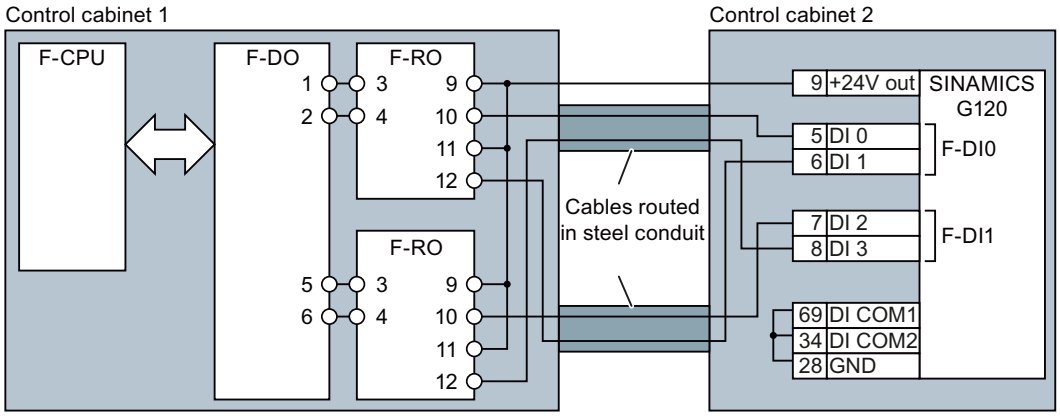


Figure 3-14 Interconnecting the converter and I/O modules in separate control cabinets

3.3 Evaluating via F-DO

3.3.1 Fail-safe output

Only the converters for configurations without control cabinet SINAMICS G120D have a fail-safe digital output.

In the factory setting of the converter, the fail-safe digital output is assigned to none of the integrated safety functions. Only when commissioning do you define whether you use, for example, the digital outputs DO 0 and DO 1 for standard functions, or by combining, you create a fail-safe two-channel output.

Table 3- 5 Converters for cabinet-free installation (IP65)

SINAMICS G120D with Control Unit CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	Connector.pin	Digital output	Fail-safe digital output
	X5.4	DO 0	F-DO 0
	X5.2	DO 1	

The converter monitors the two signals of its fail-safe output for inconsistency.

Connect devices

The fail-safe output is designed for the following devices:

- Direct connection of a fail-safe input.
- Connection of two relays.

The two signals of the fail-safe output each have the same state:

- High signal: Fail-safe output is active.
- Low signal: Fail-safe output is not active.

3.3.2 Connecting a fail-safe output

Testing a fail-safe output

You must interconnect the fail-safe output corresponding to your application in order that the converter can test its fail-safe output at regular intervals.

During the self-test the converter temporarily switches off the connected actuator. With the self test, the converter checks whether the output transistors and the connected components can be switched off.

Information on how you can set the particular test mode is provided in Section: Commissioning (Page 65).

Connecting a relay

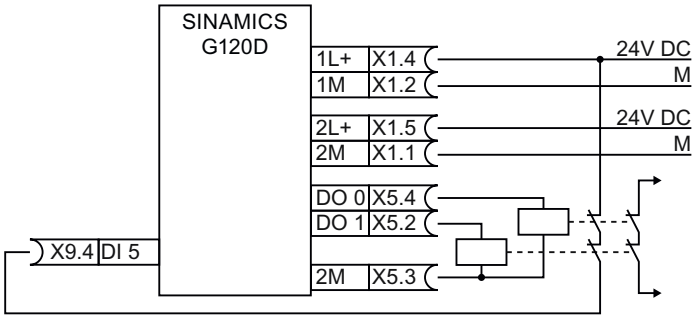


Figure 3-15 Connecting a relay at the F-DO

When testing the fail-safe output, the converter switches off the two outputs one after the other and evaluates the feedback signal via digital input DI 5.

Connecting an actuator with feedback signal

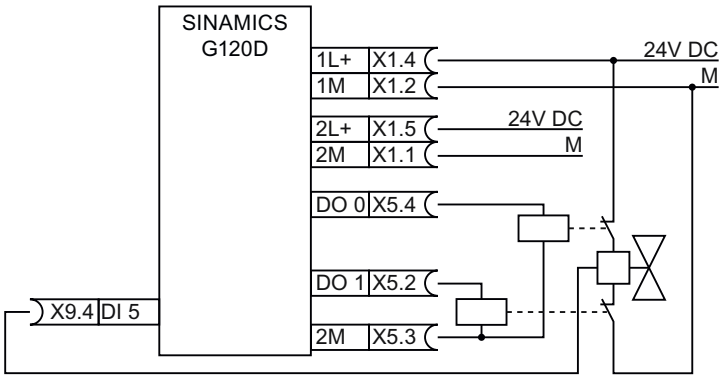


Figure 3-16 Connecting the F-DO of the G120D, mode3

When testing the fail-safe output, the converter switches off the two outputs one after the other and evaluates the feedback signal via digital input DI 5.

Connecting a fail-safe digital input

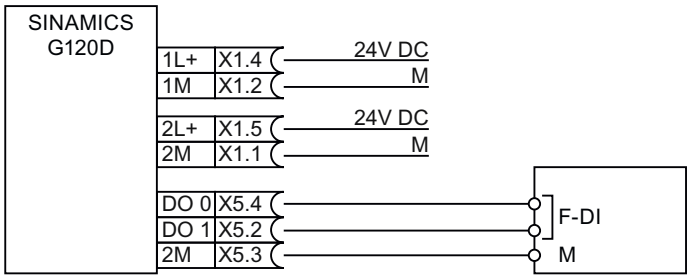


Figure 3-17 Connecting the F-DO of the G120D, mode4

When testing the fail-safe output, the converter evaluates internal feedback signals.

3.4 PROFIsafe

3.4.1 Communication via PROFIsafe

Communication via PROFIsafe

You must connect the converter via a fieldbus with a central fail-safe control (F-CPU).

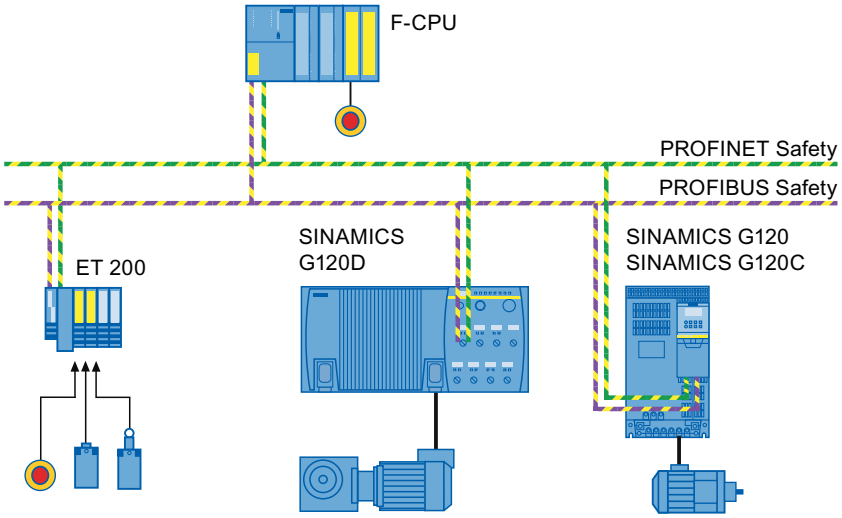


Figure 3-18 PROFIsafe communication between F-CPU and converter

Shared Device

The PROFINET "Shared Device" function allows two controls to just access one converter:

- A fail-safe control system (F-CPU) controls the safety functions in the converter.
- A standard control transfers the commands and setpoints required for operation.

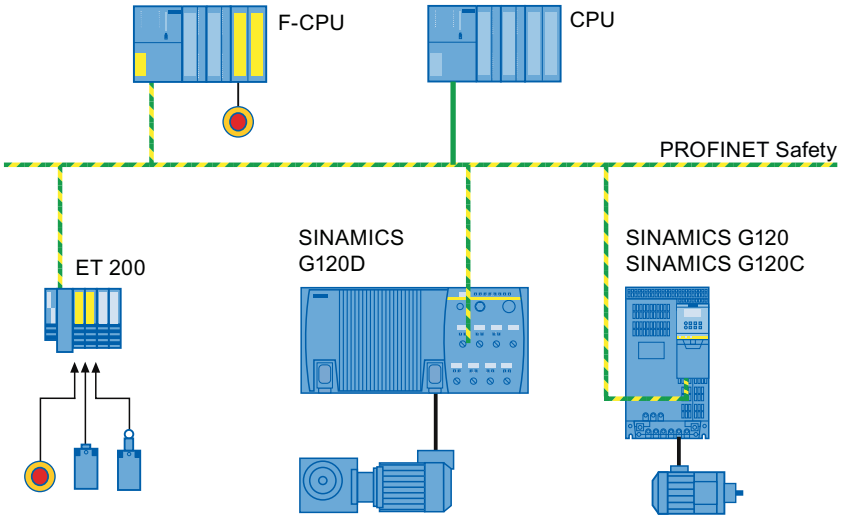


Figure 3-19 Bus configuration, shared device

Not possible: Communication I-slave ↔ slave

PROFIsafe communication between the converter and a F-CPU as slave (I-slave) is not possible.

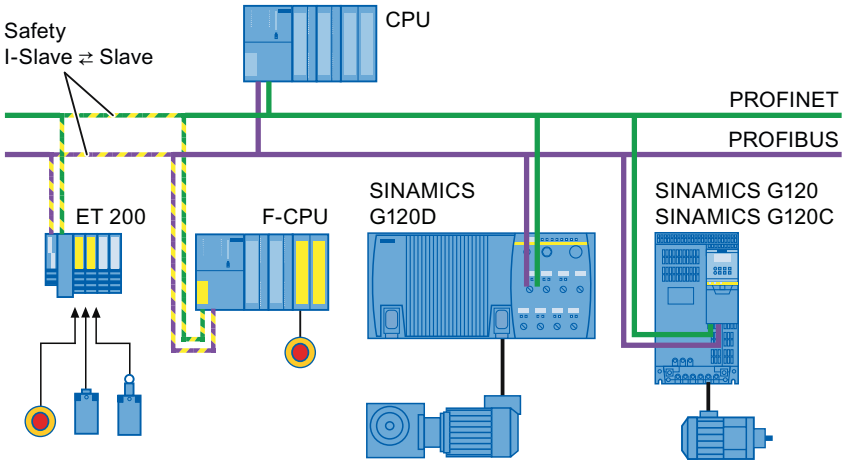


Figure 3-20 No PROFIsafe communication between F-CPU as I-slave and converter

3.4.2 Telegram types

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

Table 3- 6 Telegram types

Telegram type	Process data (PZD) - control and status words	
	PZD1	PZD2
Telegram 30 PZD 1/1	STW1	---
	ZSW1	---
Telegram 900 PZD 2/2	STW1	STW5
	ZSW1	ZSW5

STW: Control word; ZSW: Status word

The higher-level controller triggers the safety functions in the converter via the control word. The converter uses the status word to report the status of the safety functions to the controller.

Which converters have which telegram type?

SINAMICS G120	SINAMICS G120D	SINAMICS G120C
		
Telegram 30		
with Control Unit	with Control Unit	G120C DP G120C PN
CU240E-2 DP CU240E-2 DP-F CU240E-2 PN CU240E-2 PN-F	CU240D-2 DP CU240D-2 DP-F CU240D-2 PN CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	
Telegram 900		
with Control Unit	with Control Unit	---
CU240E-2 DP-F CU240E-2 PN-F	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU250D-2 PN-F PP	

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

Table 3- 7 Control word 1 (bit 0 ... 15)

Bit	Meaning	Comment	
0	**STO**	1	STO is deselected
		0	STO is selected
1 … 6	*Reserved*		
7	**Internal event ack**	1	Acknowledge serious safety function faults with a signal change 1 → 0
		0	Do not acknowledge faults
8 … 15	*Reserved*		

Table 3- 8 Status word 1 (bit 0 ... 15)

Bit	Meaning	Comment	
0	**Power removed**	1	STO is active
		0	STO is not active
1 … 6	*Reserved*		
7	**Internal Event**	1	The converter has detected a severe fault in the safety functions.
		0	Fault-free operation
8 … 15	*Reserved*		

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

Table 3- 9 Control word 1 (bit 0 ... 15)

Bit	Meaning	Comment	
0	**STO**	1	STO is deselected
		0	STO is selected
1	**SS1**	1	SS1 is deselected
		0	SS1 is selected
2, 3	*Reserved*		
4	**SLS**	1	SLS is deselected
		0	SLS is selected
5, 6	*Reserved*		
7	**Internal event ack**	1	Acknowledge serious safety function faults with a signal change 1 → 0
		0	Do not acknowledge faults
8	*Reserved*		

Bit	Meaning	Comment				
9	**SLS-level, bit 0**		Selection of the SLS level		Bit 10	Bit 9
				Level 1 level 2 level 3 level 4	0 0 1 1	0 1 0 1
10	**SLS-level, bit 1**					
11	*Reserved*					
12	**SDI Positive**	1	SDI with positive direction of rotation is deselected			
		0	SDI with positive direction of rotation is selected			
13	**SDI Negative**	1	SDI with negative direction of rotation is deselected			
		0	SDI with negative direction of rotation is selected			
14, 15	*Reserved*					

Table 3- 10 Status word 1 (bit 0 ... 15)

Bit	Meaning	Comment				
0	**Power removed**	1	STO is active			
		0	STO is not active			
1	**SS1 active**	1	SS1 is active			
		0	SS1 is not active			
2, 3	*Reserved*					
4	**SLS active**	1	SLS is active			
		0	SLS is not active			
5, 6	*Reserved*					
7	**Internal Event**	1	The converter has detected a severe fault in the safety functions.			
		0	Fault-free operation			
8	*Reserved*					
9	**SLS-level, bit 0**		Active SLS level		Bit 10	Bit 9
				Level 1 level 2 level 3 level 4	0 0 1 1	0 1 0 1
10	**SLS-level, bit 1**					
11	*Reserved*					
12	**SDI positive active**	1	SDI positive direction of rotation is active			
		0	SDI positive direction of rotation is not active			
13	**SDI negative active**	1	SDI negative direction of rotation is active			
		0	SDI negative direction of rotation is not active			
14	*Reserved*					
15	**Status SSM**	1	Speed is within the SSM limit value			
		0	Speed is outside the SSM limit value			

3.4.5 Control word 5 and status word 5

Telegram 900 of the PROFIsafe profile also contains control and status word 5. The converter uses status word 5 to transfer the status of the fail-safe digital inputs to the controller.

Table 3- 11 Control word 5 (bit 0 ... 15)

Bit	Meaning	Comment
0 … 15	*Reserved*	Assign the value 0 to the reserved bits.

Table 3- 12 Status word 5 (bit 0 ... 15)

Bit	Meaning	Comment		SINAMICS G120	SINAMICS G120D
0 … 7	*Reserved*	-			
8	**Status of fail-safe 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 fail-safe inputs can be found in the section Fail-safe inputs (Page 34).

The status bit of a fail-safe input in status word 5 is always 0 if one of the following two conditions is fulfilled:

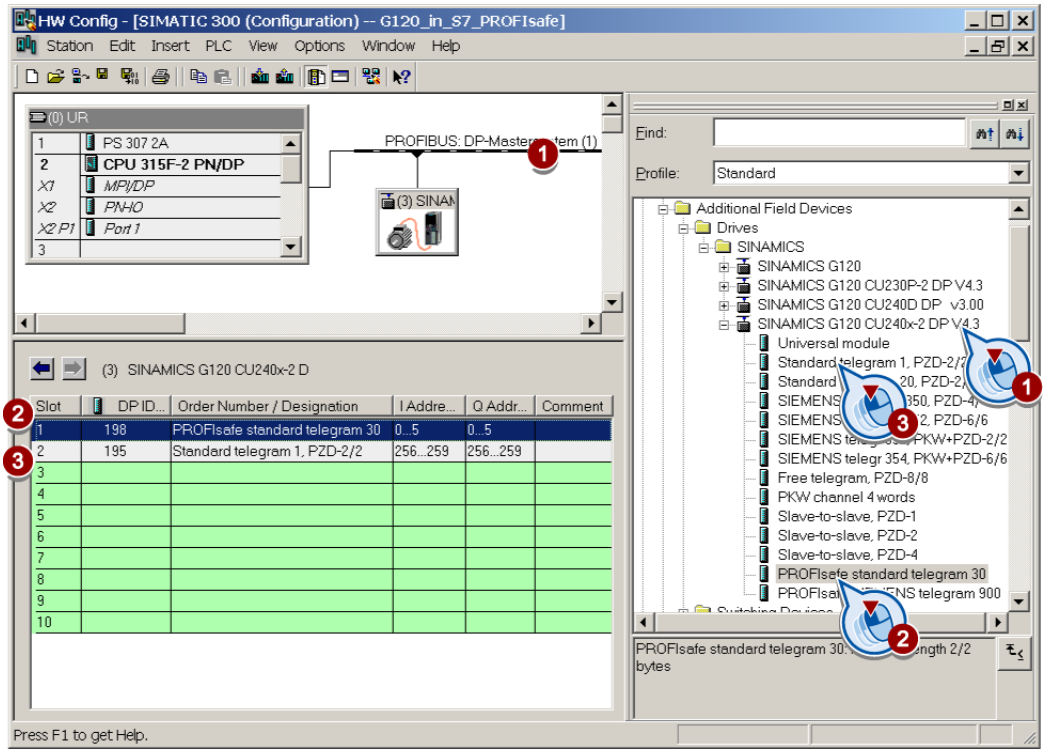
- The relevant fail-safe input is not used.
- The converter has deactivated the relevant fail-safe input due to a discrepancy.

3.4.6 STEP 7 example: Configuring PROFIsafe communication (telegram 30) via PROFIBUS

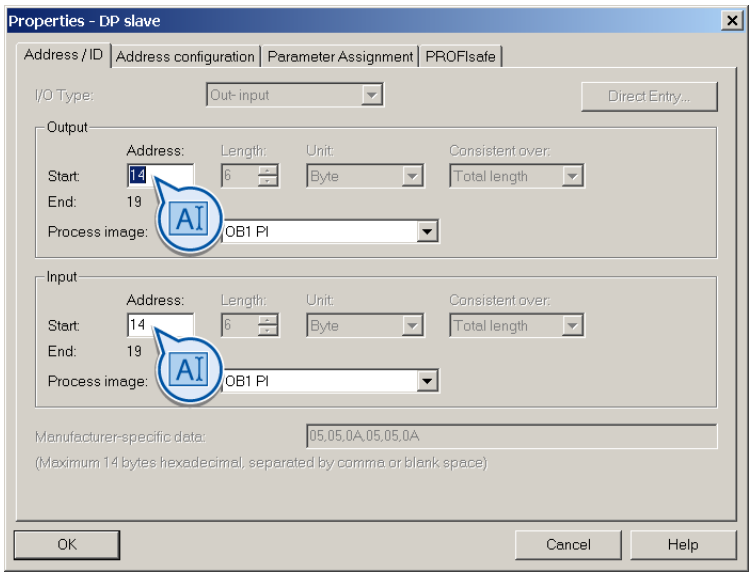
Hardware configuration using PROFIBUS communication as example

In STEP 7, the converter is integrated into the PROFIsafe communication via HW Config.

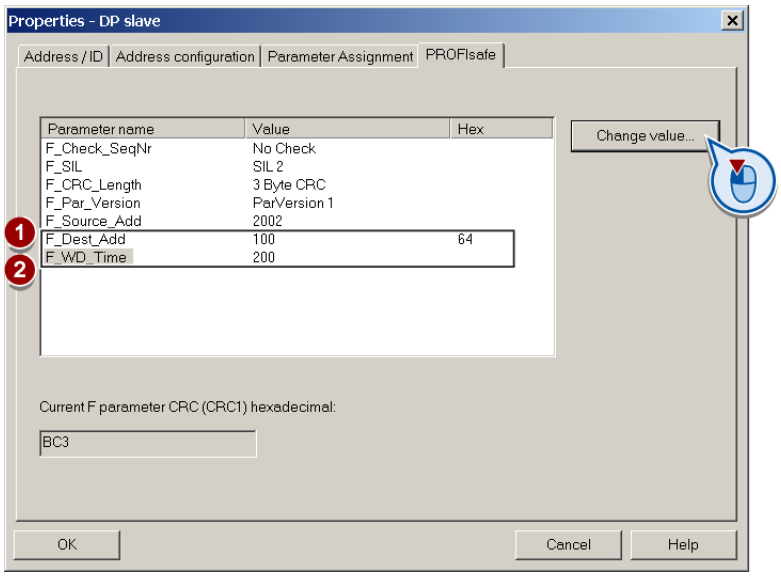
- Configure your SIMATIC CPU (for example, a CPU315F-2 PN/DP) with a PROFIBUS network.
- Integrate the converter via its GSD into the PROFIBUS network.
- Assign the first frequency converter slot to the PROFIsafe telegram.
- Assign standard telegram 1, for example, to the other slots of the converter.
  The operating instructions contain further information on the telegrams and slot sequence.



- With a double-click, open the dialog of the properties of the PROFIsafe telegram and set the input and output range, e.g. to address 14:



- Then choose the "PROFIsafe" tab page:
  - ① F_Dest_Add:
    You require this address when commissioning the safety functions.
  - ② F_WD_Time:
    Set a value which is larger 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.



- Save and compile your project and download the data to your SIMATIC CPU.
- Close HW Config.

3.4.7 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 converter to specific output and input addresses of the SIMATIC controller. In the section STEP 7 example: Configuring PROFIsafe communication (telegram 30) via PROFIBUS (Page 59), start address 14, for example, was assigned. This results in the following assignments between the I/O addresses and converter signals for this example:

Table 3- 13 Control word 1

I/O address	Meaning	Comment	
A14.0	Select STO	1	Deselect STO
		0	Select STO
A14.1	Select SS1	0	Select SS1
A14.4	Select SLS	0	Select 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
A15.5	Select SDI negative	0	Select SDI negative

Table 3- 14 Status word 1

I/O address	Meaning	Comment	
E14.0	Power removed	1	The motor torque has been switched off safely.
		0	The motor torque has not yet been switched off safely.
E14.1	SS1 active	1	SS1 is active
E14.4	SLS active	1	SLS is active
E14.7	Internal event	1	The converter 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	1	SDI positive direction of rotation is active
E15.5	SDI negative active	1	SDI negative direction of rotation is active
E15.7	Status SSM	1	Speed is within the SSM limit value

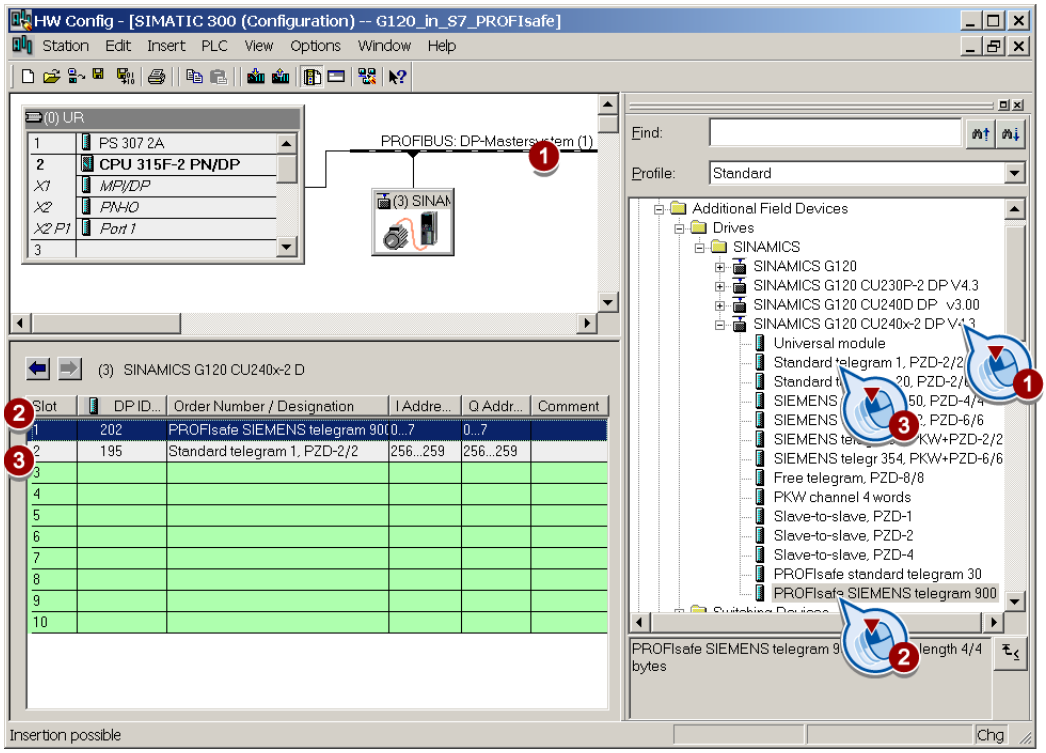
A detailed description of the PROFIsafe interface can be found in the section Control word 1 and status word 1 (extended functions) (Page 56).

3.4.8 STEP 7 example: Configuring PROFIsafe communication (telegram 900) via PROFIBUS

If you want to evaluate the status of the fail-safe inputs in the higher-level controller directly, select PROFIsafe telegram 900. The converter writes the signals of its fail-safe inputs to status word 5.

Hardware configuration

The basic procedure is described in the section STEP 7 example: Configuring PROFIsafe communication (telegram 30) via PROFIBUS (Page 59). Instead of telegram 30, select telegram 900:



3.4.9 STEP 7 example: Configuring Shared Device communication via PROFINET

Introduction

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.

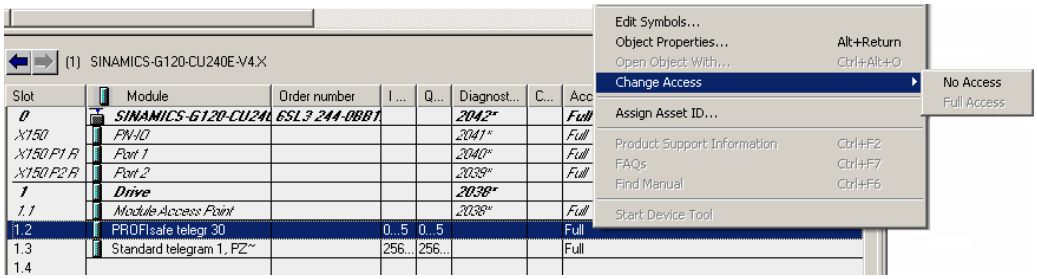
Software requirements

"Shared Device" is available from the following software versions:

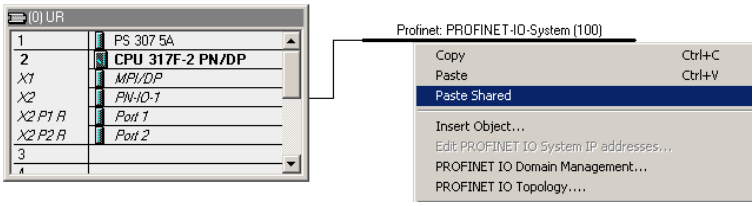
- S7 300: from software version V3.2 and higher
- S7 400: from software version V6.0 and higher

Procedure

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 a converter.
5. Copy the converter into the standard control
6. Insert the converter as "Shared" into the F-CPU.
   This causes the access rights to be "reversed".



7. Select the F-CPU in HW Config and open the dialog window "Object properties".
8. In this window, select the "Protection" tab.
9. Activate the access protection for F-CPU and assign a password.

10. Check the box for "CPU contains safety program" and exit the screen with OK.
11. Save and compile your project.
12. Load your project via into the fail-safe control.

You must appropriately set the communication in the converter if you commission the safety functions. See also Section: Commissioning (Page 65).

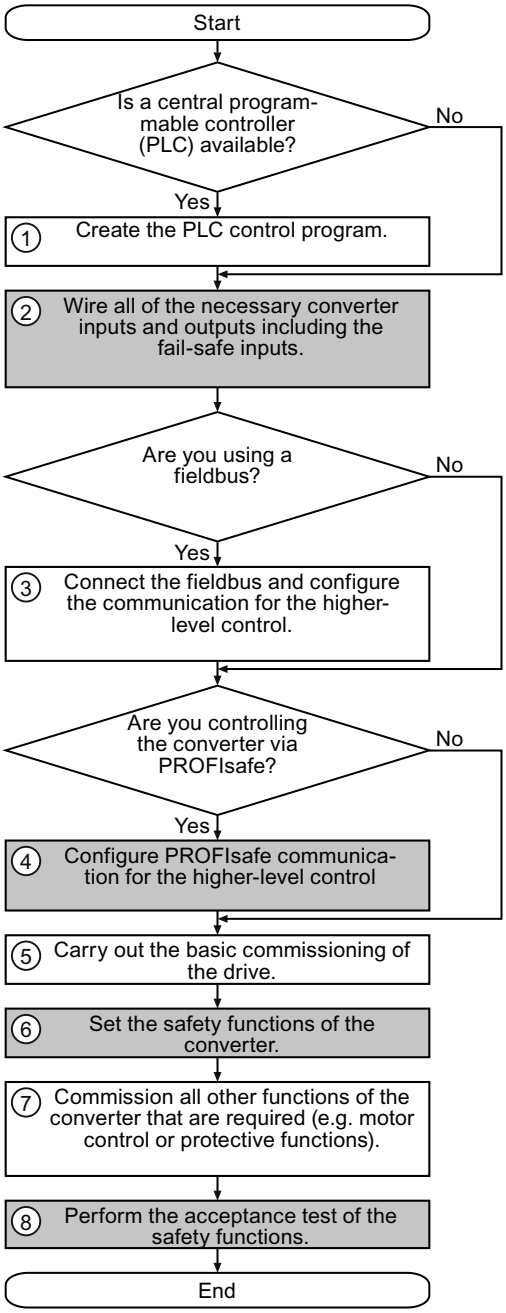
3.4.10 Further steps

Once you have completed the controller side, configure PROFIsafe communication in the inverter. This is described in the chapter Commissioning (Page 65).

Commissioning

4

4.1 Commissioning guidelines



The steps for commissioning the safety functions form part of the activities for commissioning the entire drive. We recommend the following steps for the complete commissioning.

The commissioning steps marked in gray are described in this manual.

① For this step you need the manual for your control system, e.g. the Step 7 manuals.

② You can find information on this step in the operating instructions of your converter and in this manual, in section: Fail-safe inputs (Page 34)

③ For this step you need the manual for your control system and the operating instructions for the converter.

④ Information on this step is provided in this manual in section: PROFIsafe (Page 53).

⑤ Information on this step can be found in the operating instructions of your converter.

⑥ The commissioning instructions are provided on the following pages in this section.

⑦ Information on this step can be found in the operating instructions of your converter.

⑧ Instructions for this step are provided in this manual in section: Acceptance tests for the safety functions (Page 126)

4.2 Commissioning tool

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

If you use STARTER 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 4- 1 STARTER commissioning tool (PC software)

Download	Order number
STARTER (http://support.automation.siemens.com/WW/view/en/10804985/130000)	6SL3255-0AA00-2CA0 PC Connection Kit, includes STARTER DVD and USB cable

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 123) 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.

4.3 Password

The safety functions are protected against unauthorized changes by a password.

Note

If you want to change the parameters of the safety functions, but do not know the password, please contact customer support.

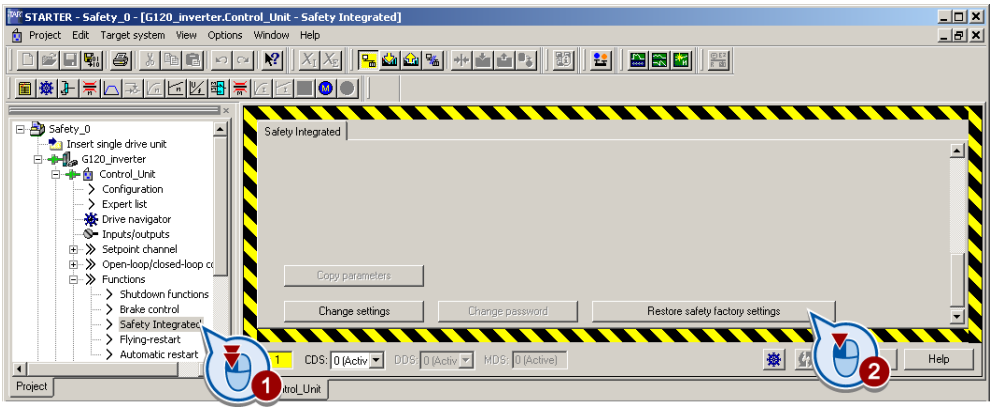
Table 4- 2 Parameter

Parameter	Description
p9761	**Entering a password** (factory setting: 0000 hex) Permissible passwords lie in the range 1 … FFFF FFFF.
p9762	**New password**
p9763	**Confirm password**

4.4 Resetting the safety function parameters to the factory setting

Proceed as follows if you wish to reset the safety function parameters to the factory setting, without influencing the standard parameters:

- Go online with STARTER .
- ① Open the screen form of the safety functions.



- ② Select the button to restore the factory settings.
- Enter the password,for the safety functions.
- Confirm saving parameters (RAM to ROM).
- Go offline with STARTER .
- Switch off the converter supply voltage.
- Wait until all of the LED on the converter go dark. Now switch on the converter power supply again (power on reset).

Table 4- 3 Parameter

Parameter	Description	
p0010	**Drive, commissioning parameter filter**	
	0	Ready
	95	Safety Integrated commissioning
p0970	**Reset drive parameters**	
	0	Inactive
	5	Starts a safety parameter reset. After the reset, the converter sets p0970 = 0.

4.5 Changing settings

Procedure

- ① Go online with STARTER.
- ② In STARTER, select the fail-safe functions.
- ③ Change the settings.

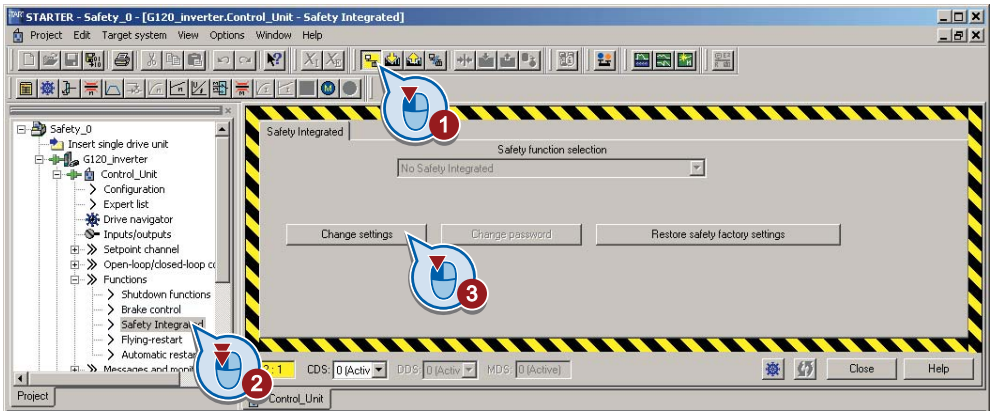
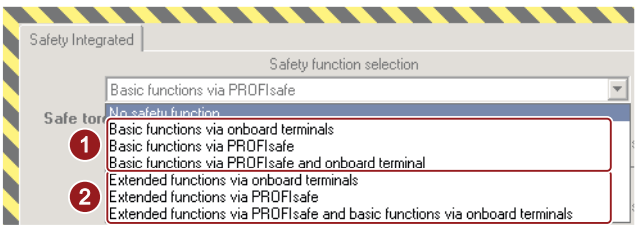


Table 4- 4 Parameter

Parameter	Description
p0010 = 95	**Drive commissioning parameter filter** Safety Integrated commissioning

- Define what the results of your commissioning should look like.

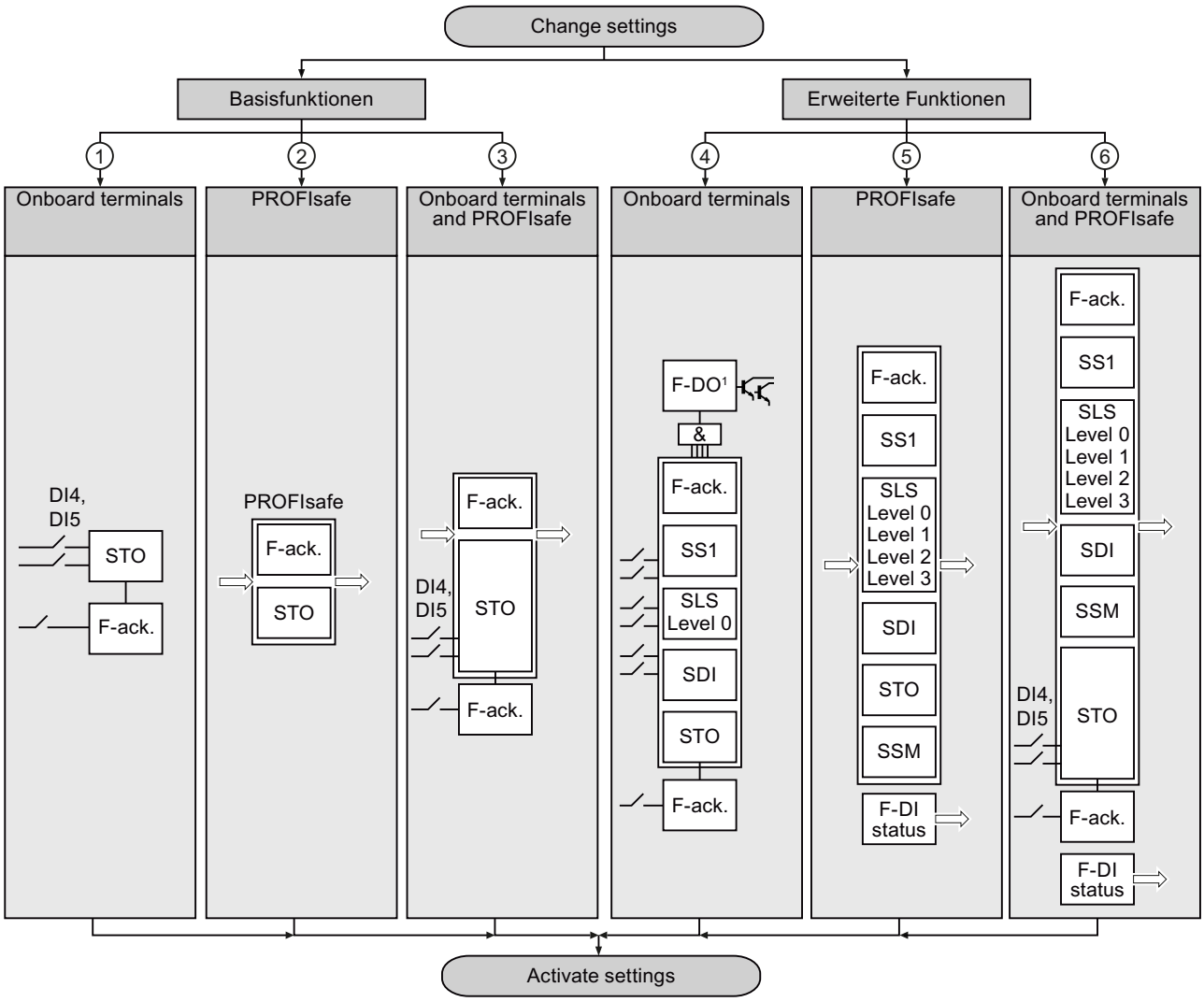


- ① If you are only using STO as safety function of the converter, select the basis functions with the interface that matches your particular application.
- ② if, in addition to STO , you use other safety functions, then select the extended functions with the interface that matches your particular application.

Table 4- 5 Parameter

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

The overview below shows the options that the converter offers and the result of the commissioning depending on your particular choice.



[1] Only a few Control Units of the SINAMICS G120D have a fail-safe output, also refer to Section: Overview of the interfaces (Page 33).

[2] Some converters only offer the basic functions, refer to the following section.

	Outcome of commissioning	See section ...
①	• Select STO via F-DI . • Acknowledge safety faults via standard DI after selecting and deselecting STO.	Setting basic functions (Page 73).
②	• Select STO via PROFIsafe . • Evaluate the state of STO via PROFIsafe . • Acknowledge safety faults via PROFIsafe .	
③	• Select STO via F-DI as well as also via PROFIsafe . • Evaluate the state of STO via PROFIsafe. • Acknowledge safety faults: – via PROFIsafe – via standard DI after selecting and deselecting STO	
④	• Select safety functions via F-DI . • Only one monitoring limit of SLS can be used (SLS level 0). • Acknowledge safety faults: – via F-DI – via standard DI after selecting and deselecting STO	Setting extended functions (Page 83).
⑤	• 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 faults via PROFIsafe . • Evaluate the state of the fail-safe inputs via PROFIsafe.	
⑥	• Select safety functions via PROFIsafe . • Select STO additionally 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 faults: – via F-DI – via standard DI after selecting and deselecting STO • Evaluate the state of the fail-safe inputs via PROFIsafe.	

4.6 Converter with basic functions and extended functions

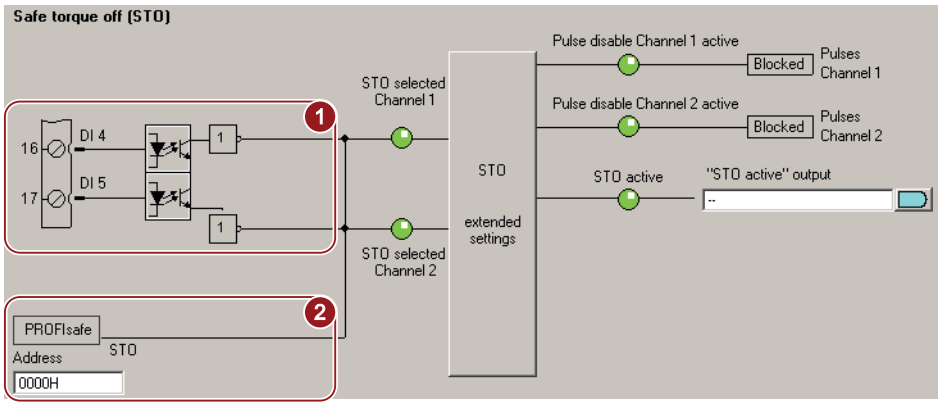
For the integrated safety functions, your converter offers either basic or extended functions depending on the particular version.

Frequency converter		Interface	
		Fail-safe inputs	PROFIsafe
	SINAMICS G120C USS SINAMICS G120C CAN	Basic functions	No
	SINAMICS G120C DP SINAMICS G120C PN	Basic functions	
	SINAMICS G120 with Control Unit …		
	CU240E-2	Basic functions	No
	CU240E-2 DP CU240E-2 PN	Basic functions	
	CU240E-2 F	Basic functions and extended functions	No
	CU240E-2 DP-F CU240E-2 PN-F	Basic functions and extended functions	
	SINAMICS G120D with Control Unit …		
	CU240D-2 DP CU240D-2 PN	Basic functions	
	CU240D-2 DP-F CU240D-2 PN-F CU240D-2 PN-F PP CU250D-2 DP-F CU250D-2 PN-F CU240D-2 PN-F PP	Basic functions and extended functions	

4.7 Setting basic functions

Overview

Depending on the interface that has been selected, the main screen form either shows the onboard terminals ① or the PROFIsafeinterface ② or both:



4.7.1 Interconnecting the "STO active" signal

Procedure

- If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.

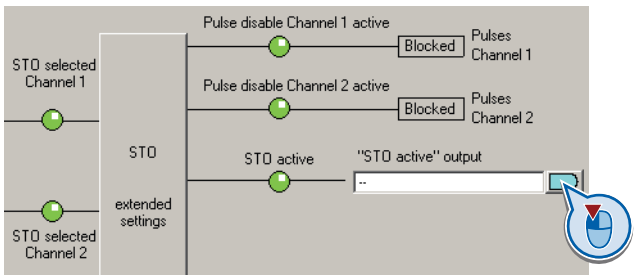


Table 4- 6 Parameter

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

4.7.2 Configuring PROFIsafe

Procedure

Setting the address

- Enter the same PROFIsafe address as a hexadecimal value that you defined in the hardware configuration (F_Dest_Add).
  See section: STEP 7 example: Configuring PROFIsafe communication (telegram 30) via PROFIBUS (Page 59).

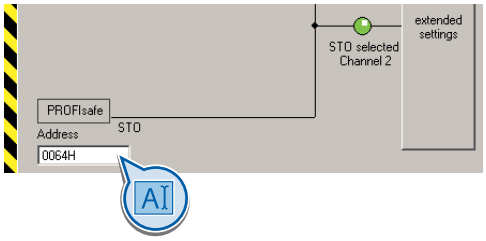


Table 4- 7 Parameter

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

Enabling Shared Device

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

- Using the expert list in STARTER, set p8929 = 2 in the converter.

Start communication via PROFIsafe

When you connect the converter to the central controller via the fieldbus for the first time, the central controller sends the PROFIsafe configuration to the converter. Once the configuration data has been received, the converter interconnects its internal signals to the PROFIsafe telegram.

Note

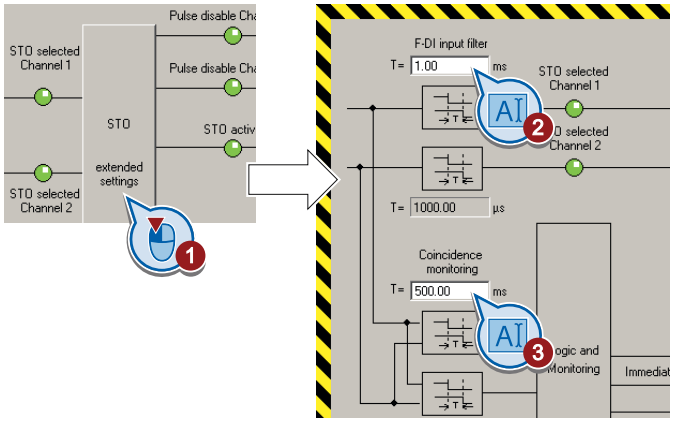
Monitoring PROFIsafe communication

The converter monitors communication with the central controller. The converter does not start monitoring communication until the configuration data has been received from the central controller.

4.7.3 Setting the signal filter

Procedure

- ① Select the advanced settings for STO.



- ② Set the debounce time for the F-DI input filter.
- ③ Set the discrepancy for the monitoring for simultaneous operation.
- Close the screen form.

Description

The following are available for the signal processing of the fail-safe inputs:

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

A tolerance for the simultaneous monitoring

The converter 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 fail-safe input, e.g. a wire break.

When appropriately set, the converter tolerates brief discrepancies.

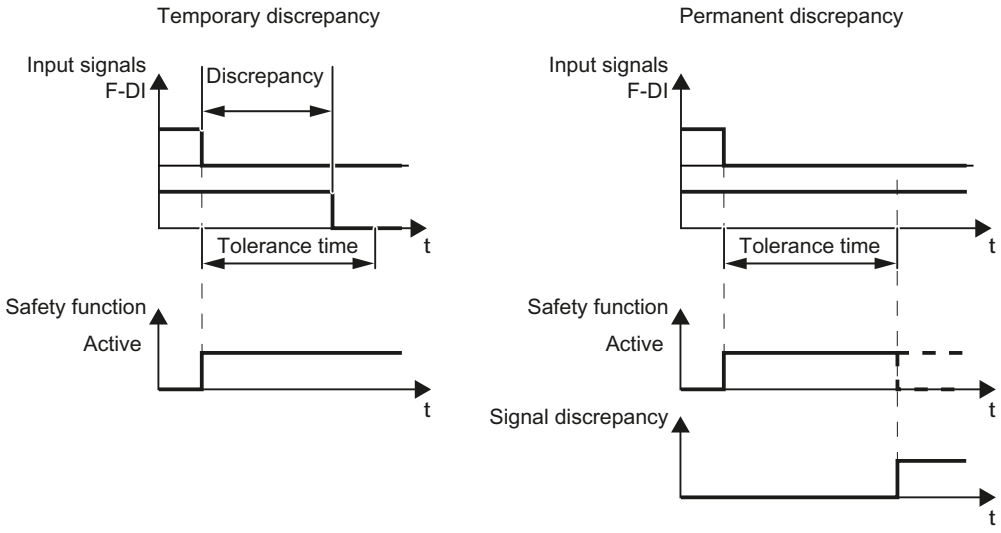


Figure 4-1 Tolerance regarding discrepancy

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

Filter to suppress short signals

The converter normally responds immediately to signal changes at its fail-safe inputs. This is not required in the following cases:

1. When you interconnect a fail-safe input of the converter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the converter responds.
2. Several control modules test their fail-safe outputs using bit pattern tests (on/off tests), in order to identify faults due to either short-circuit or cross-circuit faults. When you interconnect a fail-safe input of the converter with a fail-safe output of a control module, the converter 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 fail-safe input signals too many signal changes within a certain time, then the converter responds with a fault.

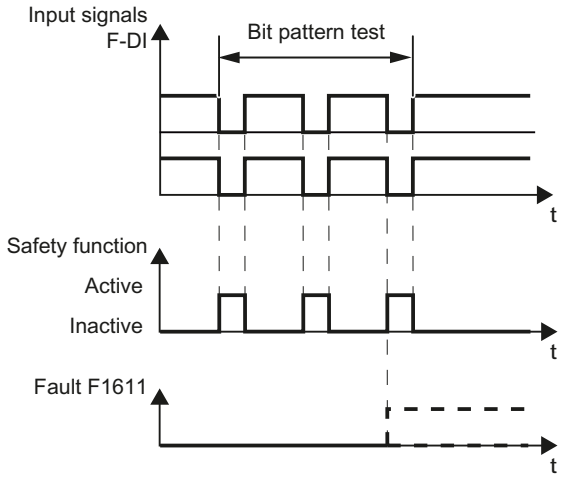


Figure 4-2 Converter response to a bit pattern test

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

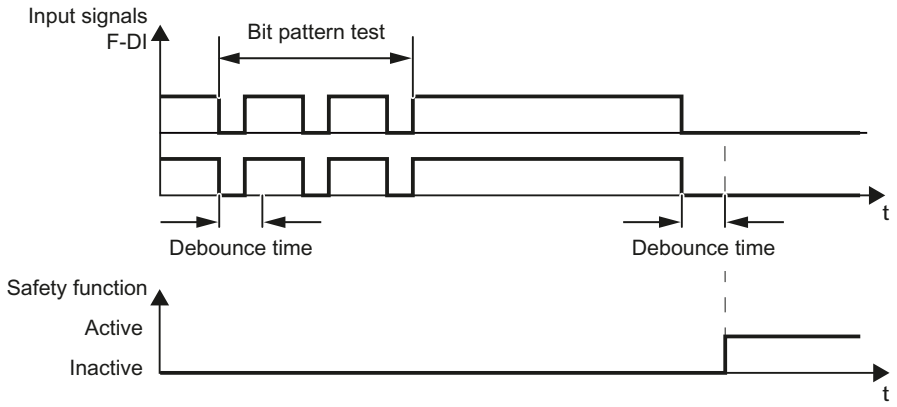


Figure 4-3 Filter for suppressing temporary signal changes

Note

The filter increases the converter response time. The converter only selects its safety function after the debounce time has elapsed.

Table 4- 8 Parameters for the filters

Parameter	Description
p9650	**F-DI changeover tolerance time** (factory setting: 500 ms) Tolerance time to changeover the fail-safe digital input for the basic functions.
p9651	**STO debounce time** (factory setting: 1 ms) Debounce time of the fail-safe digital input for the basic functions.

Note

Debounce times for standard and safety functions

The debounce time p0724 for "standard" digital inputs has no influence on the fail-safe input signals. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

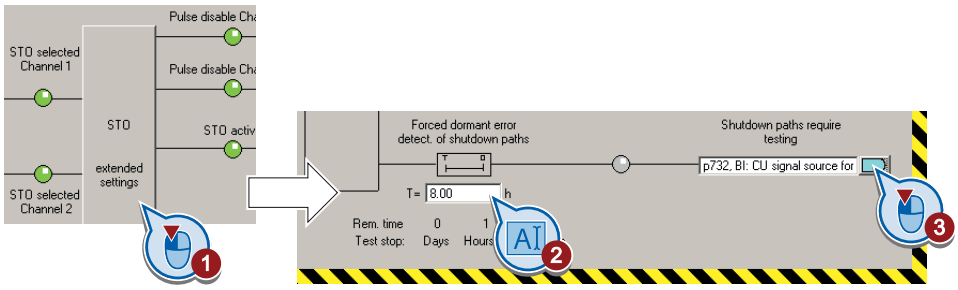
If you use an input as a standard input, set the debounce time using parameter p0724 .

If you use an input as a fail-safe input, set the debounce time as described above.

4.7.4 Setting forced dormant error detection

Procedure

- ① Select the advanced settings for STO.



- ② Set the monitoring time to a value to match your particular application.
- ③ Using this signal, the converter signals that a forced checking procedure is required. Interconnect this signal - for example - with a digital output of your choice.

Description

To meet the requirements of the standards ISO 13849-1 and IEC 61508 in terms of timely fault detection, the converter must test its safety-related circuits regularly - at least once a year - to ensure that they are functioning correctly.

Forced checking procedure of the basic functions

The forced checking procedure of the basic functions is the regular self-test of the converter that causes the converter to check its circuits to switch-off the torque.

The converter executes a forced checking procedure under the following circumstances:

- every time the supply voltage is connected.
- every time after the STOfunction has been selected.

The converter monitors the regular forced checking procedure.

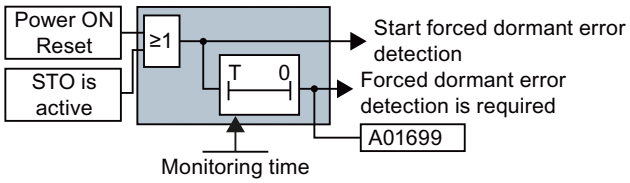


Figure 4-4 Triggering and monitoring the forced checking procedure

Table 4- 9 Parameters for the forced checking procedure

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

Time of the forced checking procedure

In the case of warning A01699 , you must initiate a forced checking procedure at the next opportunity. These alarms do not affect the operation of your machine.

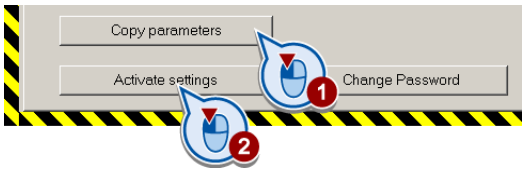
- Stop the drive.
- Select function STO or switch off the converter supply voltage temporarily and on again.

Examples for the times when forced checking procedure is performed:

- When the drives are at a standstill after the system has been switched on.
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent).

4.7.5 Activate settings

- ① Copy the parameters of the safety functions in order to create a redundant image of the settings.



- ② Activate the settings.
- 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.
  Further information can be found in the section Password (Page 66).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the converter supply voltage.
- Wait until all of the LEDs on the converter go dark. Now switch on the converter supply voltage again. Your settings only become effective after this power-on reset.

Parameter

Table 4- 10 Parameters for the forced dormant error detection

Parameter	Description
p9700 = 57 hex	**SI copy function** (factory setting: 0) Start copy function SI parameter.
p9701 = AC hex	**Confirm data change** (factory setting: 0)Confirm data change overall.
p0010 = 0	**Drive commissioning parameter filter** 0: Ready

4.7.6 Checking the assignment of the digital inputs

- Check whether the digital inputs used as fail-safe input are also assigned a further function.

NOTICE
Both, the assignment of digital inputs with the selection of a safety function or with a "standard" function can lead to an unexpected behavior of the motor.

- Remove multiple assignments of the digital inputs:

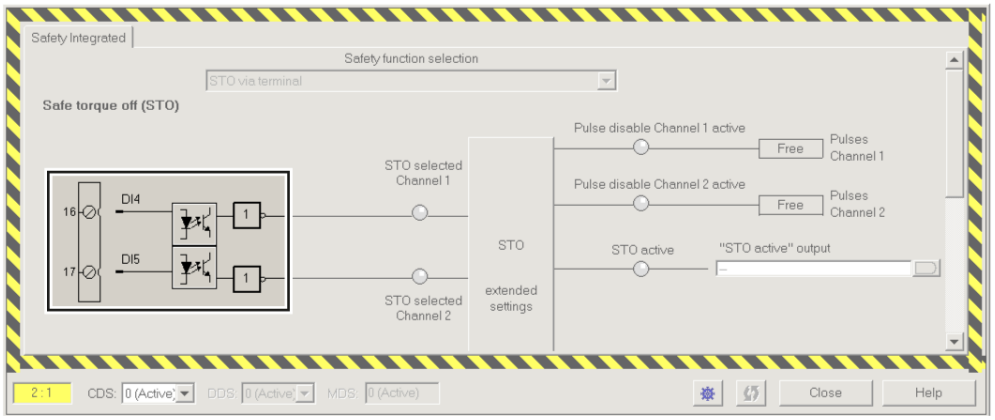


Figure 4-5 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

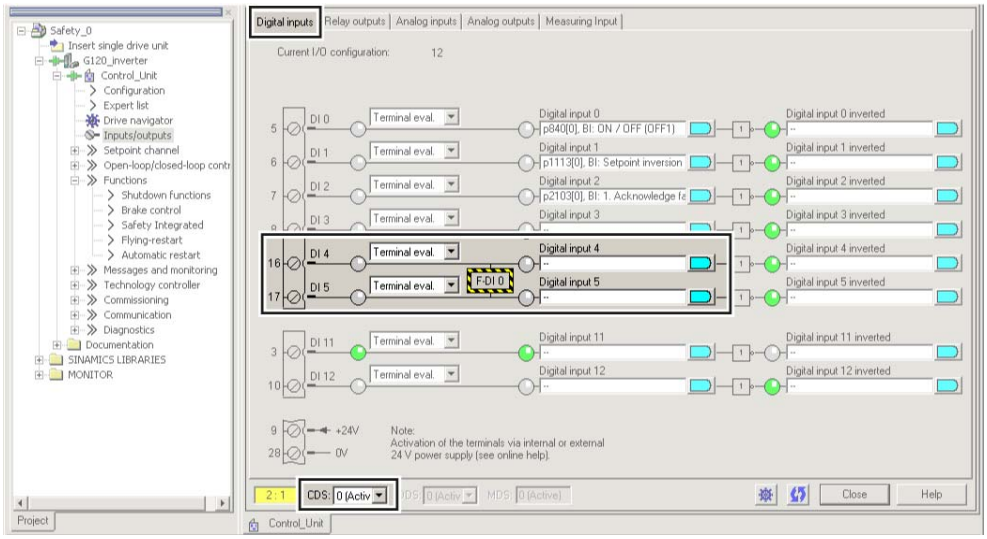


Figure 4-6 Remove pre-assignment of digital inputs DI 4 and DI 5

- When you use the data set changeover CDS, you must delete the multiple assignment of the digital inputs for all CDS.

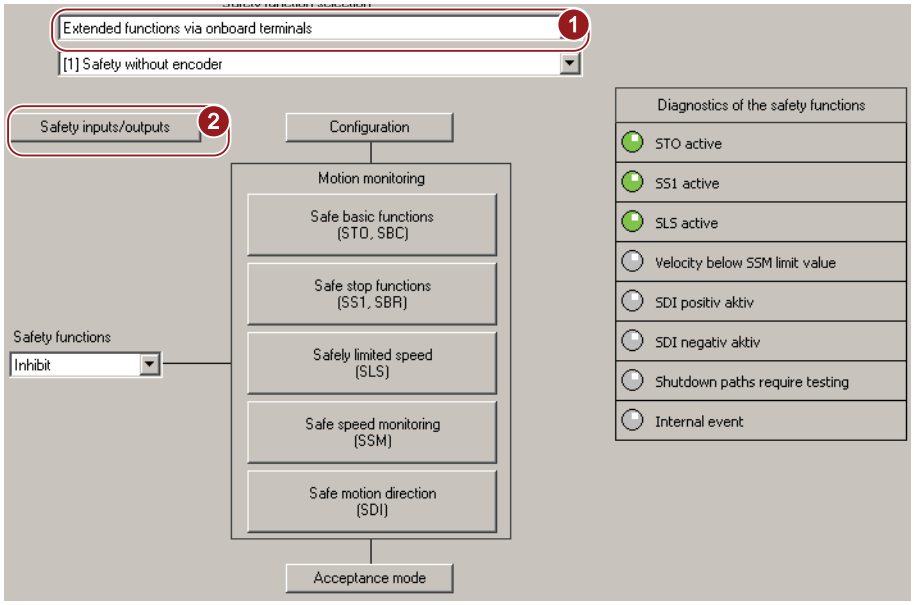
4.7.7 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Manuals for your inverter (Page 242).
- Perform an acceptance test for the safety functions:
  - Document your settings in an acceptance report.
  - Check whether the safety functions are functioning correctly in your application.
  - The instructions for the acceptance test can be found in the section Acceptance tests for the safety functions (Page 126).

4.8 Setting extended functions

Overview

If you have selected the extended functions, then you go to the following main screen form. The meaning of button ② depends on the interface ① you selected:



Starting with this screen form you must do the following:

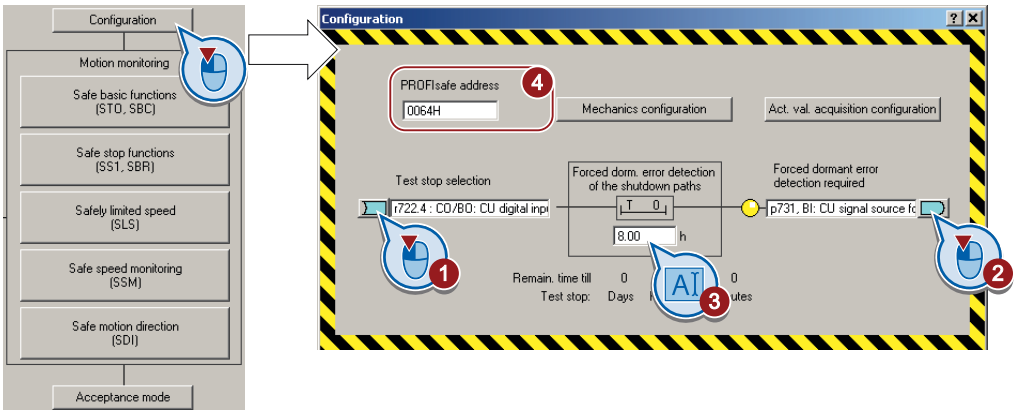
1. Basic settings for all safety functions. See section:
   Basic settings (Page 84).
2. If necessary, interconnected the fail-safe inputs and outputs. See sections:
   - Fail-safe inputs (Page 89)
   - Fail-safe output (Page 95).
3. If necessary, configure the communication using PROFIsafe. See section: Configuring PROFIsafe (Page 100).
4. Adapt the safety functions to suit your application. See sections:
   - Setting SS1 (Page 103)
   - Setting SLS (Page 109)
   - Setting SSM (Page 113)
   - Setting SDI (Page 116)
5. Activate the settings. See also Section:
   Complete commissioning (Page 119).

4.8.1 Basic settings

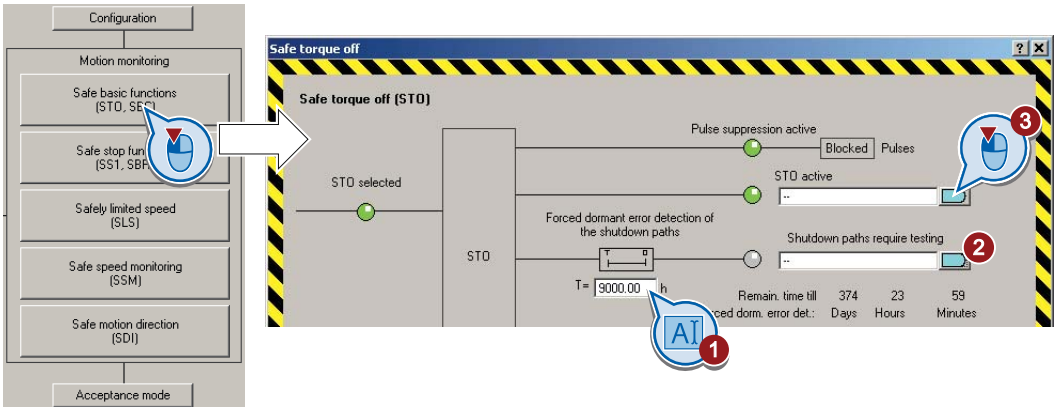
4.8.1.1 Setting forced dormant error detection

Procedure

- In the main screen form of the safety functions, select "Configuration".



- Select the values compatible with your application.
  - ① This signal starts the forced checking procedure and sets the monitoring time to zero. Interconnect this signal, for example with a digital input or a control bit in the fieldbus.
  - ② You must conduct a forced checking procedure for this signal. Interconnect this signal, for example with a digital output of your choice or a status bit in the fieldbus.
  - ③ Monitoring time for forced checking procedure.
  - ④ See also section: Configuring PROFIsafe (Page 100).
- Close the screen form.
- In the main screen form of the safety functions, select the "STO" function:



- Configure the following settings in this screen form:
  - ① Set this monitoring time to the maximum value (9000 hours). This means that you deactivate the monitoring of the forced checking procedure for the basic functions. This monitoring is not required when testing extended functions because in the test of the extended functions the test of the basic functions is included.
  - ② No setting is required.
  - ③ If necessary, interconnect the status of the function STO with a digital output of your choice, for example.
- Close the screen form.

Description

To meet the requirements of the standards ISO 13849-1 and IEC 61508 in terms of timely fault detection, the converter must test its safety-related circuits regularly - at least once a year - to ensure that they are functioning correctly.

Forced checking procedure of the extended functions

The forced checking procedure of the extended functions involves the regular self-test of the converter. Here, the converter checks its circuits to monitor the speed and to shut down the torque.

The converter monitors the regular forced checking procedure using a time block.

You must start the forced checking procedure with a signal of your choice.

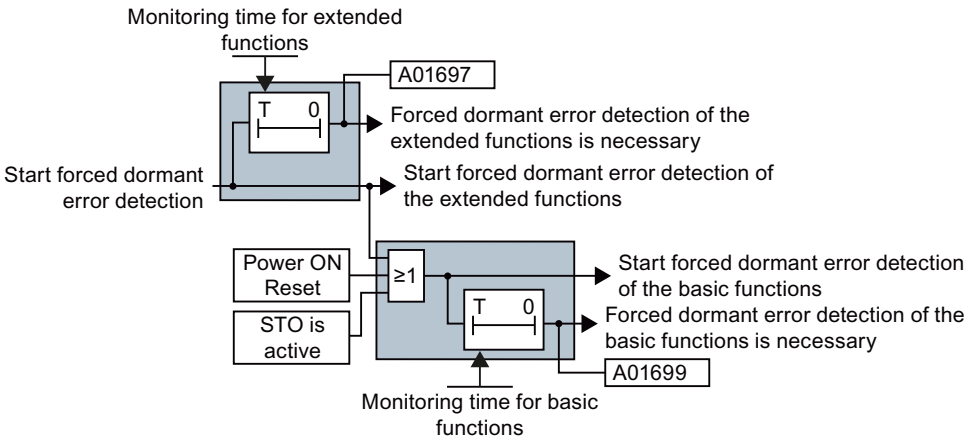


Figure 4-7 Triggering and monitoring the forced checking procedure

Table 4- 11 Parameters for the forced checking procedure

Parameter	Description
p9559	**Forced checking procedure timer** (Factory setting: 8 h) Monitoring time for the forced checking procedure of the extended functions.
p9659	**Forced checking procedure timer** (Factory setting: 8 h) Monitoring time for the forced checking procedure of the basic functions.
r9660	**Forced checking procedure remaining time** Displays the remaining time up to performing the forced checking procedure of the basic functions.
p9705	**Forced checking procedure signal source** (Factory setting: 0) Signal source for the forced checking procedure of the basic functions and the extended functions.
p9723.0	**1 signal: Forced checking procedure of the extended functions is necessary** Signal for the higher-level control.
p9765	**Forced checking procedure remaining time** Displays the remaining time up to performing the forced checking procedure of the extended functions.
r9773.31	**1 signal: Forced checking procedure of the basic functions is required**

Time of the forced checking procedure

If the converter outputs alarm A01699 or A01697 , you must initiate forced checking procedure at the next opportunity. These alarms do not influence the operation of your machine.

- Stop the drive.
- Start the forced checking procedure using a signal of your choice, for example a digital input.

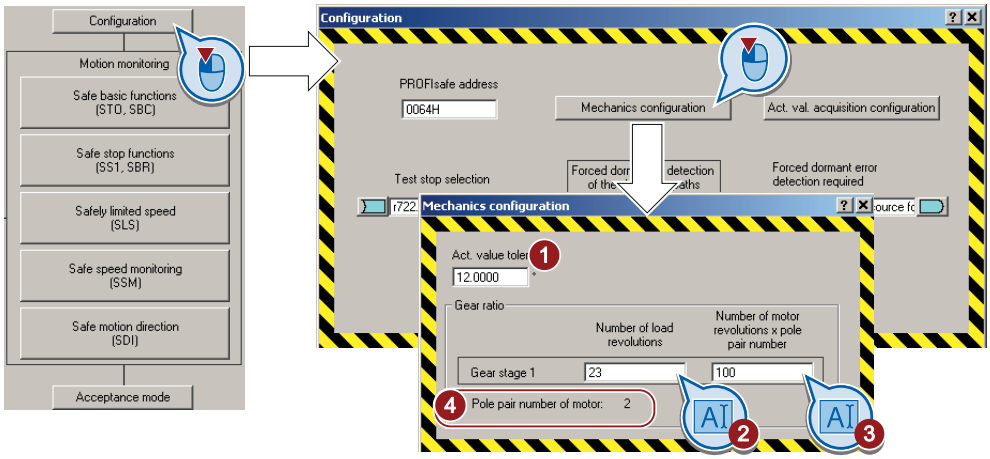
Examples for the times when forced checking procedure is performed

- When the drives are at a standstill after the system has been switched on.
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent).

4.8.1.2 Setting the gear ratio and tolerance

Procedure

- In the main screen form of the safety functions, select "Configuration".
- Select the "Mechanics parameterization".



- Set the following:
  - ① **Actual value tolerance**:
    In most cases you do not have to change this value. For the "flying restart" function, if the converter responds with message C01711 or C30711, increase this value step-by-step until the message to longer occurs.
    Note: If you increase this value, the speed monitoring of the converter becomes less sensitive to limit violations.
  - ② ③ **Gear ratio**:
    Enter the data of your machine
- Close the screen forms.

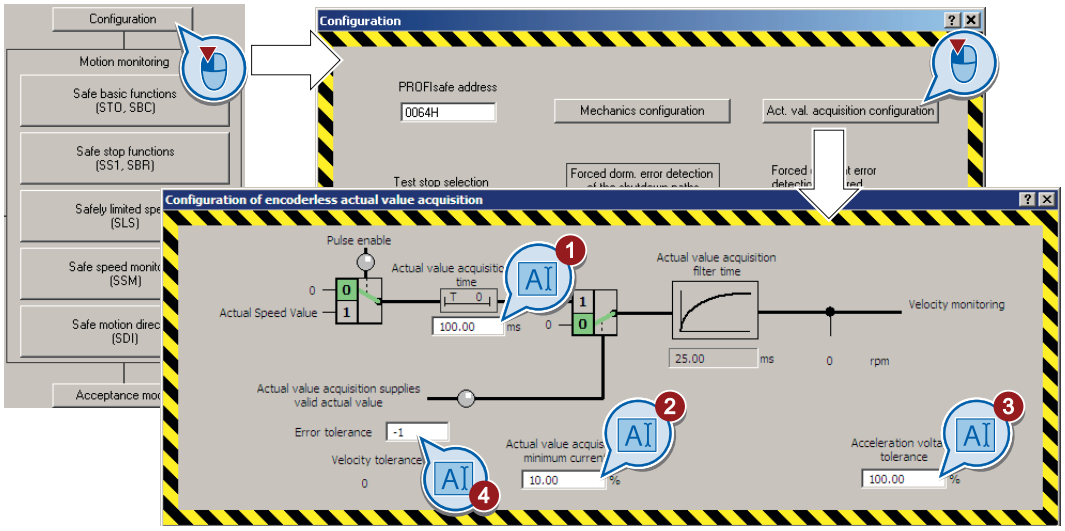
Description of the gear ratio

	② Number of load revolutions	③ Number of motor revolutions
Without gear	1	Number of pole pairs ④
Gear with speed ratio Load/motor = L/M	L	M x number of pole pairs ④
Example: Gear with speed ratio Load/motor = 1/3	1	3 x number of pole pairs ④

4.8.1.3 Setting encoderless actual value sensing

Procedure

- In the main screen form of the safety functions, select "Configuration".
- Select "Configuration actual value sensing".

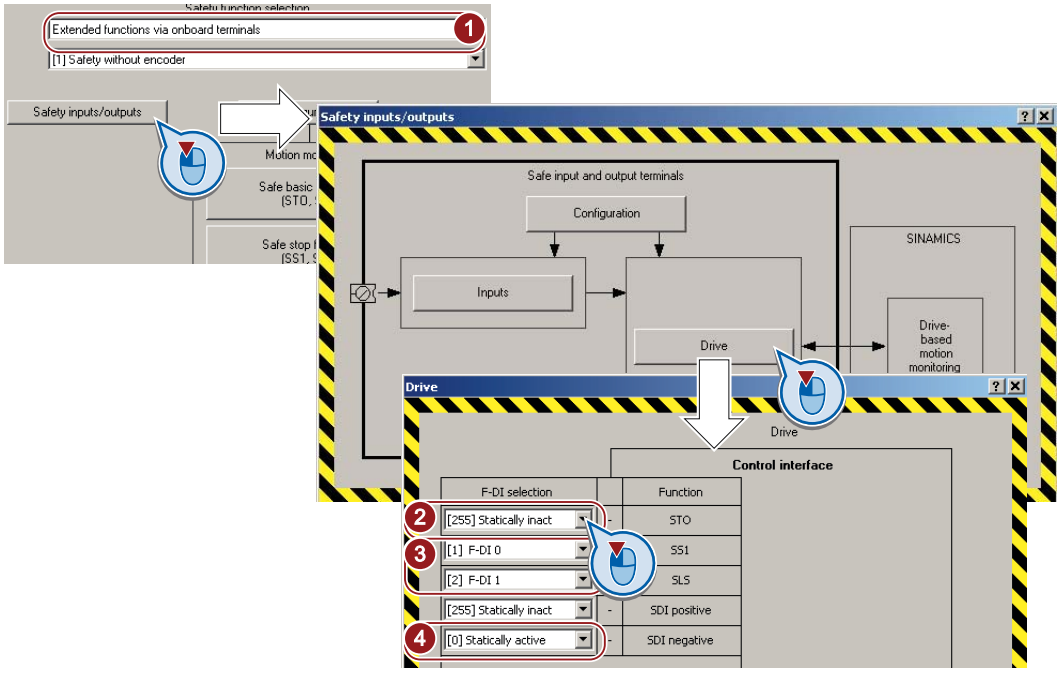


- Set the following:
  - ① **Delay time actual value sensing**:
    In most cases you do not have to change this value. If you switch on the motor with the safety functions active (SLS, SDI or SSM) and the converter responds when switching on with a safety fault, increase this value in the range 50 % … 100 % of the motor excitation build-up time (p0346).
  - ② **Minimum current actual value sensing**:
    Keep this value at the factory setting (10 %).
  - 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 converter 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 converter tolerates its internal plausibility monitoring per second.
- Close the screen forms.

4.8.2 Fail-safe inputs

Procedure

- In the main screen form, select the safety inputs and outputs STARTER only shows this button, if you have selected the extended functions via onboard terminals ①.
- Click the "Drive" button.

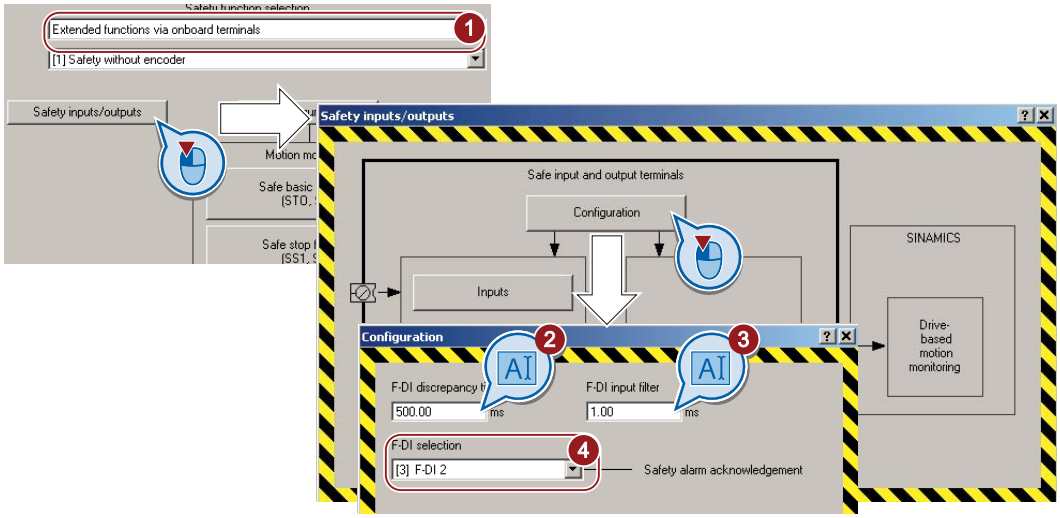


- Interconnect the fail-safe inputs with the safety functions:
  - ② If you do not want to use a particular safety function, set the relevant input to "[255] Statically inactive".
  - ③ Interconnect the fail-safe inputs with the safety functions that you wish to select via F-DI.
  - ④ If a safety function should always be active, set the relevant input to "[0] static active".
- Close the screen forms.

4.8.2.1 Setting the filter for fail-safe inputs

Procedure for control via onboard terminals

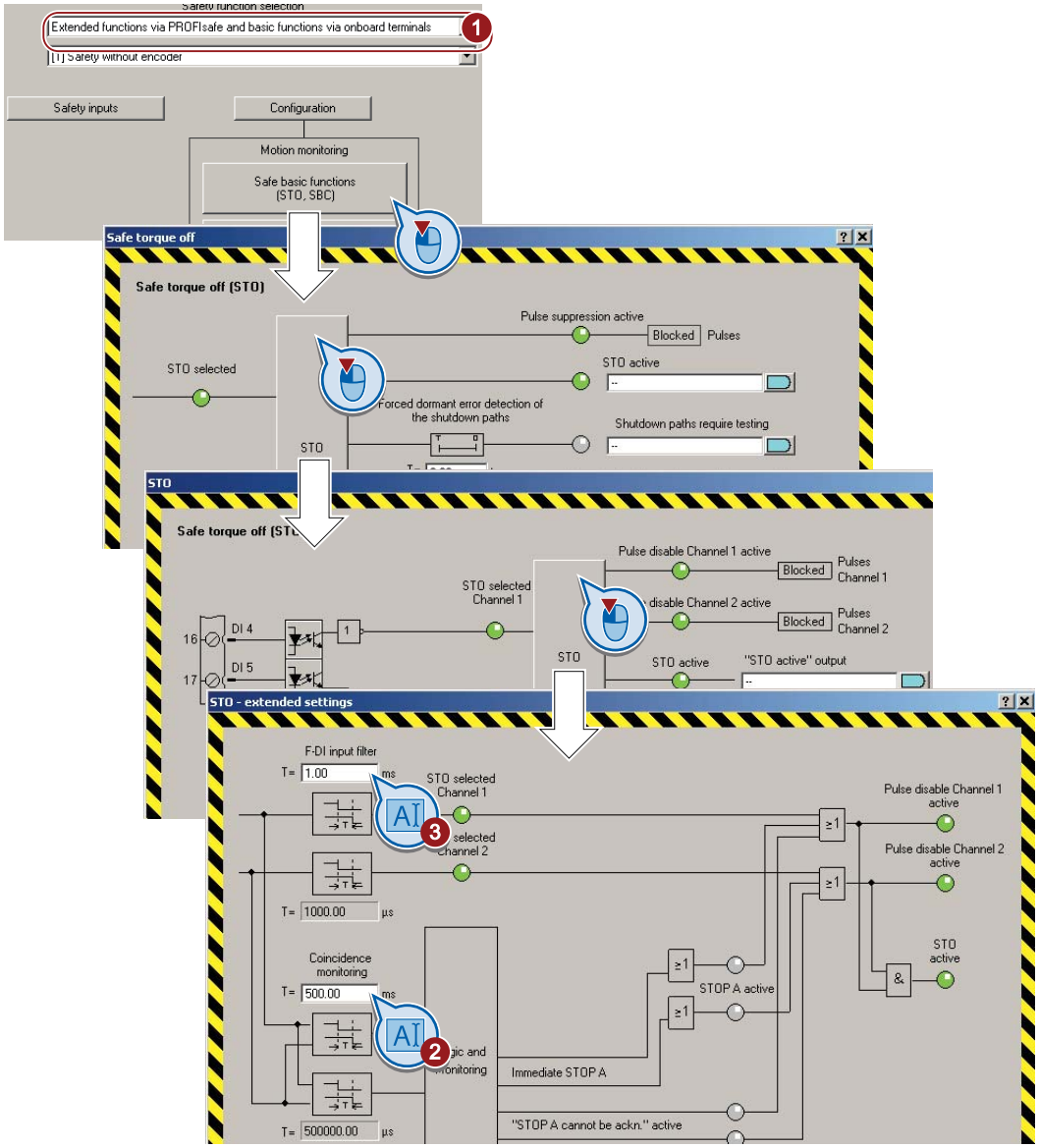
- If you use the extended functions via onboard terminals ①, in the main screen form, select the button for the safety inputs and outputs.
- Click the "Configuration" button.



- Set the following:
  - ② Discrepancy time of the fail-safe digital inputs.
  - ③ Input filter of the fail-safe digital inputs.
- Close the screen forms.

Procedure for control via PROFIsafe and onboard terminals

- If you use the extended functions via PROFIsafe and onboard terminals ①, in the main screen form, select the button for the STO function.
- In the following screen forms, select the button for STO another two times.



- Set the following:
  - ② Discrepancy time (monitoring for simultaneous operation) of the fail-safe digital input.
  - ③ Input filter of the fail-safe digital input.
- Close the screen forms.

Description

The following are available for the signal processing of the fail-safe inputs:

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

A tolerance for the simultaneous monitoring

The converter 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 fail-safe input, e.g. a wire break.

When appropriately set, the converter tolerates brief discrepancies.

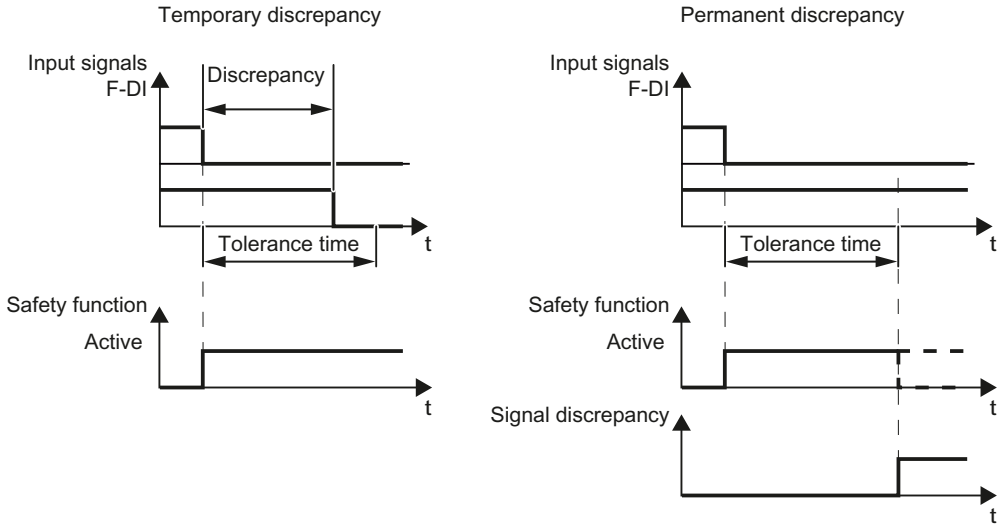


Figure 4-8 Tolerance regarding discrepancy

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

Filter to suppress short signals

The converter normally responds immediately to signal changes at its fail-safe inputs. This is not required in the following cases:

1. When you interconnect a fail-safe input of the converter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the converter responds.

2. Several control modules test their fail-safe outputs using bit pattern tests (on/off tests), in order to identify faults due to either short-circuit or cross-circuit faults. When you interconnect a fail-safe input of the converter with a fail-safe output of a control module, the converter 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 fail-safe input signals too many signal changes within a certain time, then the converter responds with a fault.

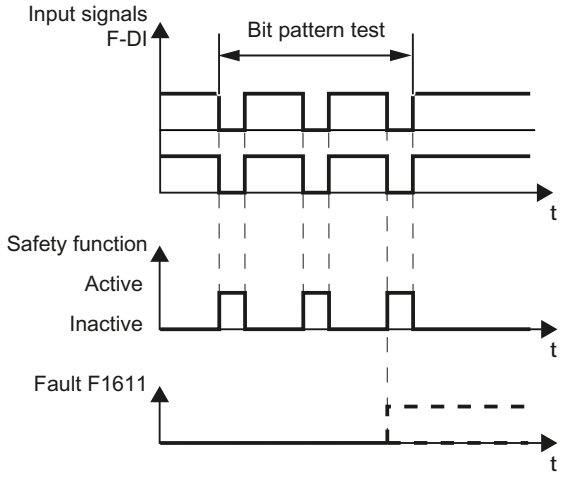


Figure 4-9 Converter response to a bit pattern test

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

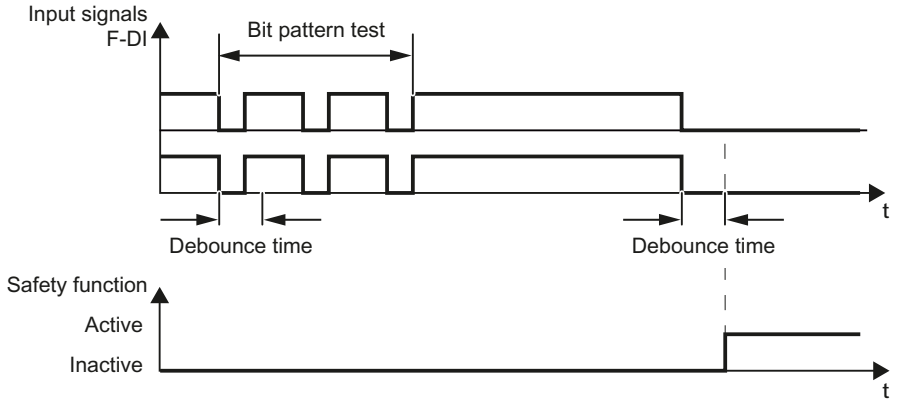


Figure 4-10 Filter for suppressing temporary signal changes

Note

The filter increases the converter response time. The converter only selects its safety function after the debounce time has elapsed.

Table 4- 12 Parameters for the filters

Parameter	Description
p9650	**F-DI changeover tolerance time** (factory setting: 500 ms) Tolerance time to changeover the fail-safe digital input for the basic functions.
p9651	**STO debounce time** (factory setting: 1 ms) Debounce time of the fail-safe digital input for the basic functions.
p10002	**Discrepancy monitoring time** (factory setting: 500 ms) Tolerance time to changeover the fail-safe digital inputs for the extended functions.
p10017	**Digital inputs debounce time** (factory setting: 1 ms) Debounce time of the fail-safe digital inputs for the extended functions.

Note

Debounce times for standard and safety functions

The debounce time p0724 for "standard" digital inputs has no influence on the fail-safe input signals. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

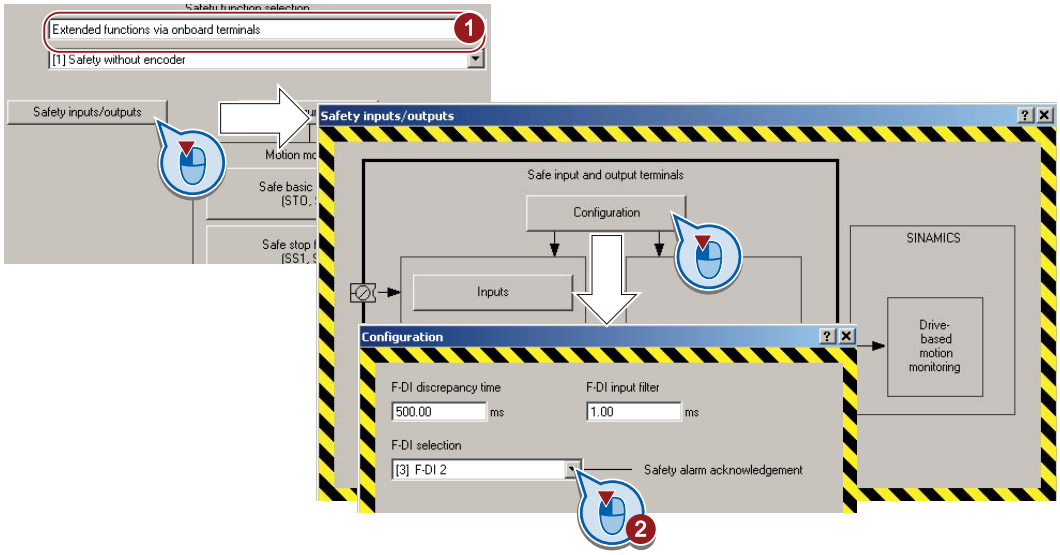
If you use an input as a standard input, set the debounce time using parameter p0724 .

If you use an input as a fail-safe input, set the debounce time as described above.

4.8.2.2 Acknowledgment signal

Procedure

- In the main screen form, select the safety inputs and outputs STARTER only shows this button, if you have selected the extended functions via onboard terminals ①.
- Click the "Configuration" button.



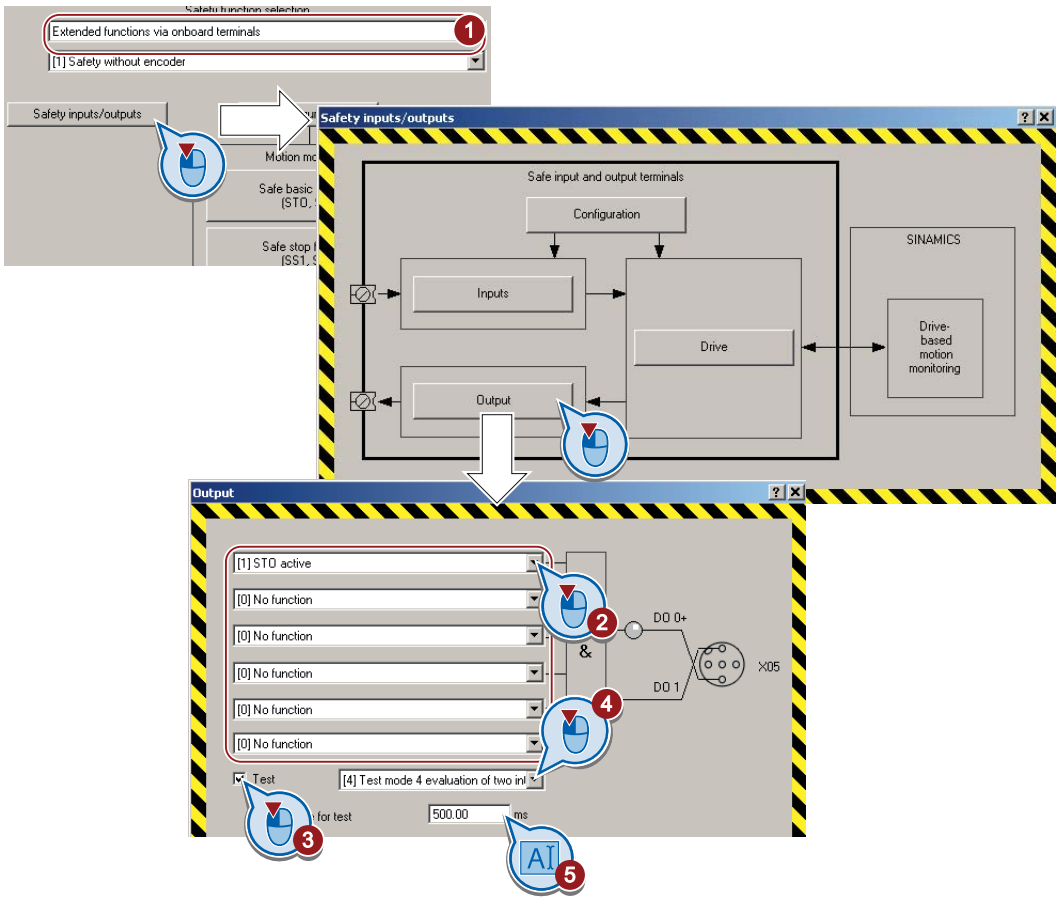
- ② Select a free fail-safe input for acknowledging. If there are no free fail-safe inputs available, you have to acknowledge the safety function faults using a different method. See also Section: Fail-safe acknowledgment (Page 193).

4.8.3 Fail-safe output

Procedure

Output signal and setting the test mode

- In the main screen form, select the safety inputs and outputs STARTER only shows this button, if you have selected the extended functions via onboard terminals ①.
- Click the "Output" button.



- ② Interconnect the status signals of your choice with the fail-safe output. The converter logically combines the status signals according to the following rules:
  - The converter ignored inputs without interconnection.
  - If none of the inputs is interconnected, then the output signal = 0.
- ③ Activate the test for the fail-safe output.
- ④ Select the test mode that is compatible with your application.
- ⑤ Set the wait time.
- Close the screen forms.

Description

Test mode of the fail-safe output

To meet the requirements of the standards ISO 13849-1 and IEC 61508 in terms of timely fault detection, the converter must test its fail-safe output regularly - at least once a year - for correct functioning.

Depending on the interconnection of the fail-safe output, in the converter you must set one of the three test modes 2, 3 or 4. For test modes 2 and 3 you must adapt the wait time to your particular application.

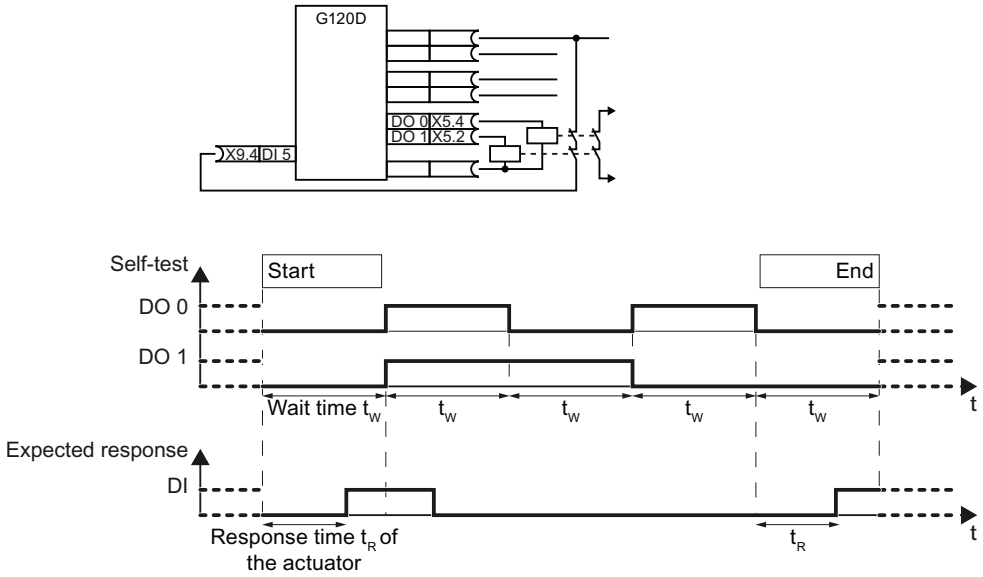


Figure 4-11 Expected response at the digital input for test mode 2

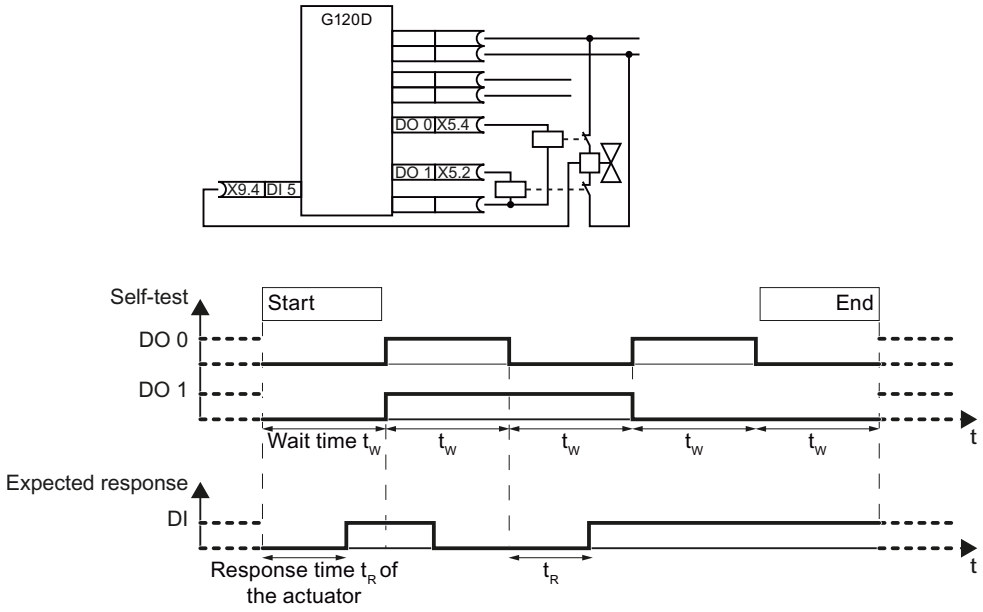


Figure 4-12 Expected response at the digital input for test mode 3

For test mode 4, the converter evaluates internal signals.

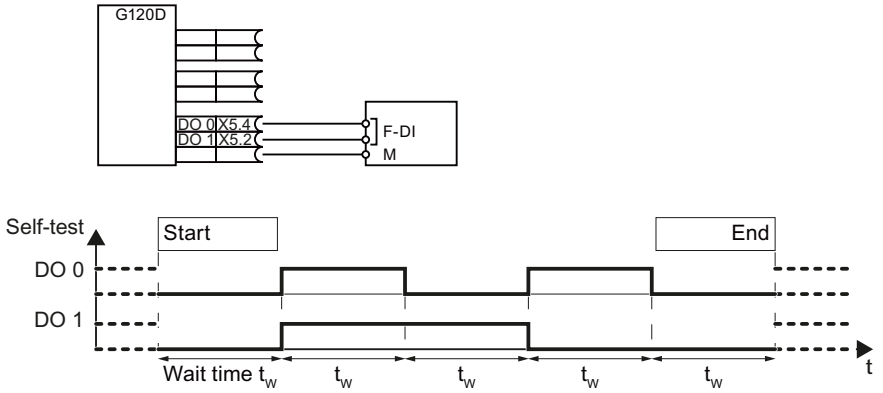


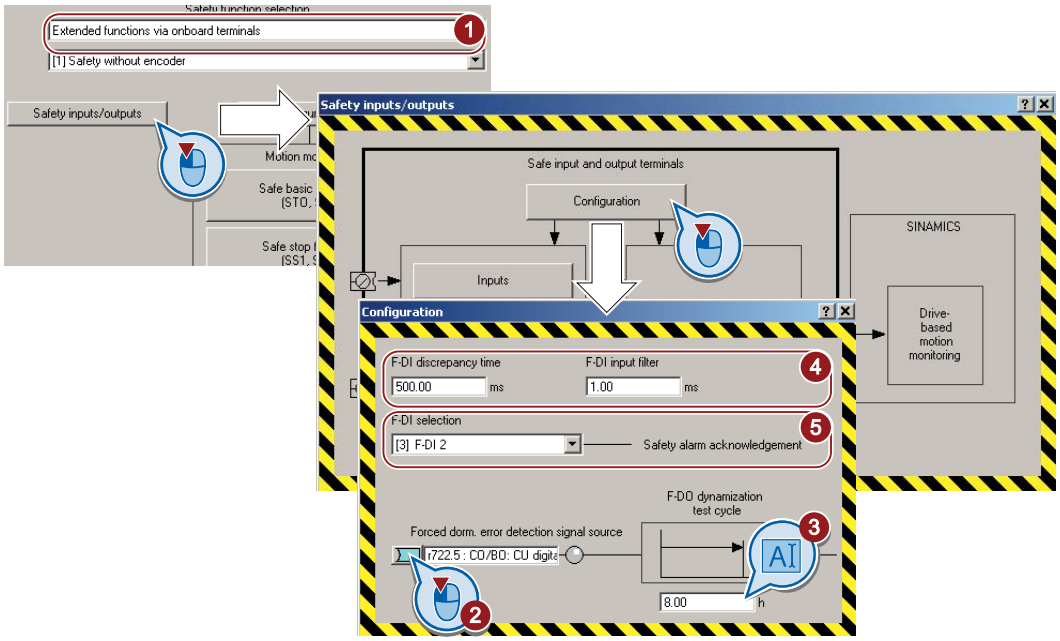
Figure 4-13 Test mode 4

Table 4- 13 Parameters for the function of the fail-safe output and the test mode

Parameter	Description
p10039	**Safe State signal selection** (factory setting: 0000 0001 bin) Setting the signals for the "Safe State" signal.
p10042	**F-DO signal sources** (Factory setting: 0) Setting the signal sources for F-DO.
p10046	**F-DO feedback signal input activation** (Factory setting: 0000 bin) Activation of the feedback input for the safe digital output.
p10047	**F-DO test mode** (Factory setting: 0100 bin) Setting the test mode for the safe digital output
p10001	**Wait time for the forced checking procedure at DO** (Factory setting: 500 ms) Within this time, for a forced checking procedure of the digital output, the signal must have been detected via the corresponding feedback inputp10047).

Setting forced checking procedure

- In the main screen form, select "Safety inputs/outputs". STARTER only shows this button, if you have selected the extended functions via onboard terminals ①.
- Click the "Configuration" button.



- The forced checking procedure of the fail-safe output can be started using a dedicated signal.
  - ② This signal starts the forced checking procedure of the fail-safe output and sets the monitoring time to zero. Interconnect this signal, for example with a digital input or a control bit in the fieldbus.
  - ③ Monitoring time for forced checking procedure. Set a time greater than or equal to the time for monitoring the forced checking procedure of the extended functions. See also section: Setting forced dormant error detection (Page 84).
- ④ See section: Setting the filter for fail-safe inputs (Page 90).
- ⑤ See section: Acknowledgment signal (Page 95).

Description

Forced checking procedure of the fail-safe output

The forced checking procedure of the fail-safe output is the regular self-test of the converter, in which the converter checks whether the output can be shut down (deactivated).

The converter monitors the regular forced checking procedure of the fail-safe output using a time block.

You must start the forced checking procedure with a signal of your choice.

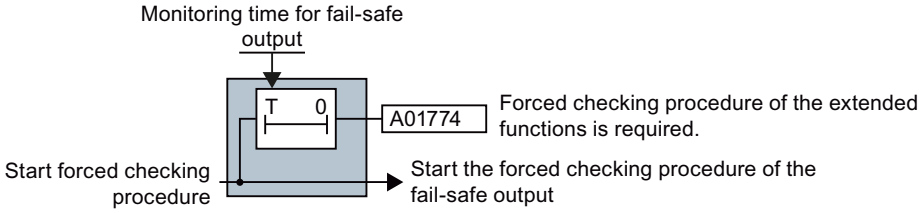


Figure 4-14 Start and monitoring of the forced checking procedure of the fail-safe output

Table 4- 14 Parameters for monitoring the forced checking procedure

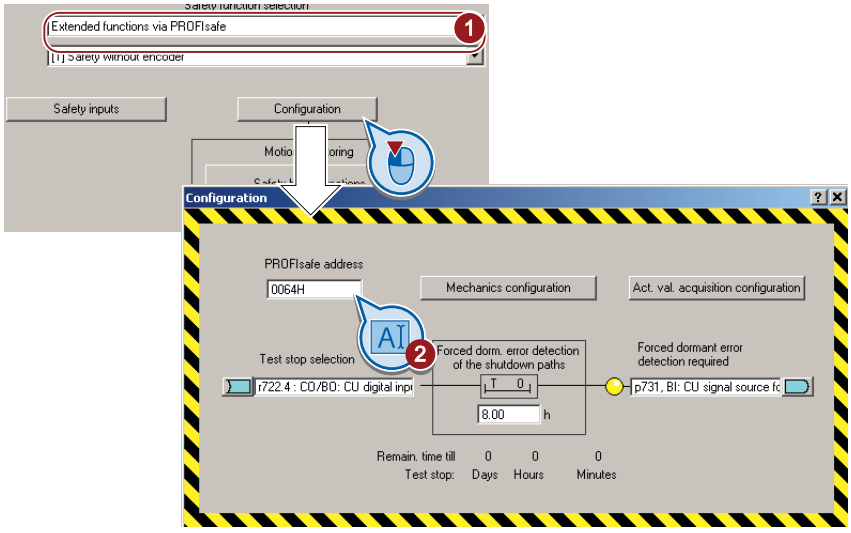
Parameter	Description
p10003	**Forced checking procedure timer** (Factory setting: 8 h))Setting the time to carry out the forced checking procedure.
p10007	**Forced checking procedure F-DO signal source** (Factory setting: 0) Select an input terminal to start the forced checking procedure.

4.8.4 Configuring PROFIsafe

Procedure

Setting the address

- In the main screen form, select the "Configuration" button.



- ② STARTER only shows this input field if you have selected the extended functions via PROFIsafe ① (or via PROFIsafe and onboard terminals).

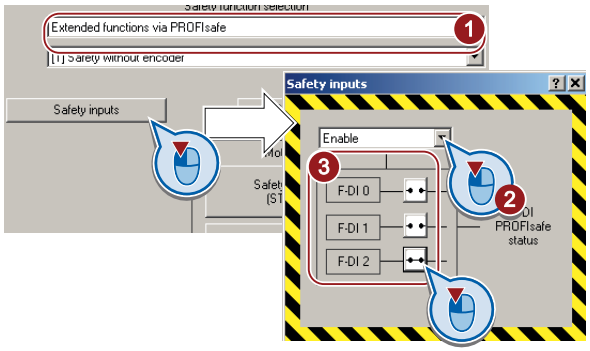
- Enter the same PROFIsafeaddress in the hexadecimal format, which you defined in the hardware configuration.
  See also section: STEP 7 example: Configuring PROFIsafe communication (telegram 30) via PROFIBUS (Page 59).
- Close the screen form.

PROFIsafe telegram 30

After enabling the safety functions with communication via PROFIsafe , the converter operates with telegram 30.

Set PROFIsafe telegram 900

- In the main mask, select the safety inputs STARTER only displays this button if you have selected the extended functions "via PROFIsafe" or "via PROFIsafe and onboard terminals" ①.



- ② Enable telegram 900. If you disable this function, the converter operates with telegram 30.
- ③ Specify which F-DI status you want to transfer via PROFIsafe :

Note

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

You must also configure PROFIsafe telegram 900 in the higher-level control, also see Section: STEP 7 example: Configuring PROFIsafe communication (telegram 900) via PROFIBUS (Page 62).

Enabling Shared Device

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

- Using the expert list in STARTER, set p8929 = 2 in the converter.

Start communication via PROFIsafe

When you connect the converter to the central controller via the fieldbus for the first time, the central controller sends the PROFIsafe configuration to the converter. Once the configuration data has been received, the converter interconnects its internal signals to the PROFIsafe telegram.

Note

Monitoring PROFIsafe communication

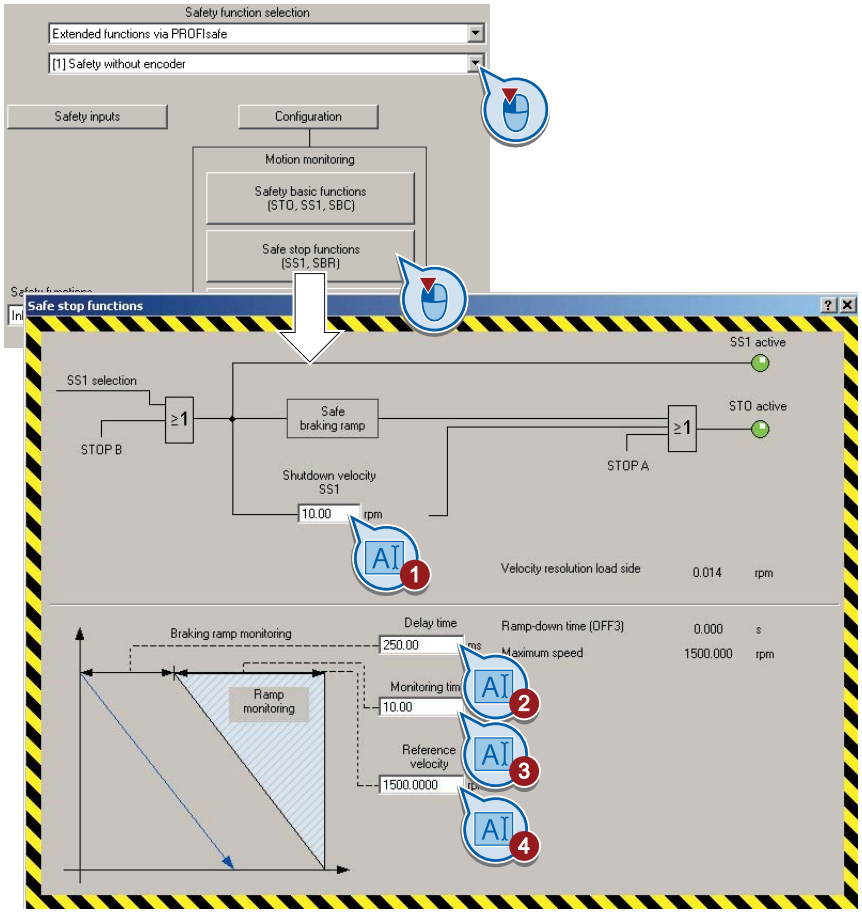
The converter monitors communication with the central controller. The converter does not start monitoring communication until the configuration data has been received from the central controller.

4.8.5 Setting SS1

4.8.5.1 Setting SS1 with braking ramp monitoring

Procedure

- In the main mask of the extended functions, select the monitoring mode [1] (brake ramp monitoring).
- Select the safety function SS1.



- Set the following:
  - ① Shutdown speed SS1.
  - ② 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.
    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-.

- ③ 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 converter can reduce its monitoring curve faster than the load can be braked.
  The longer you set the monitoring times, the more tolerant the monitoring.
- ④ Reference velocity (reference speed):
  Set the reference speed to the value of the maximum speed.

- Close the screen form.

Description

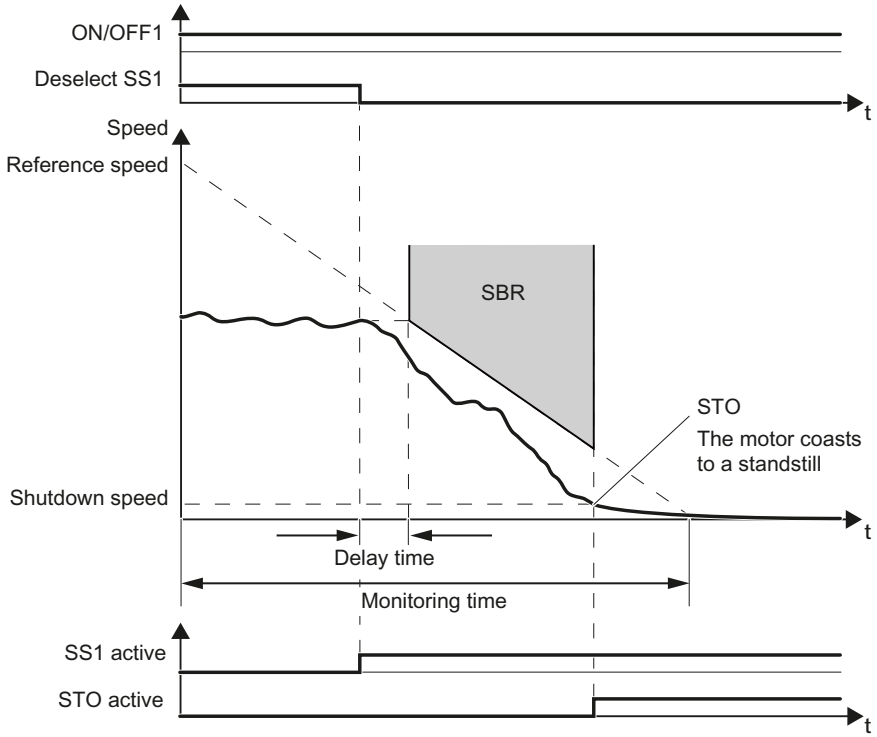


Figure 4-15 SS1 with braking ramp monitoring

Reference speed and monitoring time

The two values define the gradient of the monitoring SBR .

Delay time

The SBR function only starts after an adjustable time. The monitoring starts with the speed setpoint that applied when SS1 was selected.

Braking

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

Shutdown speed

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

Parameter

Table 4- 15 Parameters for the SS1function

Parameter	Description	
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Inhibit extended functions.	
p9506	**Function specification:** (Factory setting: 1)	
	1:	With braking ramp monitoring
	3:	With acceleration monitoring
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	

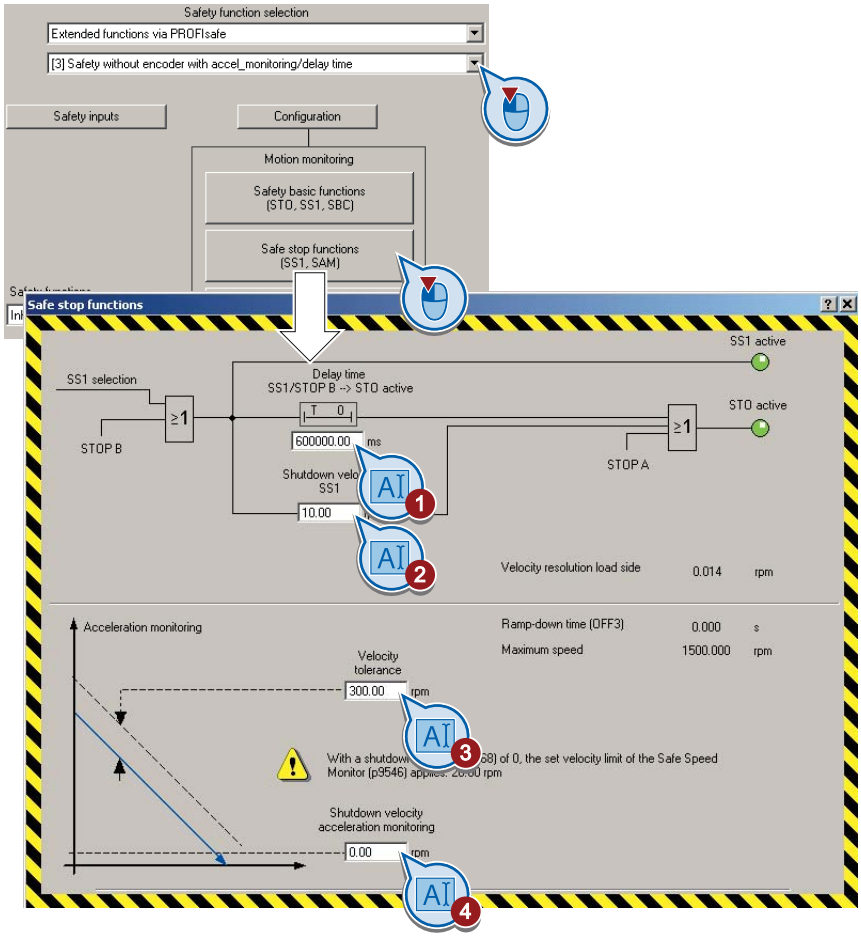
Table 4- 16 Standard function for switching the motor off

Parameter	Description
p1135	**OFF3 ramp-down time**
p1226	**Standstill detection, speed threshold** (Factory setting: 20 rpm)
p1227	**Standstill detection monitoring time** (Value depends on the power unit)
	The converter switches off the motor torque if the speed either fulfills the condition for standstill detection or the shutdown speed p9569 has been reached.

4.8.5.2 Setting SS1 with acceleration monitoring

Procedure

- In the main mask of the extended functions, select the monitoring mode [3] (with acceleration monitoring).
- Select the safety function SS1.



- Set the following:
  - ① Delay time
    After this time the converter safely switches off the motor torque - regardless of the actual speed.
  - ② Shutdown speed SS1
  - ③ Speed tolerance
  - ④ Shutdown speed acceleration monitoring
- Close the screen form.

Description

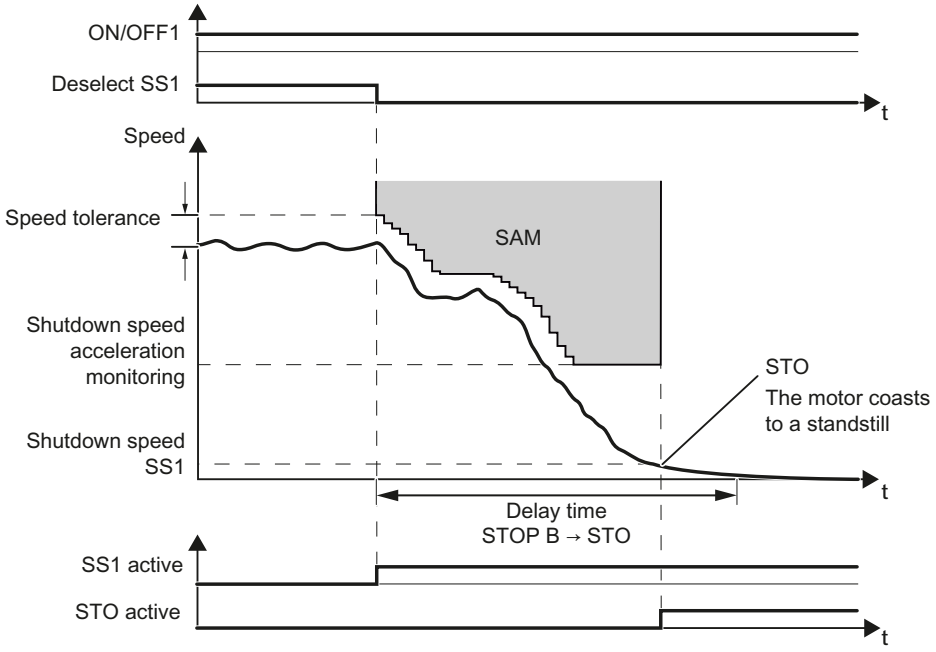


Figure 4-16 SS1 with acceleration monitoring

Speed tolerance

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

Shutdown speed acceleration monitoring

The converter reduces the monitoring threshold until it reaches the value of the "Shutdown speed SS1".

Shutdown speed SS1 and delay time

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

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

Parameter

Table 4- 17 Parameters for the SS1function

Parameter	Description
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Inhibit 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

Table 4- 18 Standard function for switching the motor off

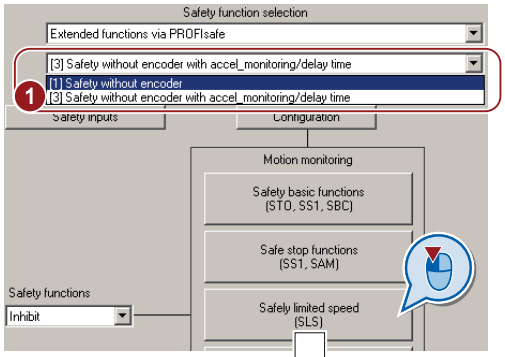
Parameter	Description
p1226	**Standstill detection, speed threshold** (Factory setting: 20 rpm)
p1227	**Standstill detection monitoring time** (Value depends on the power unit)
	The converter switches off the motor torque if the speed either fulfills the condition for standstill detection or the shutdown speed p9569 has been reached.

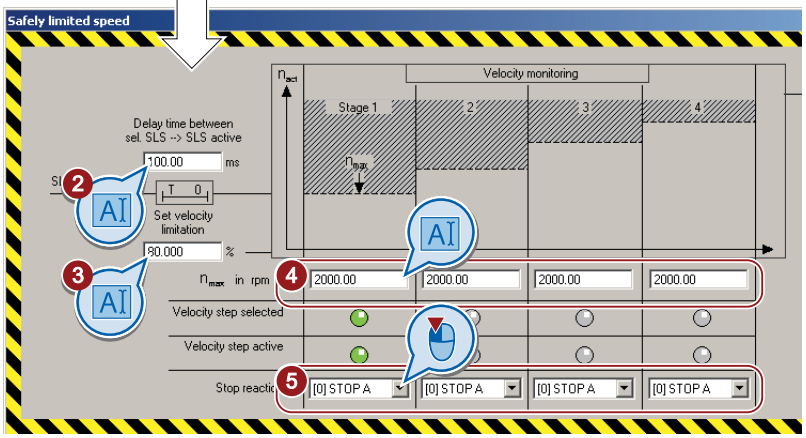
4.8.6 Setting SLS

4.8.6.1 Setting the monitoring functions

Procedure

- ① In the main screen form of the extended functions, select the monitoring mode:
  - [1] with braking ramp monitoring.
  - [3] without braking ramp monitoring.
- Select the safety function SLS.





- Set the following:
  - ② The delay time only appears if you have not selected brake ramp monitoring. The delay time must be higher than the time, when SLS is selected, that the motor needs to brake with the maximum load from the maximum speed and to the lowest SLS level.
  - ③ Setpoint speed limiting as a % of the speed monitoring. When SLS is active, the converter limits the speed to this value.

- ④ Speed monitoring.
  Set the speed to be monitored. The converter calculates the maximum motor speed based on this value and the gear ratio.
  If you have not set PROFIsafe as interface, you can only set level 1.
- ⑤ Set the response when the monitoring responds.
  Also see section: Stop responses (Page 192).

- Close the screen form.

Description

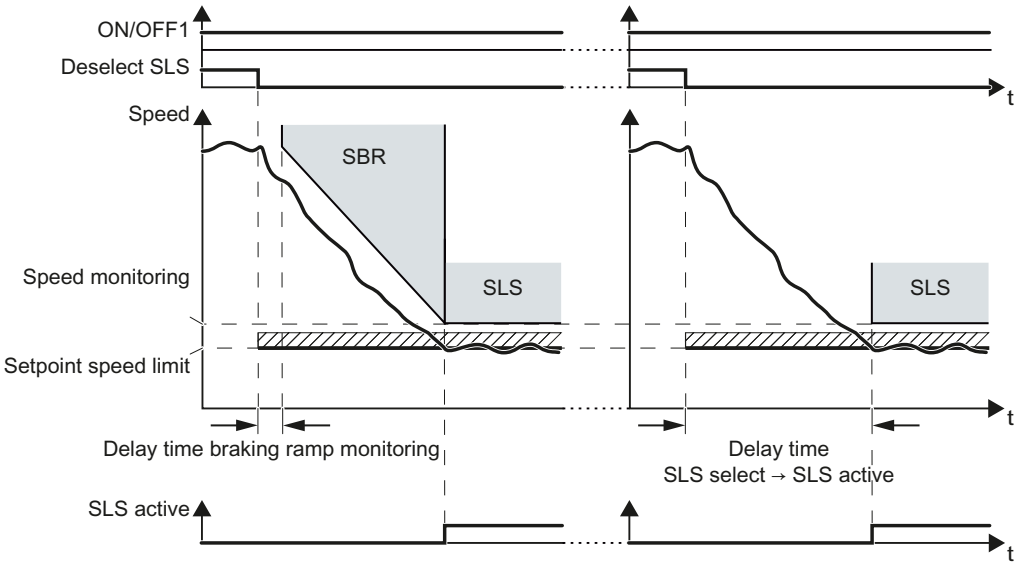


Figure 4-17 Behavior after selecting SLS. Left: with braking ramp monitoring; right: without braking ramp monitoring

After selecting SLS , the converter 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 103).

Parameter

Table 4- 19 Parameters for the SLSfunction

Parameter	Description	
p1135	**OFF3 ramp-down time**	
p9501.00	**1 signal:** SLS and enable extended functions. **0 signal:** SLS and inhibit 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 converter limits the setpoint to the value r9733. r9733[0] = p9531[x] × p9533.	
p9551	**Delay time SLS Select → 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	

Table 4- 20 Parameters for braking the motor

Parameter	Description
p1135	**OFF3 ramp-down time**

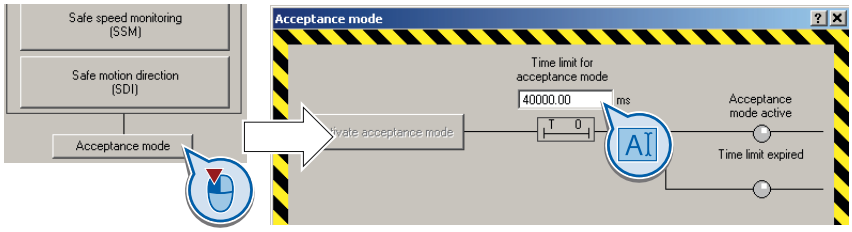
4.8.6.2 Settings for acceptance test

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 converter.

Starter offers you the possibility to temporarily deactivating speed limiting.

Procedure

- In the main screen form of the extended functions, select the "Acceptance mode" button.
- Set the time in which the converter deactivates its internal speed limiting. During the acceptance test, you must reach the monitored limit value within this time.

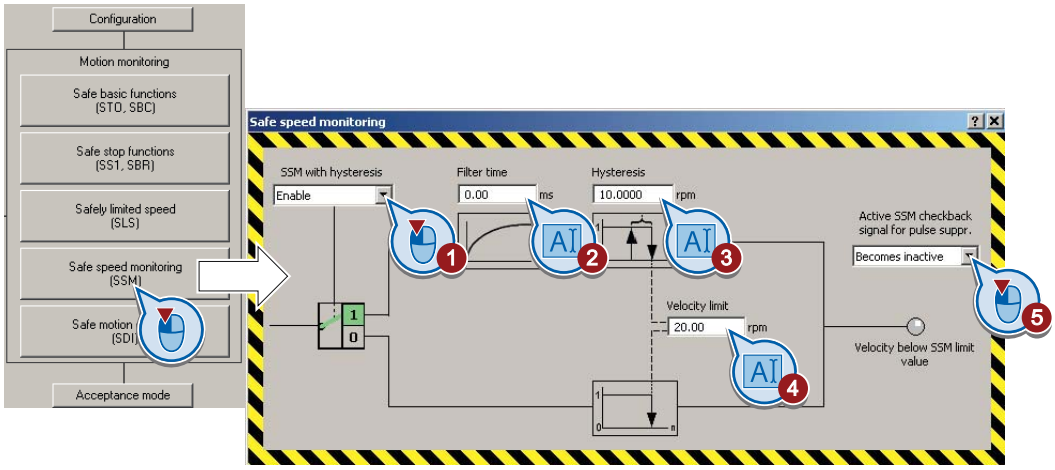


- Close the screen form.

4.8.7 Setting SSM

Procedure

- In the main screen form of the extended functions, select the SSMsafety function.



- Set the following in this screen form:
  - ① Enable the function with hysteresis.
  - ② The filter time.
  - ③ The hysteresis.
  - ④ The speed limit: the speed to be monitored.
  - ⑤ The behavior when the motor is switched off. See also Section: Switching off the motor when SSM is active (Page 171).

Note

Switching-on the motor after commissioning SSM

After commissioning, the SSM function is immediately active. In order to switch on the motor after SSM has been commissioned, please observe the procedure described in Section Switching the motor off and on again when SSM is active (Page 173).

Description

The safety function SSM cannot be selected or deselected using external control signals. SSM is active when you have set a monitoring velocity > 0 for SSM .

Speed monitoring

- When the motor is switched on, the converter compares the load speed with the speed limit.

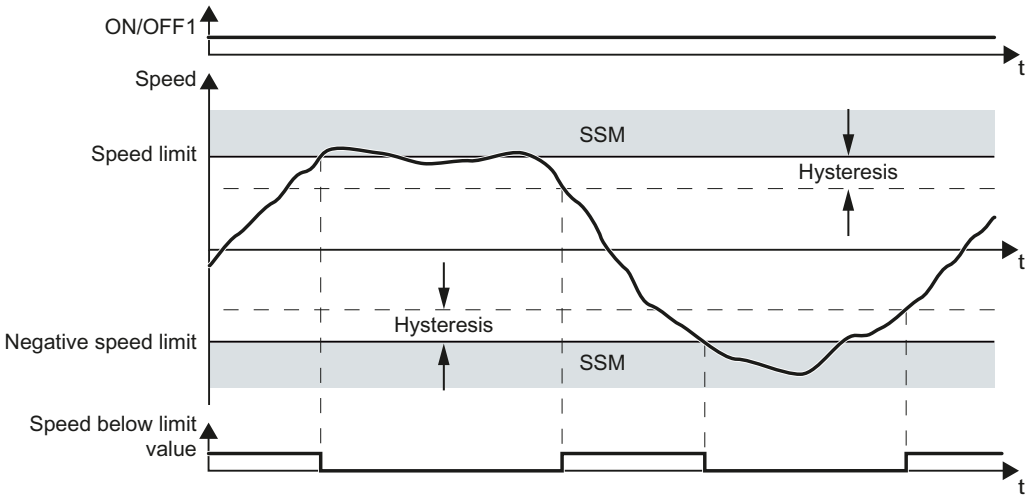


Figure 4-18 Time response of the safety function SSM (Safe Speed Monitor)

Filter

The signal filters smoothes the speed measured by the converter. Use the filter if you wish to monitor speeds that lie just below the speed limit.

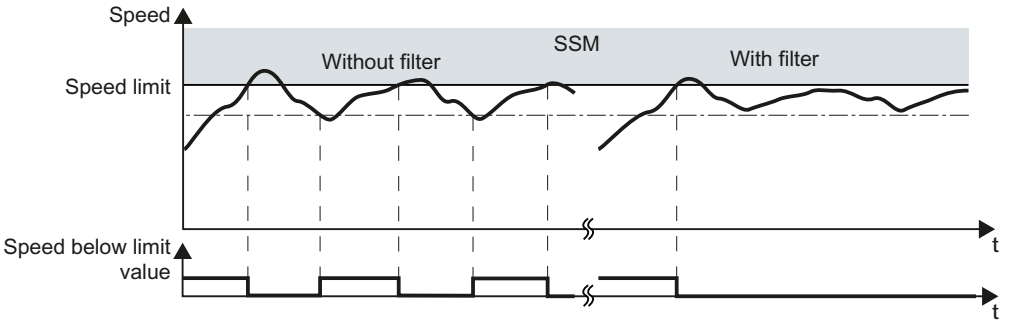


Figure 4-19 Mode of operation of the filter of the SSM function

Feedback signal SSM when the motor is switched off

You can select whether the converter monitors the speed when the motor is switched off or not. See also Section: Switching the motor off and on again when SSM is active (Page 173).

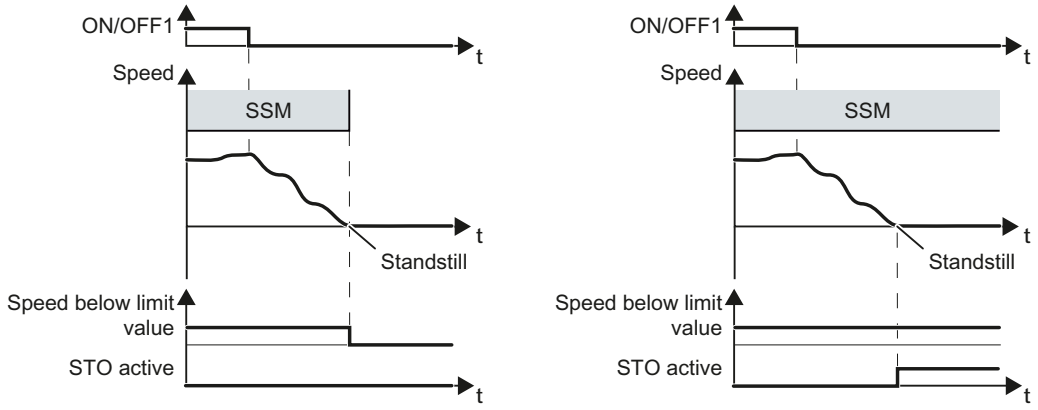


Figure 4-20 Behavior when the motor is switched off. Left: SSM is inactive. Right: SSM remains active

Parameter

Table 4- 21 Parameters for the SSM function

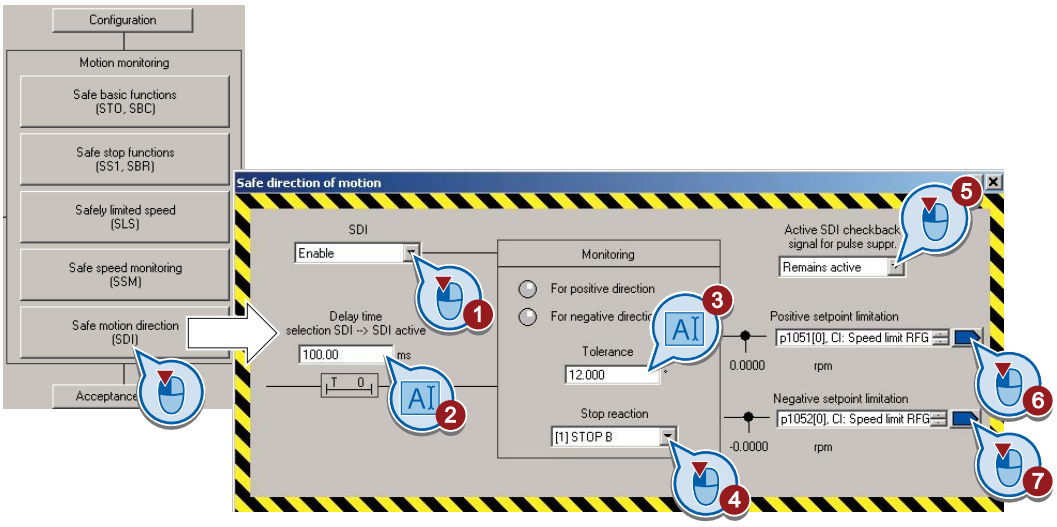
Parameter	Description
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Inhibit extended functions.
p9501.16	**1 signal:** Enable hysteresis and filtering **0 signal:** Disable hysteresis and filtering
p9509.00	**1 signal:** SSM becomes inactive when the motor is switched off **0 signal:** SSM remains active when the motor is switched off
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

4.8.8 Setting SDI

4.8.8.1 Setting the monitoring functions

Procedure

- In the main screen form of the extended functions, select the SDI safety function.



- 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 192)
  - ⑤ The behavior when the motor is switched off. See also Section: Switching off the motor when SDI is active (Page 175)
  - ⑥ ⑦ If you leave this interconnection to the factory setting, whenSDI is selected, the converter limits the speed.

Description

Time response

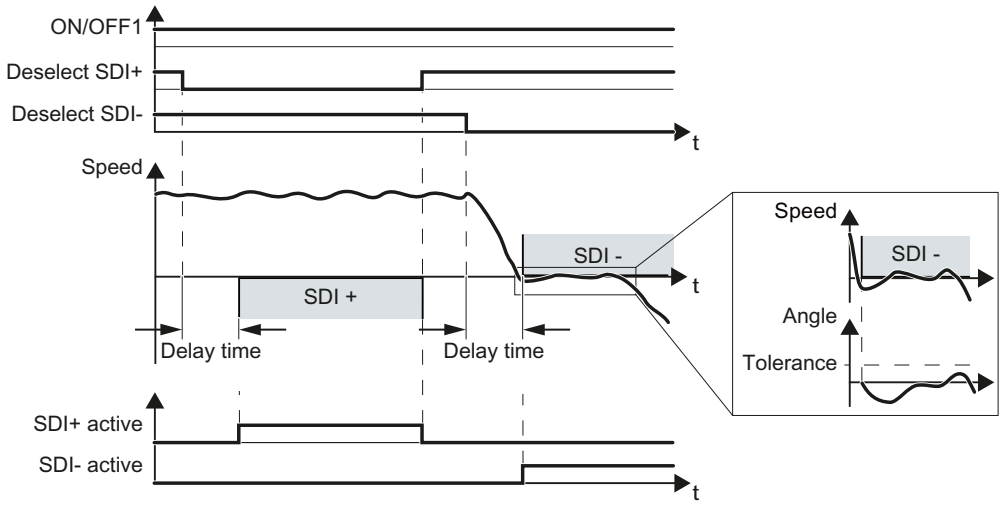


Figure 4-21 Delay time and tolerance

Delay time

If you select SDI , then the converter monitors the selected motor direction of rotation after the delay time expires. 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 converter brakes the motor with the OFF3 ramp-down time.

Tolerance

The converter permits brief motion in the monitored direction, for example for brief speed overshoots after braking down to standstill. To do this, the converter 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 whether the converter monitors the speed when the motor is switched off or not. See also Section: Switching the motor off and on again when SDI is active (Page 177).

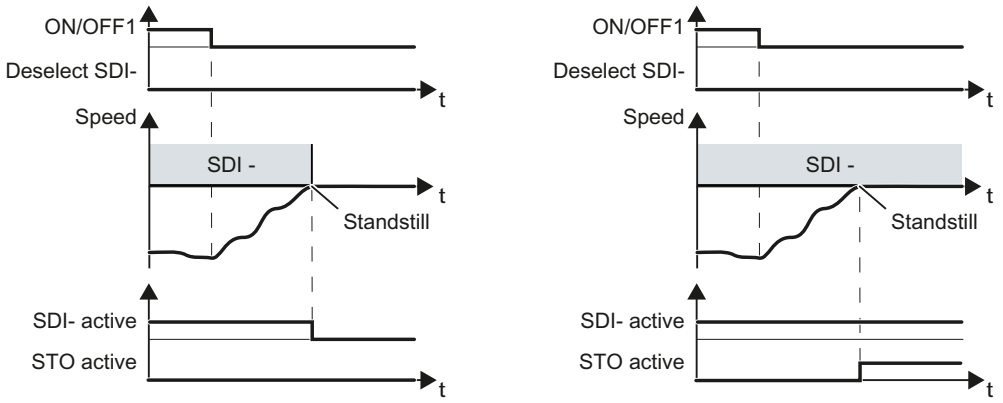


Figure 4-22 Behavior when the motor is switched off. Left: SDI becomes inactive. Right: SDI remains active

Parameter

Table 4- 22 Parameters for the SDI function

Parameter	Description	
p9501.00	**1 signal:** Enable extended functions. **0 signal:** Inhibit extended functions.	
p9501.17	**1 signal:** SDI enable **0 signal:** SDI inhibit	
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	

Table 4- 23 Parameters for braking the motor

Parameter	Description
p1135	**OFF3 ramp-down time**

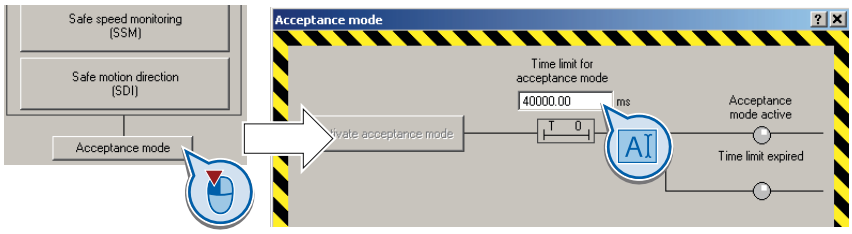
4.8.8.2 Settings for acceptance test

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 converter.

Starter offers you the possibility to temporarily deactivating speed limiting.

Procedure

- In the main screen form of the extended functions, select the "Acceptance mode" button.
- Set the time in which the converter deactivates its internal speed limiting. During the acceptance test, you must reach the monitored limit value within this time.

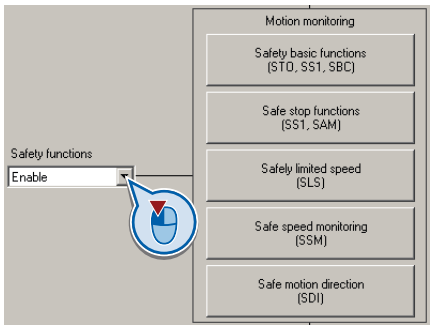


- Close the screen form.

4.8.9 Complete commissioning

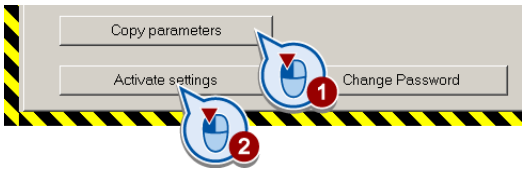
4.8.9.1 Enabling safety functions

- In the main screen, enable the safety functions



4.8.9.2 Activate settings

- ① Copy the parameters of the safety functions in order to create a redundant image of the settings.



- ② Activate the settings.
- 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.
  Further information can be found in the section Password (Page 66).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the converter supply voltage.
- Wait until all of the LEDs on the converter go dark. Now switch on the converter supply voltage again. Your settings only become effective after this power-on reset.

Parameter

Table 4- 24 Parameters for the forced dormant error detection

Parameter	Description
p9700 = 57 hex	**SI copy function** (factory setting: 0) Start copy function SI parameter.
p9701 = AC hex	**Confirm data change** (factory setting: 0)Confirm data change overall.
p0010 = 0	**Drive commissioning parameter filter** 0: Ready

4.8.9.3 Checking the assignment of the digital inputs

- Check whether the digital inputs used as fail-safe input are also assigned a further function.

NOTICE
Both, the assignment of digital inputs with the selection of a safety function or with a "standard" function can lead to an unexpected behavior of the motor.

- Remove multiple assignments of the digital inputs:

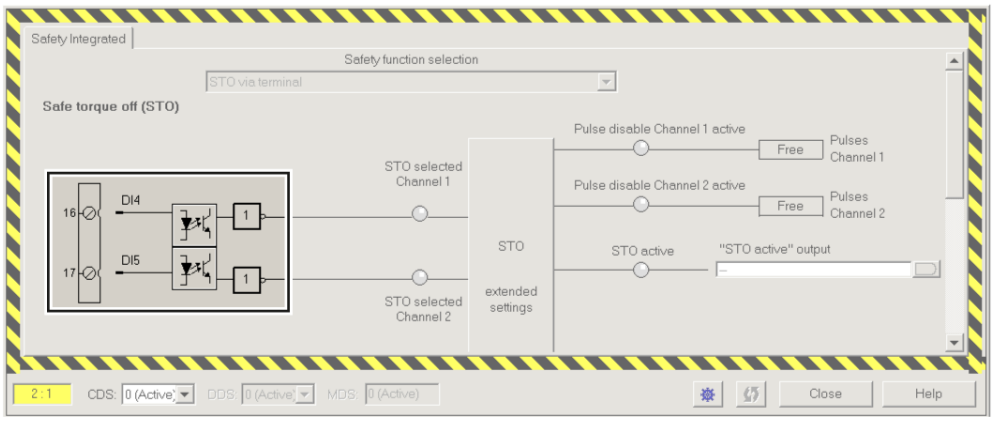


Figure 4-23 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

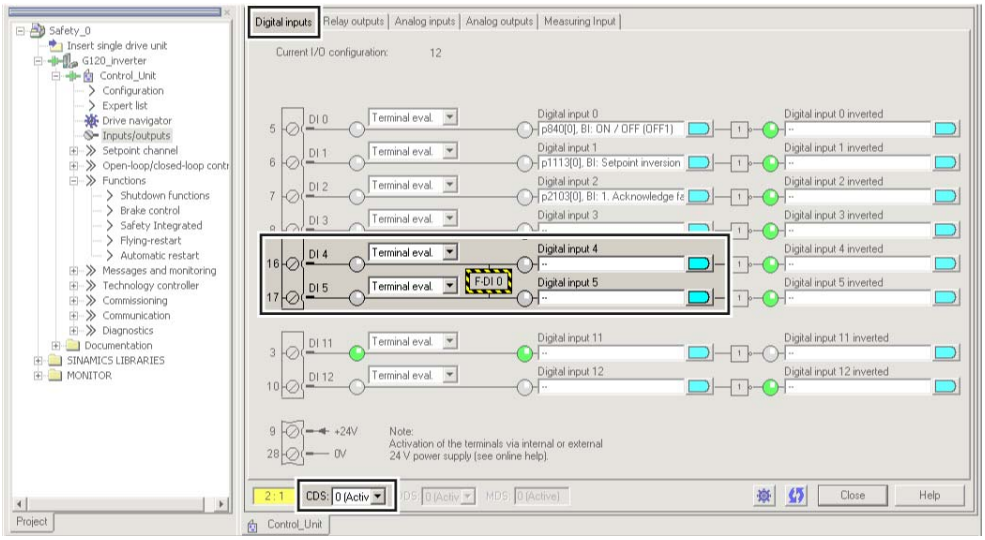


Figure 4-24 Remove pre-assignment of digital inputs DI 4 and DI 5

- When you use the data set changeover CDS, you must delete the multiple assignment of the digital inputs for all CDS.

4.8.10 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Manuals for your inverter (Page 242).
- Perform an acceptance test for the safety functions:
  - Document your settings in an acceptance report.
  - Check whether the safety functions are functioning correctly in your application.
  - The instructions for the acceptance test can be found in the section Acceptance tests for the safety functions (Page 126).

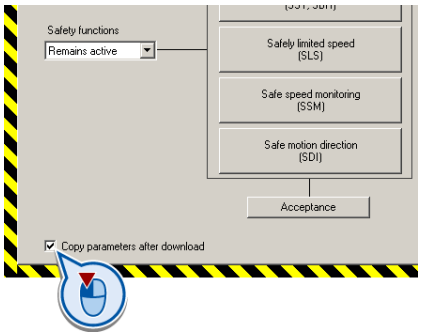
4.9 Offline commissioning

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).

4.9.1 Offline parameterization

- Call up the safety functions in STARTER .
- Select the checkbox at the bottom of the dialog to copy the parameters:



- Set the safety function parameters offline.
  Follow the descriptions in this manual starting with the section Changing settings (Page 68).
- Once you have finished setting the parameters, save your project by clicking the button.

4.9.2 Downloading parameters

Procedure

- Go online with STARTER and start to download to the converter using the button .
  After the download, the converter signals faults. Ignore these faults, as they will be automatically acknowledged by the following steps."
- Call the safety functions screen form
- Select the button to change the settings.
- Activate the settings using the associated button.
- Save your settings (copy RAM to ROM).

- Switch off the converter supply voltage.
- Wait until all of the LED on the converter go dark. Now switch on the converter supply voltage again. Your settings only become effective after this power-on reset.

4.9.3 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Manuals for your inverter (Page 242).
- Perform an acceptance test for the safety functions:
  - Document your settings in an acceptance report.
  - Check whether the safety functions are functioning correctly in your application.
  - The instructions for the acceptance test can be found in the section Acceptance tests for the safety functions (Page 126).

4.10 Series commissioning

In order to perform standard commissioning, you must have saved a project in STARTER .

Procedure

To copy all the parameters of one converter to a second converter, follow the instructions in the section Downloading parameters (Page 123).

Steps to be carried out after downloading the parameters:

- If you control your converter via PROFIsafe , then you must adapt the PROFIsafe address. For further information, refer to the following sections:
  - Basic functions: Configuring PROFIsafe (Page 74)
  - Extended functions: Configuring PROFIsafe (Page 100)
- Perform a reduced acceptance for the safety functions. The necessary measures are described in the section: Reduced acceptance (Page 127).

4.11 Acceptance tests for the safety functions

4.11.1 Prerequisites and authorized persons

Requirements for an acceptance are derived from the EC Machinery Directive and ISO 13849-1:

- You must check safety-related functions and machine parts after commissioning.
- You must create an "acceptance report" showing the test results.

Prerequisites for the acceptance test

- The machine is properly wired.
- All safety equipment such as protective door monitoring devices, light barriers or emergency-off switches are connected and ready for operation.
- Commissioning of the open-loop and closed-loop control has been completed. These include, for example:
  - Configuration of the setpoint channel.
  - Closed loop control in the higher-level controller.
  - Motor control.

Authorized persons

Authorization within the scope of the acceptance test is a person authorized by the machine manufacturer who, on account of his or her technical qualifications and knowledge of the safety functions, is in a position to perform the acceptance test in the correct manner.

4.11.2 Full acceptance tests

The full acceptance tests for the safety functions include the following:

1. Acceptance test
   - Check the safety functions in the machine or in the plant/system
2. Documentation
   - Described the safety-relevant components and functions of the machine or plant
   - Logging of the settings of the safety functions
   - Countersigning documentation

4.11.3 Reduced acceptance

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

The acceptance test must be carried out individually for each drive as far as the machine allows it.

Table 4- 25 Reduced scope acceptance test for function expansions

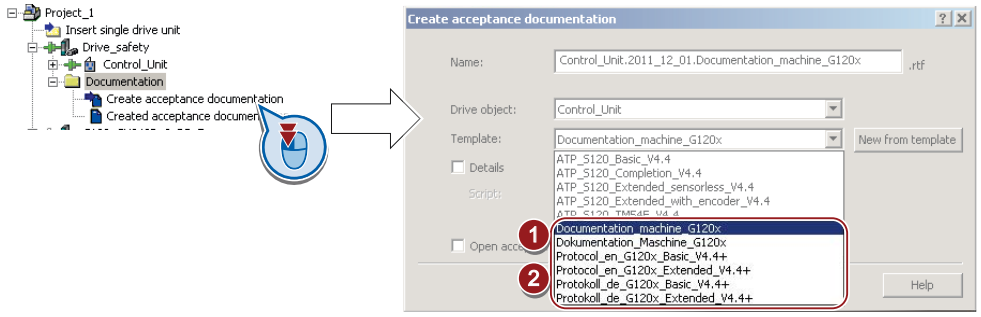
Measure	Acceptance test	
	Acceptance test	Documentation
Replacing the Control Unit (SINAMICS G120) or the inverter.	Yes	• Supplement inverter data • Log the new checksum • Countersignature
Replacing the Power Module.	Yes	Supplement the hardware version in the inverter data
Replacing the motor	Yes, but only for the safety function SDI.	No change
Replacing the gear unit	Yes	No change
Replacing the safety-related peripherals (e.g. Emergency Stop switch).	Yes, but only for the replaced components.	No change
Inverter firmware update.	Yes	• Supplement firmware version in the inverter data • Log the new checksum • Countersignature
Changing a single limit (e.g. SLS level).	Yes, but only for the changed limit value.	• Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Functional expansion of the machine (additional drive).	Yes, but only for the additional functions.	• Supplement machine overview • Supplement inverter data • Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Functional expansion of a drive (e.g. additional SLS level).	Yes, but only for the additional functions.	• Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Transfer of inverter parameters to other identical machines by means of standard commissioning.	Yes	• Supplement machine description • Check the checksums • Check the firmware versions

4.11.4 Documents for acceptance

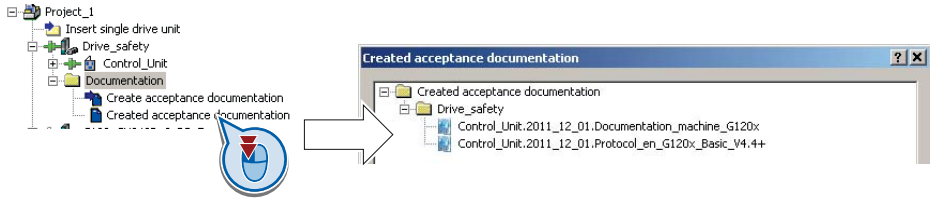
STARTER creates a log of the settings of the safety functions, which you can use for your machine documentation.

Procedure

- In STARTER create the acceptance documentation:



- ① This template contains a recommendation for your machine or plant documentation.
  Dokumentation_Maschine_G120x: German template.
  Documentation_machine_G120x: English template.
- ② Select the suitable template and create a report for each drive of your machine or plant:
  - Basic functions for firmware version V4.4 and higher:
    Protokoll_de_G120x_Basic_V4.4+: German template.
    Protocol_en_G120x_Basic_V4.4+: English template.
  - Extended functions for firmware version V4.4 and higher:
    Protokoll_de_G120x_Extended_V4.4+: German template.
    Protocol_en_G120x_Extended_V4.4+: English template.
- You load the created reports for archiving and the machine documentation for further processing:



- Archive the protocols and the machine documentation.

The reports and the machine documentation can also be found in Section: Documentation for acceptance (Page 221).

4.11.5 Recommended acceptance test

The following descriptions for the acceptance test are recommendations that illustrate the principle of acceptance. You may deviate from these recommendations if you check the following once you have completed commissioning:

- Correct assignment of the interfaces of each converter with safety function:
  - Fail-safe inputs
  - Fail-safe outputs
  - PROFIsafe address
- Correct setting for the limit values and brake and monitoring times.

Note

Perform the acceptance test with the maximum possible velocity and acceleration in order to test the expected maximum braking distances and braking times.

Note

Non-critical alarms

The following alarms are issued following each system ramp-up and are not critical for acceptance:

- A01697
- A01796

4.11.5.1 Acceptance test STO (basic functions)

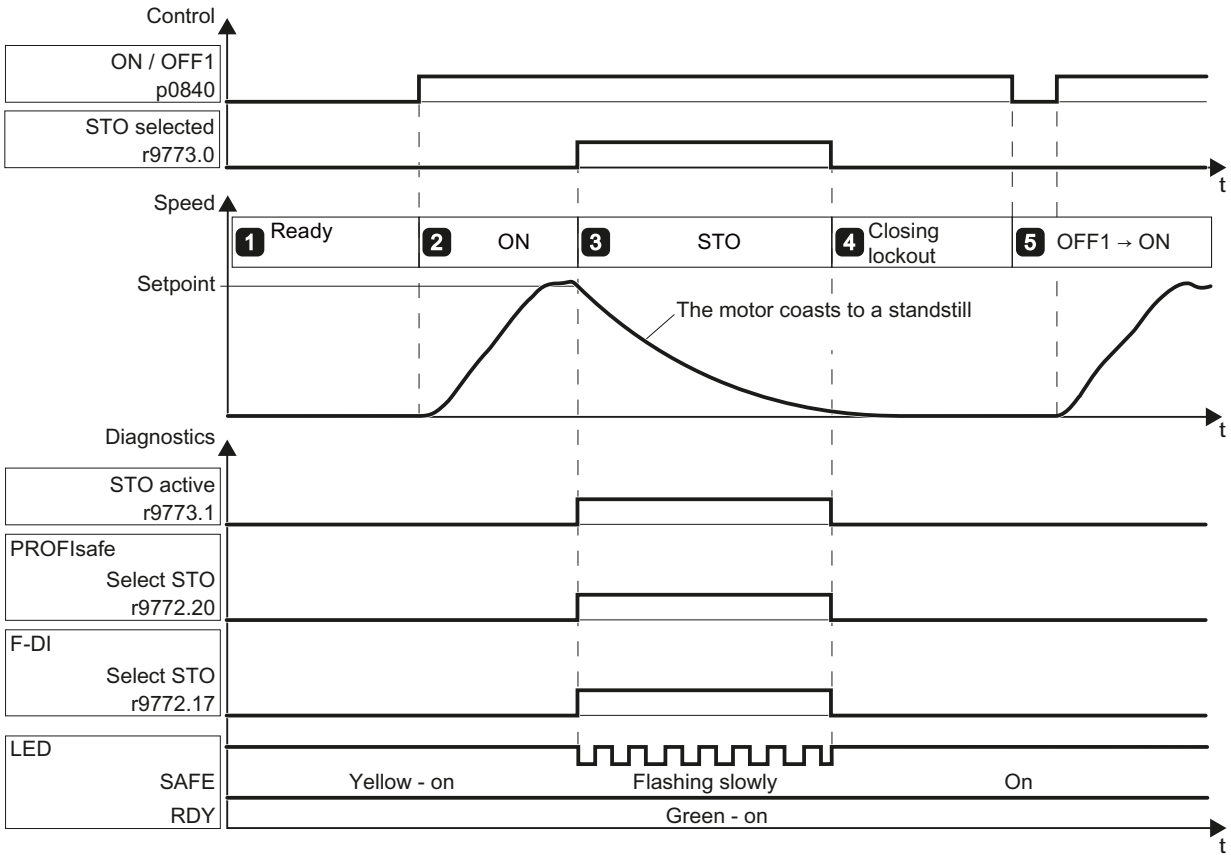


Figure 4-25 STO acceptance test for basic functions

Table 4- 26 Function "Safe Torque Off" (STO)

No.	Description		Status
1.	**Initial state**		
	• The converter is "ready" (p0010 = 0).		
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• STO is not active (r9773.1 = 0).		
2.	**Switch on the motor**		
	• Enter a speed setpoint ≠ 0, and switch on the motor (ON command).		
	• Ensure that the correct motor is running.		
3.	**STO select**		
	• Select STO while the motor is running **Note:** Test each configured control, e.g. via digital inputs and via PROFIsafe.		
	• Check the following:		
	For control via PROFIsafe	For control via terminal	
	• The converter signals the following: "STO Selection via PROFIsafe" (r9772.20 = 1)	• The converter 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 converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• The converter signals the following: "STO is selected" (r9773.0 = 1). "STO is active" (r9773.1 = 1).		
4.	**STO deselect**		
	• Deselect STO .		
	• Check the following:		
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• The converter signals the following: "STO is not selected " (r9773.0 = 0). "STO is not active" (r9773.1 = 0).		
	• The converter is in the "switching on inhibited" state (r0046.0 = 1).		
5.	**Switch on the motor**		
	• Switch the motor off (OFF1 command) and then on again (ON command).		
	• Ensure that the correct motor is running.		

4.11.5.2 Acceptance test STO (extended functions)

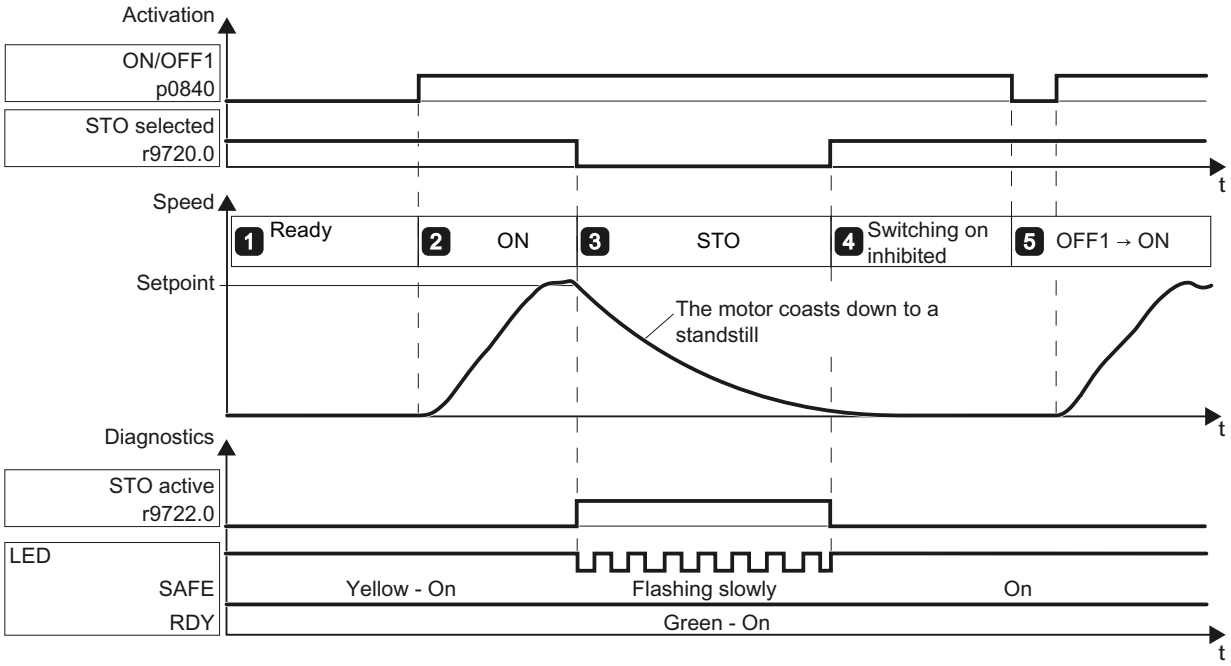


Figure 4-26 STO acceptance test for extended functions

Table 4- 27 Function "Safe Torque Off" (STO)

No.	Description	Status
1.	**Initial state**	
	• The converter is "ready" (p0010 = 0).	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• STO is not active (r9722.0 = 0).	
2.	**Switch on the motor**	
	• Enter a speed setpoint ≠ 0, and switch on the motor (ON command).	
	• Ensure that the correct motor is running.	
3.	**STO Select**	
	• Select STO while the motor is running **Note:** Test each configured control, e.g. via digital inputs and via PROFIsafe.	
	• 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 converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• The converter signals the following: "STO is selected" (r9720.0 = 0). "STO is active" (r9722.0 = 1).	
4.	**STO Deselect**	
	• Deselect STO .	
	• Check the following:	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• The converter signals the following: "STO is deselected" (r9720.0 = 1). "STO is not active" (r9722.1 = 0).	
	• The converter is in the "switching on inhibited" state (r0046.0 = 1).	
5.	**Switch on the motor**	
	• Switch the motor off (OFF1 command) and then on again (ON command).	
	• Ensure that the correct motor is running.	

4.11.5.3 SS1 acceptance test

The two diagrams show the recommended steps to take during the acceptance test. The behavior of the drive differs according to what settings you have made for SSM :

- Upper diagram: Once SS1 has been selected, the converter monitors the speed using braking ramp monitoring.
- Lower diagram: Once SS1 has been selected, the converter monitors the speed using acceleration monitoring.

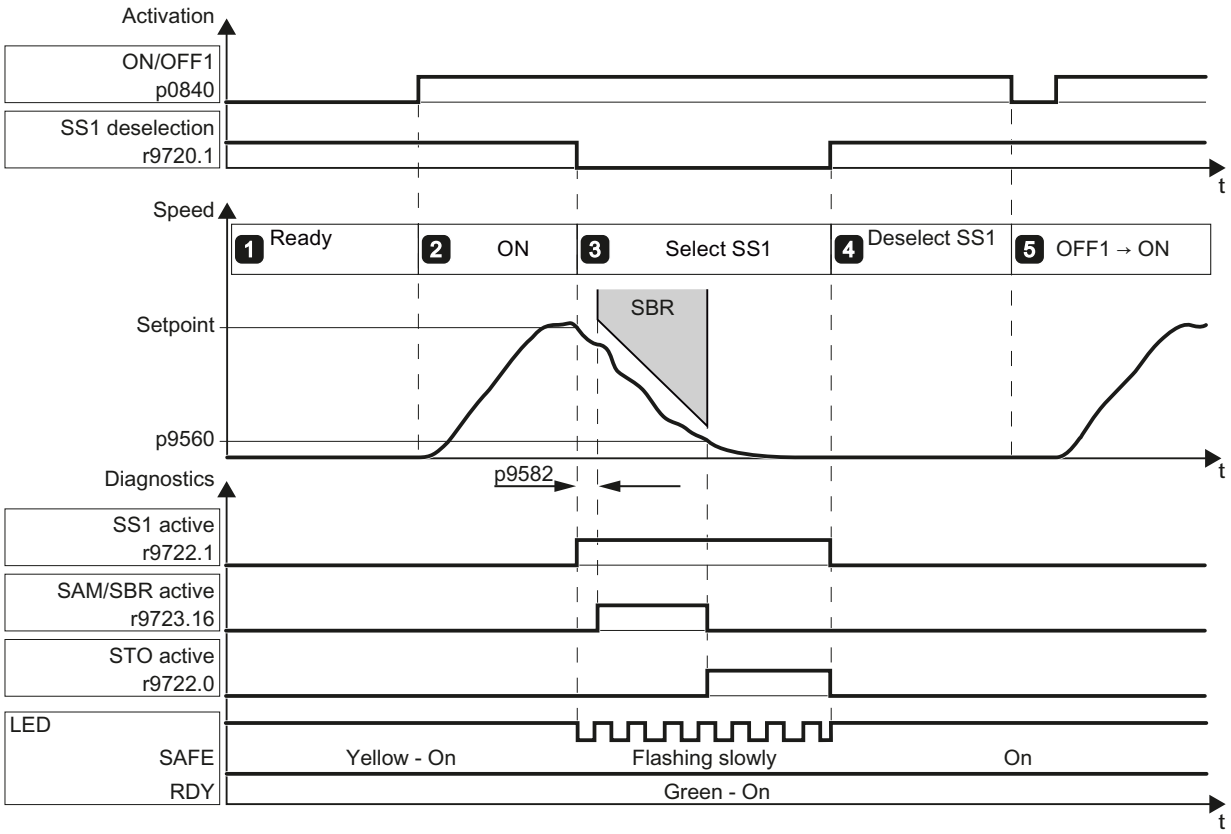


Figure 4-27 SS1 acceptance test with braking ramp monitoring

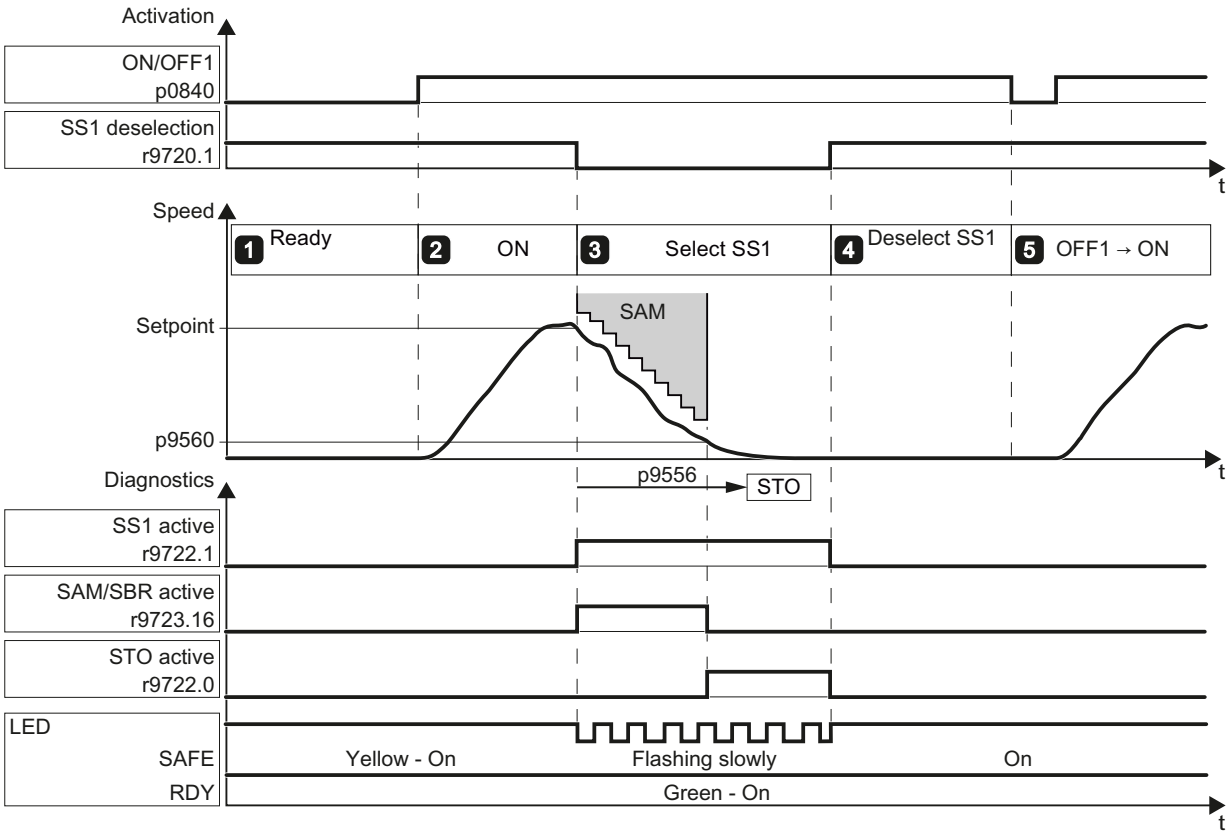


Figure 4-28 SS1 acceptance test with acceleration monitoring

Table 4- 28 Acceptance test for function "Safe Stop 1" (SS1)

No.	Description	Status
1.	**Initial state**	
	• The converter is "ready" (p0010 = 0).	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• SS1 is not active (r9722.1 = 0).	
	• In STARTER, configure a trace recording with the following signals:	
	• Trigger: On variable bit pattern	
	• Signals: r9714[0], r9720, r9722, and r9723.16	
	• Select the time interval to be recorded and the pre-trigger so that the SS1 selection and the SS1 → STO transition are displayed.	
2.	**Switch on the motor**	
	• Enter a speed setpoint ≠ 0, and switch on the motor (ON command).	
	• Ensure that the correct motor is running.	
3.	**Select SS1**	
	• Select SS1 while the motor is switched on. **Note:** Test each configured control, e.g. via digital inputs and via PROFIsafe.	
	• Check the following on the basis of the trace recording:	
	• The motor brakes with the OFF3 ramp-down time.	
	• The converter signals the following during braking: – "SS1 is selected" (r9720.1 = 0). – "SS1 is active" (r9722.1 = 1). – "SAM/SBR is active" (r9723.16 = 1).	
	• Once the motor has braked, the converter signals the following: "STO is active" (r9772.0 = 1).	
	• If a mechanical brake is not available, the motor will coast down. A mechanical brake brakes the motor and then holds it to ensure it remains at a standstill.	
	• The converter signals the active function STO via PROFIsafe (status word 1, bit 15 = 1) or via its fail-safe output.	
	• The converter signals neither faults nor alarms for the safety functions.	

No.	Description	Status
4.	**Deselect SS1**	
	• Deselect SS1 .	
	• Check the following on the basis of the trace recording:	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• The converter signals the following: – "STO is not active" (r9722.0 = 0). – "SS1 is deselected" (r9720.1 = 1).	
	• The converter is in the "switching on inhibited" state (r0046.0 = 1).	
5.	**Switch on the motor**	
	• Switch the motor off (OFF1 command) and then on again (ON command).	
	• Ensure that the correct motor is running.	

4.11.5.4 Acceptance test SLS

The two diagrams show the recommended steps to take during the acceptance test. The behavior of the drive differs according to what settings you have made for SLS :

- Upper diagram: If the speed is excessively high, the drive responds with a STOP A.
- Lower diagram: If the speed is excessively high, the drive responds with a STOP B.

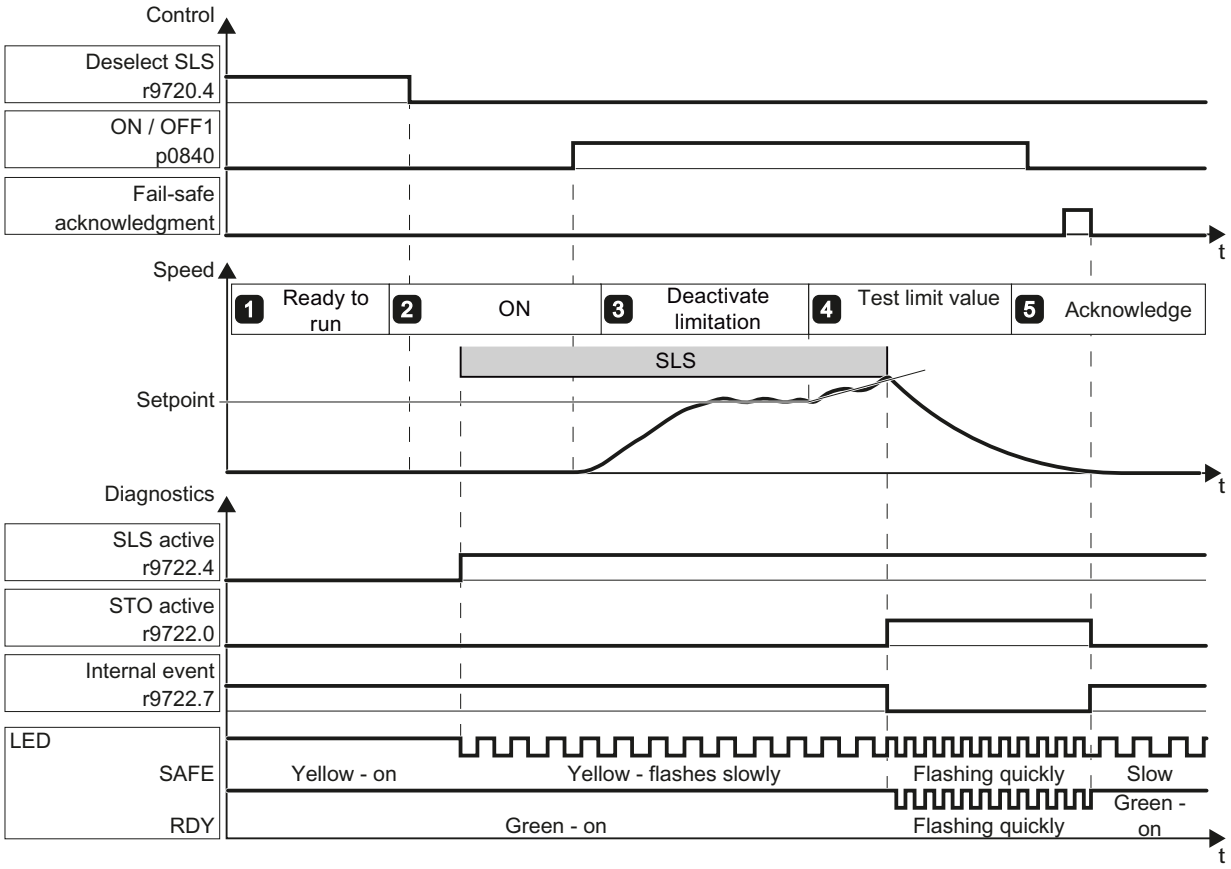


Figure 4-29 SLS acceptance test with STOP response STOP A

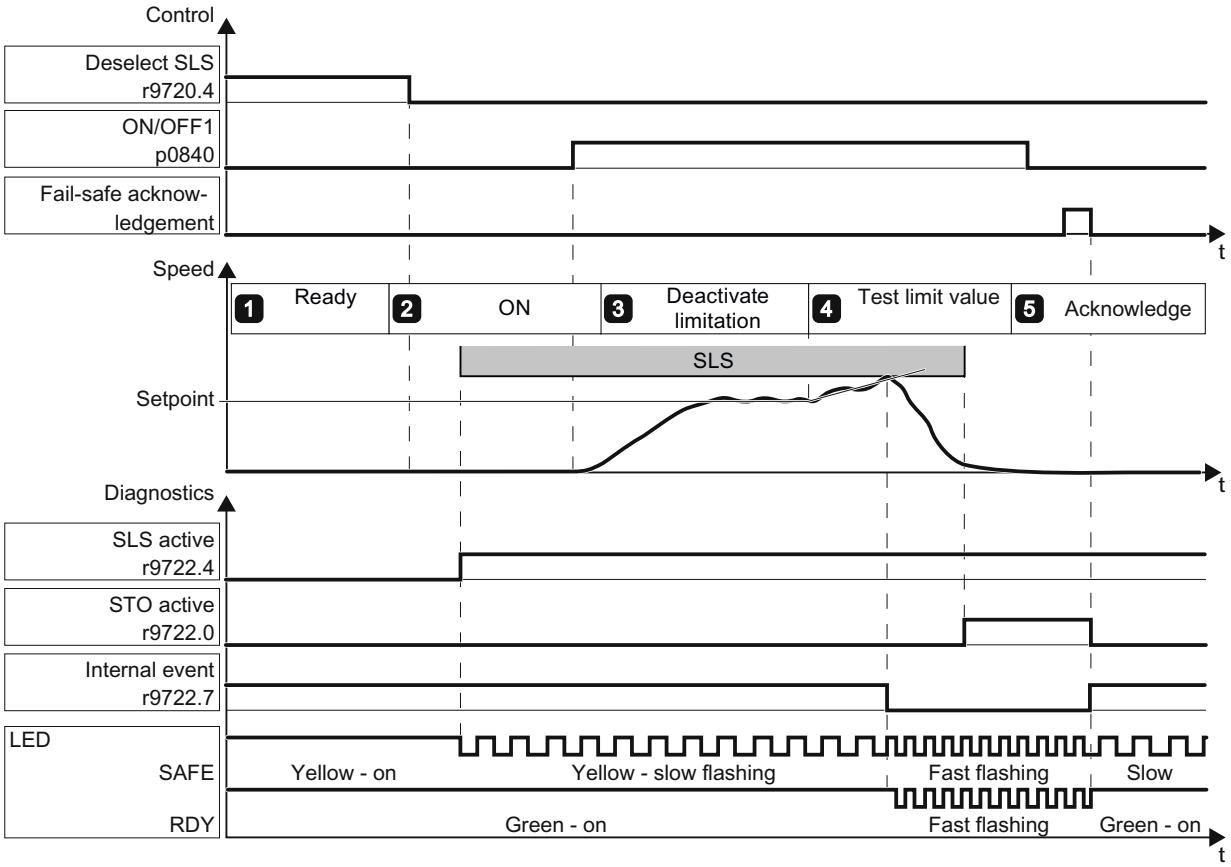
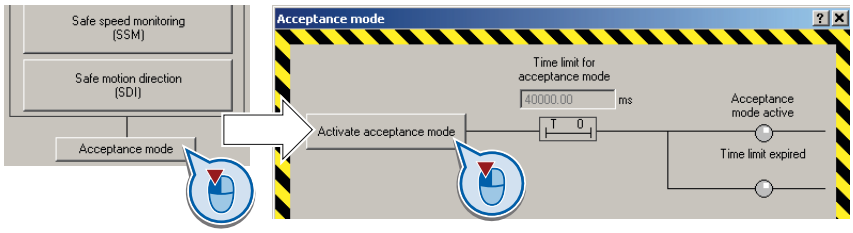


Figure 4-30 SLS acceptance test with STOP response STOP B

Table 4- 29 "Safely Limited Speed" (SLS) function

No.	Description	Status
Notes: If you are using multiple SLS levels, repeat the test for each of the SLS levels. Test each configured control, e.g. via digital inputs and via PROFIsafe.		
1.	**Initial state**	
	• The converter is "ready" (p0010 = 0).	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• SLS is not active (r9722.4 = 0).	
	• In STARTER configure a trace recording with the following signals:	
	• Trigger: On variable bit pattern.	
	• Signals: r9714[0], r9720 and r9722.	
	• Select the time interval to be recorded and the pre-trigger so that the SLS selection and the approach to the SLS limit are displayed.	
2.	**Switch on the motor**	
	• Select SLS with the SLS level to be checked.	
	• The converter signals the active function SLS via PROFIsafe (status word 1, bit 4 = 1) or via its fail-safe output.	
	• Specify a speed setpoint < SLS level.	
	• Switch on the motor within five seconds of selecting SLS (ON command). Note: If you wait longer than five seconds for the ON command, STO is activated. In this case, deselect SLS and then select it again.	
	• Ensure that the correct motor is running.	
3.	**Deactivate the setpoint limitation for the acceptance test**	
	• Go online with STARTER .	
	• Activate the Acceptance mode:	
		

No.	Description		Status
4.	**Test the set limit value**		
	• Check the speed of the motor in your machine by measuring the velocity of the conveyor belt being monitored, for example.		
	• Increase the setpoint until the converter detects an excessively high speed.		
	Upper diagram: The converter responds with STOP A in the event of a limit value violation.	Lower diagram: The converter responds with STOP B in the event of a limit value violation. STOP A follows when the motor comes to a standstill.	
	• The motor coasts down to a standstill.	• The converter brakes the motor to a standstill.	
	• The converter signals the following: – C01714 and C30714 (safely limited speed exceeded) – C01700 and C30700 (STOP A triggered)	• The converter signals the following: – C01714 and C30714 (safely limited speed exceeded) – C01701 and C30701 (STOP B triggered) – C01700 and C30700 (STOP A triggered)	
	• The converter signals the internal event via PROFIsafe (status word 1, bit 7 = 1) or via its fail-safe output.		
5.	**Acknowledge fault**		
	• Deselect SLS .		
	• Switch the motor off (OFF1 command).		
	• Acknowledge the fault messages with a fail-safe signal.		

4.11.5.5 SSM acceptance test

The two diagrams show the recommended steps to take during the acceptance test. The acceptance test differs depending on what settings you have made for SSM :

- 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.

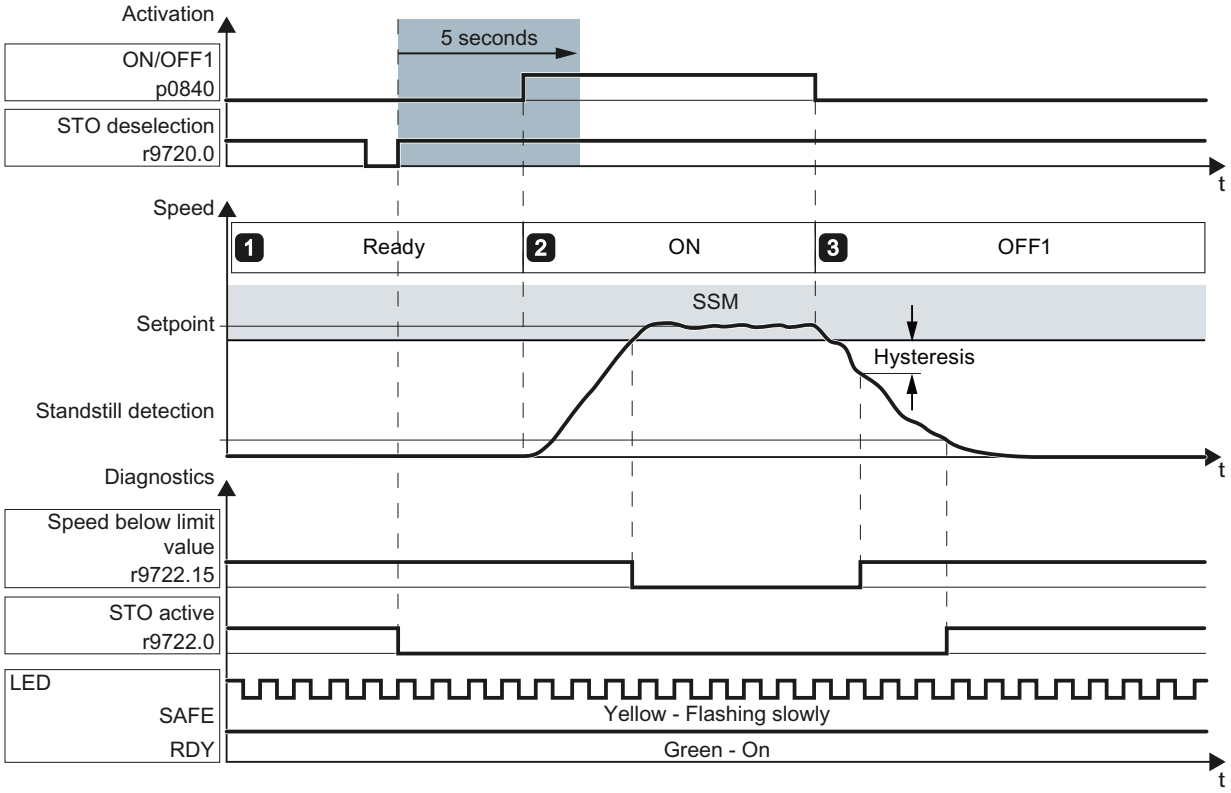


Figure 4-31 SSM acceptance test with active checkback signal when motor is switched off

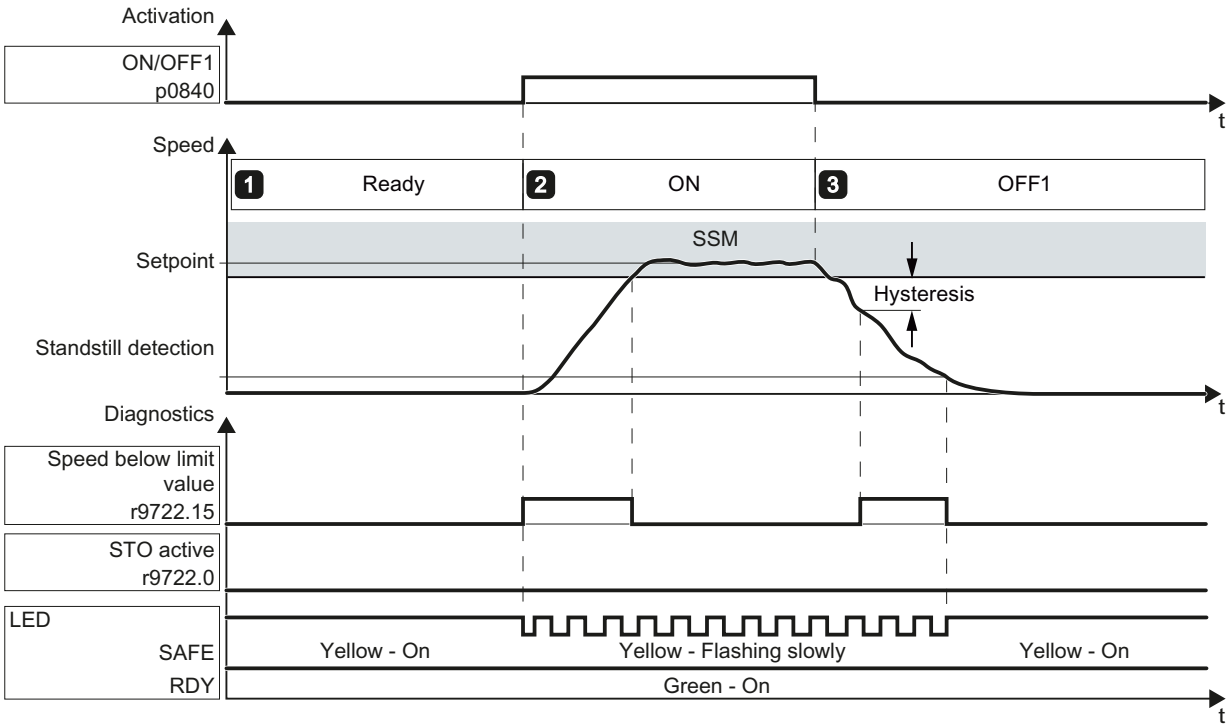


Figure 4-32 SSM acceptance test with inactive checkback signal when motor is switched off

Table 4- 30 Function "Safe Speed Monitor" (SSM)

No.	Description		Status
1.	**Initial state**		
	• The converter is in the "ready" state (p0010 = 0).		
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• In STARTER, configure a trace recording with the following signals:		
	• Trigger: On variable bit pattern (r9722.15 = 1)		
	• Signals: r9714[0], r9720 , and r9722.		
	• Select the time interval to be recorded and the pre-trigger so that the SS1 selection and the SS1 → STO transition are displayed.		
2.	**Switch on the motor**		
	• Specify a speed setpoint > SSM limit.		
	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.	
	• Select STO .	• Switch on the motor (ON command).	
	• Deselect STO again.		
	• Switch on the motor within 5 seconds of deselecting STO (ON command).		
	• Ensure that the correct motor is running.		
	• Wait until the motor speed reaches the setpoint.		
	• Check the following on the basis of the trace recording: If r9714[0] exceeds the SSM limit, r9722.15 = 0 applies.		
	• The converter signals that the SSM limit has been exceeded via PROFIsafe (status word 1, bit 15 = 0) or via its fail-safe output.		
3.	**Switch off the motor**		
	• Switch the motor off (OFF1 command).		
	• Ensure that the correct motor is braked.		
	• Wait until the motor is at a standstill.		
	• Check the following on the basis of the trace recording: If r9714[0] is below the SSM limit (minus the hysteresis), r9722.15 = 1 applies.		
	• The converter signals that the SSM limit has been undershot via PROFIsafe (status word 1, bit 15 = 1) or via its fail-safe output.		

4.11.5.6 Acceptance test SDI

The section below describes the acceptance test for SDI+ and SDI- separately. If you configure the SDI function in both directions of rotation, you must carry out both acceptance tests.

Acceptance test for SDI positive

The two diagrams show the recommended steps to take during the acceptance test. The acceptance test differs depending on what settings you have made for SDI :

- Upper diagram: The "SDI active" checkback signal remains active when the motor is switched off.
- Lower diagram: The "SDI active" checkback signal becomes inactive when the motor is switched off.

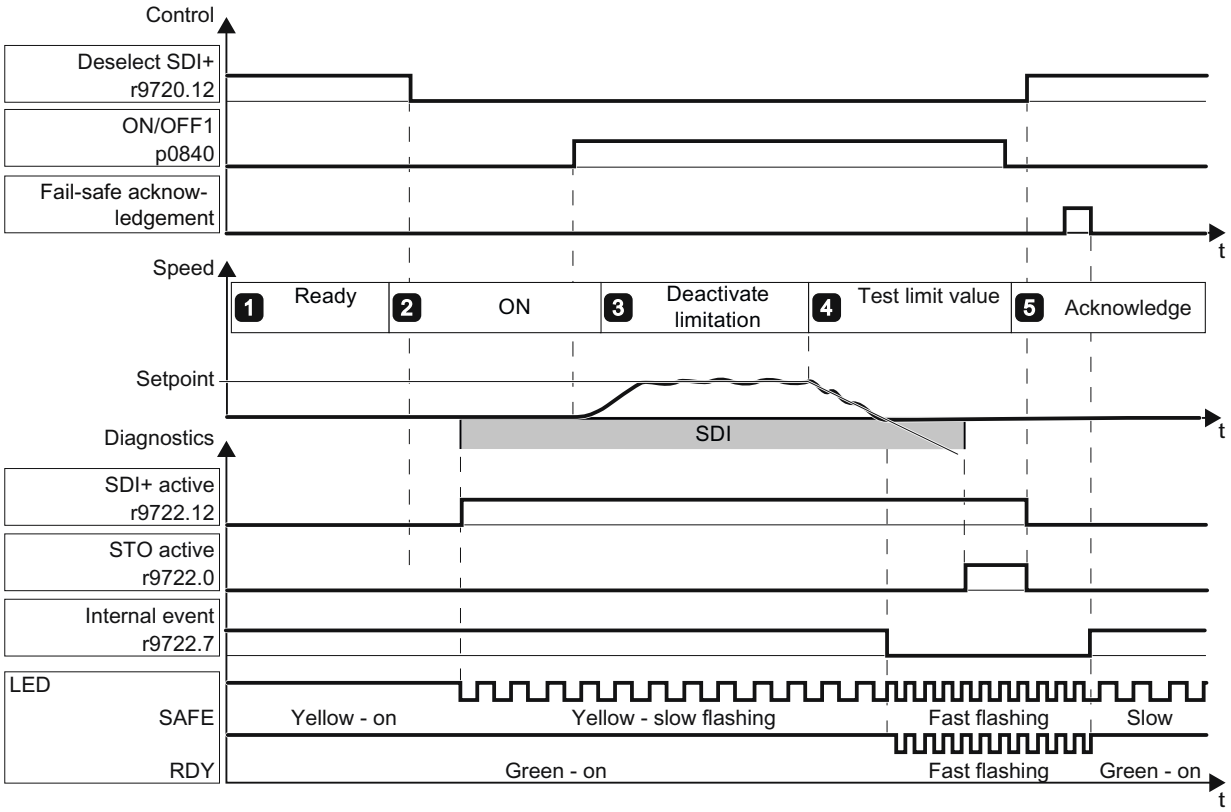


Figure 4-33 SDI acceptance for a positive direction of rotation; "SDI active" remains active when the motor is switched off

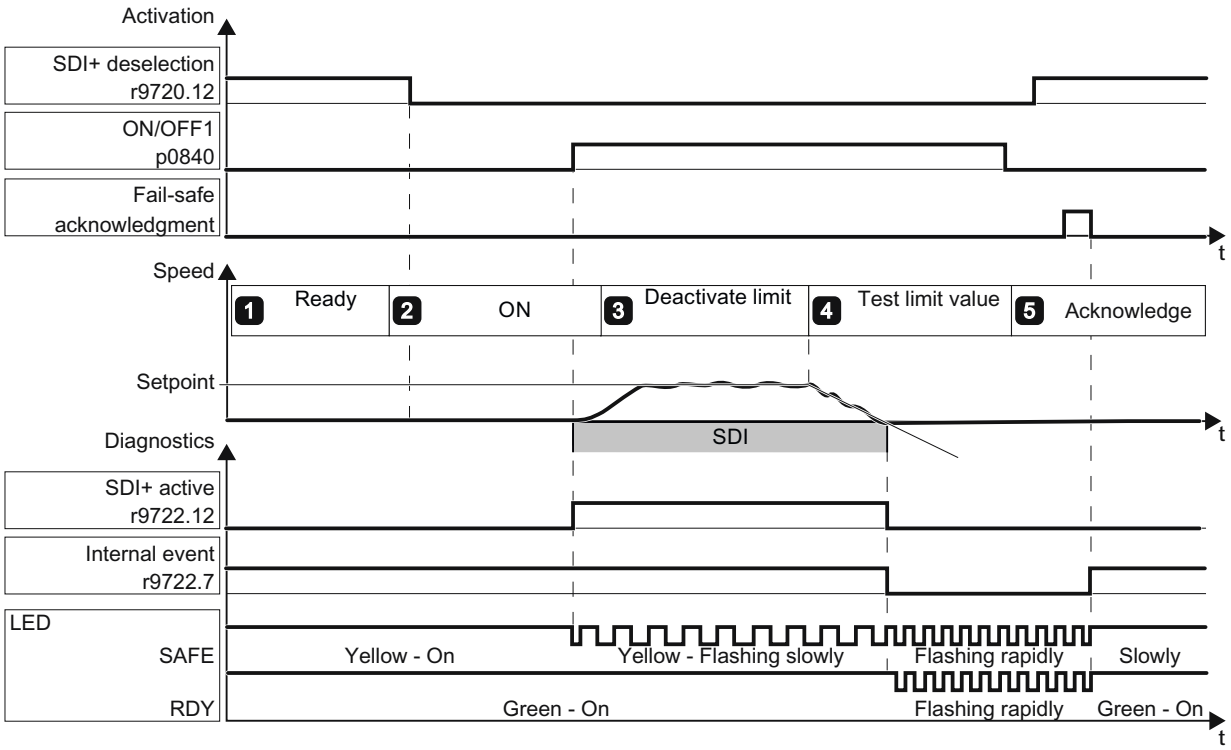
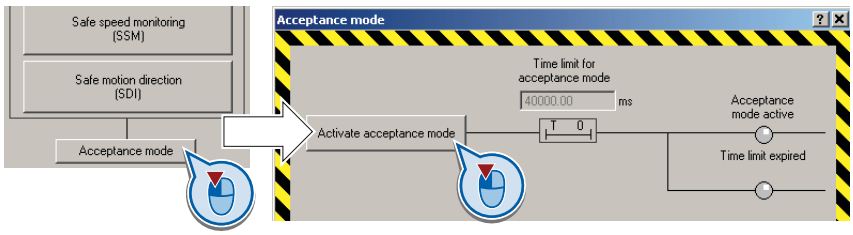


Figure 4-34 SDI acceptance for a positive direction of rotation; "SDI active" becomes inactive when the motor is switched off

Table 4- 31 "Safe Direction" (SDI) function; positive direction of rotation permitted

No.	Description		Status
1.	**Initial state**		
	• The converter is in the "ready" state (p0010 = 0).		
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• In STARTER configure a trace recording with the following signals:		
	• Trigger: On variable bit pattern (r9722.12 = 1).		
	• Signals: r9714[0], r9720 and r9722.		
	• Select the time interval to be recorded and the pre-trigger so that the SDI selection and the move to the direction of rotation being monitored are displayed.		
2.	**Switch on the motor**		
	• Enter a positive speed setpoint.		
	Upper diagram: The "SDI active" checkback signal remains active when the motor is switched off.	Lower diagram: The "SDI active" checkback signal becomes inactive when the motor is switched off.	
	• Switch on the motor within five seconds of deselecting SDI (ON command). Note: If you wait longer than five seconds for the ON command, STO is activated. In this case, deselect SDI and then select it again.	• Switch on the motor (ON command).	
	• Check that the correct motor is rotating in the expected direction.		
3.	**Deactivate the setpoint limitation for the acceptance test**		
	• Go online with STARTER .		
	• Activate the Acceptance mode:		
			

No.	Description		Status
4.	**Test the set limit value**		
	• Change the setpoint so that the motor rotates slightly in the negative direction.		
	• In your machine, check when the drive stops when it is turning in a negative direction.		
	The rest of the process depends on what settings you made for the SDI function during commissioning:		
	If the converter is to respond with STOP A if the limit value is violated:	If the converter is to respond with STOP B if the limit value is violated:	
	• The motor coasts down to a standstill.	• The converter brakes the motor to a standstill.	
	• The converter signals the following: – C01716 and C30716 (tolerance for safe direction of motion exceeded) – C01700 and C30700 (STOP A triggered)	• The converter signals the following: – C01716 and C30716 (tolerance for safe direction of motion exceeded) – C01701 and C30701 (STOP B triggered) – C01700 and C30700 (STOP A triggered)	
5.	**Acknowledge fault**		
	• Deselect SDI .		
	• Switch the motor off (OFF1 command).		
	• Acknowledge the fault messages with a fail-safe signal.		

Acceptance test for SDI negative

The two diagrams show the recommended steps to take during the acceptance test. The acceptance test differs depending on what settings you have made for SDI :

- Upper diagram: The "SDI active" checkback signal remains active when the motor is switched off.
- Lower diagram: The "SDI active" checkback signal becomes inactive when the motor is switched off.

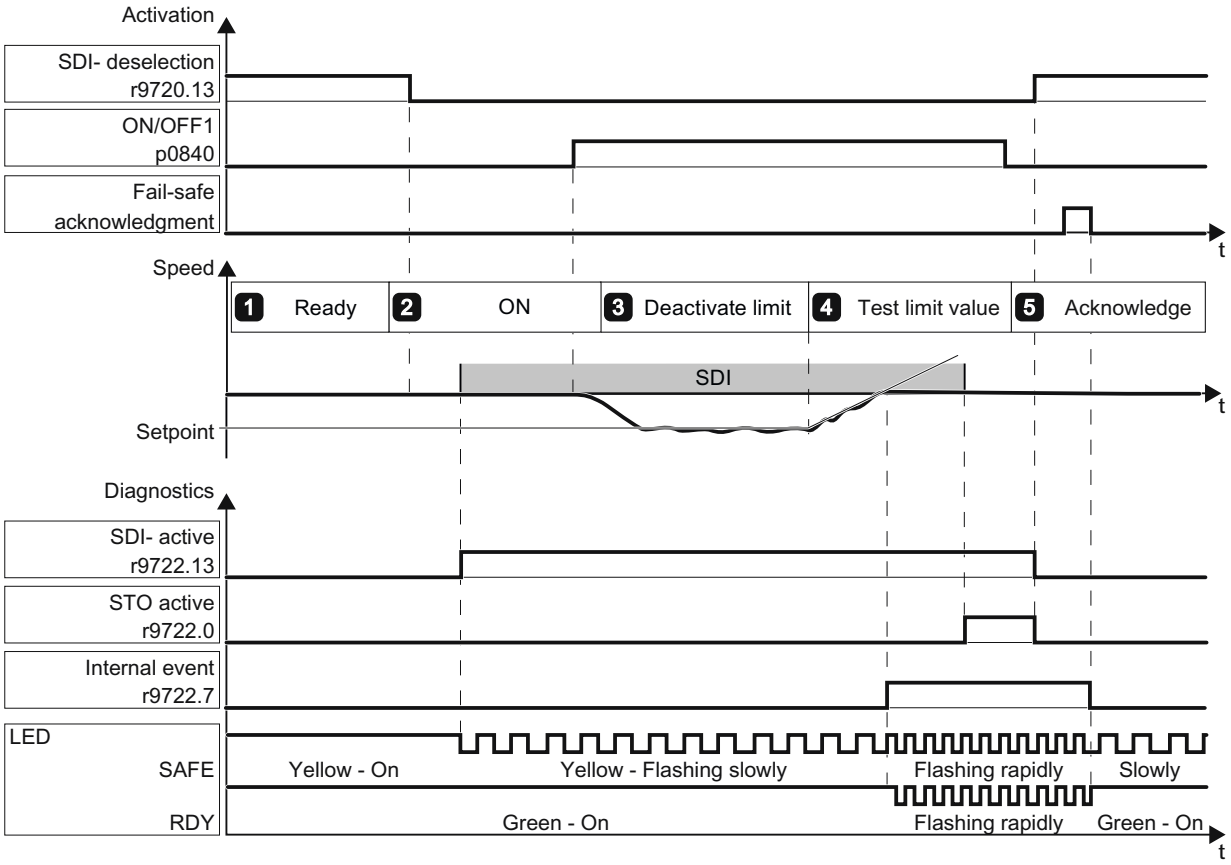


Figure 4-35 SDI acceptance for a negative direction of rotation; "SDI active" remains active when the motor is switched off

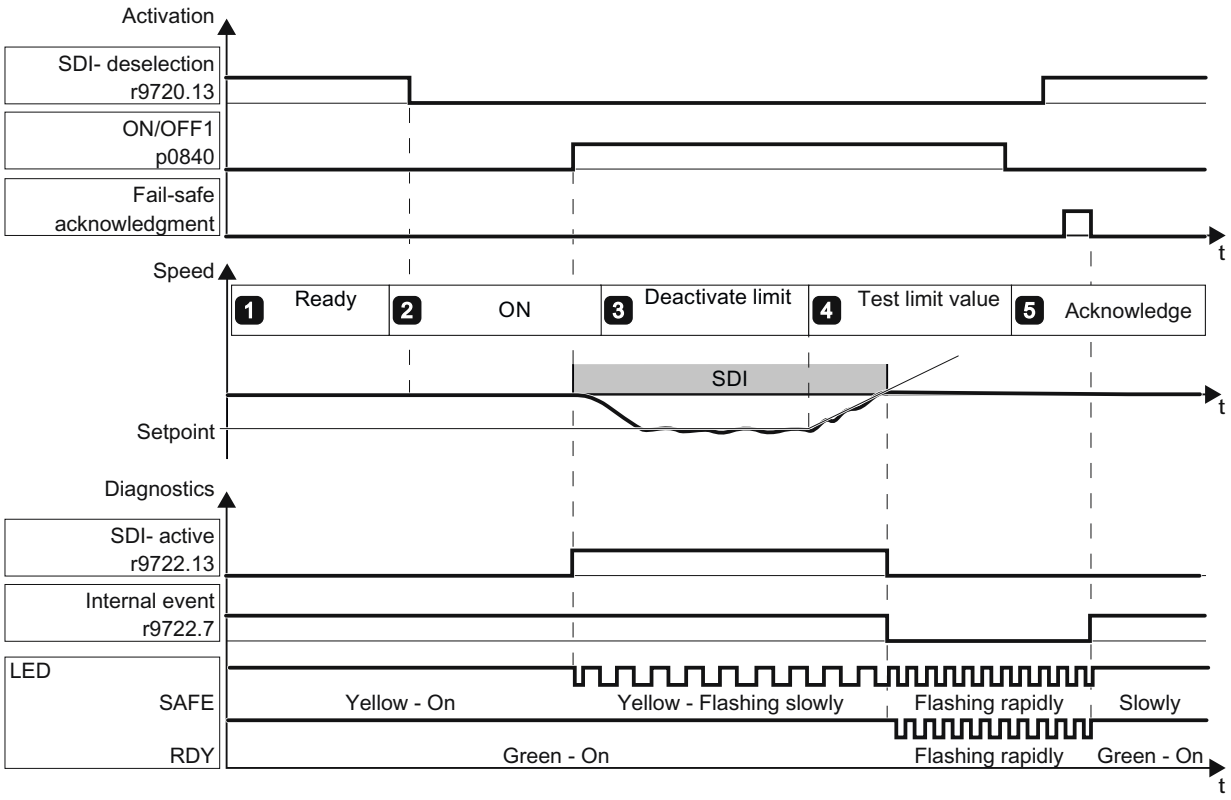
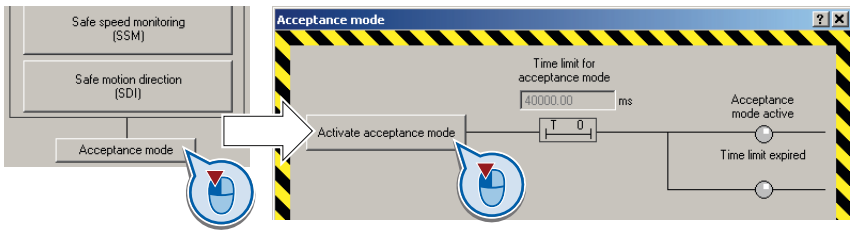


Figure 4-36 SDI acceptance for a negative direction of rotation; "SDI active" becomes inactive when the motor is switched off

Table 4- 32 "Safe Direction" (SDI) function; negative direction of rotation permitted

No.	Description		Status
1.	**Initial state**		
	• The converter is in the "ready" state (p0010 = 0).		
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).		
	• In STARTER configure a trace recording with the following signals:		
	• Trigger: On variable bit pattern (r9722.12 = 1).		
	• Signals: r9714[0], r9720 and r9722.		
	• Select the time interval to be recorded and the pre-trigger so that the SDI selection and the move to the direction of rotation being monitored are displayed.		
2.	**Switch on the motor**		
	• Enter a negative speed setpoint.		
	Upper diagram: The "SDI active" checkback signal remains active when the motor is switched off.	Lower diagram: The "SDI active" checkback signal becomes inactive when the motor is switched off.	
	• Switch on the motor within five seconds of deselecting SDI (ON command). Note: If you wait longer than five seconds for the ON command, STO is activated. In this case, deselect SDI and then select it again.	• Switch on the motor (ON command).	
	• Check that the correct motor is rotating in the expected direction.		
3.	**Deactivate the setpoint limitation for the acceptance test**		
	• Go online with STARTER .		
	• Activate the Acceptance mode:		
			

No.	Description		Status
4.	**Test the set limit value**		
	• Change the setpoint so that the motor rotates slightly in the positive direction.		
	• In your machine, check when the drive stops when it is turning in a positive direction.		
	The rest of the process depends on what settings you made for SDI during commissioning:		
	If the converter is to respond with STOP A if the limit value is violated:	If the converter is to respond with STOP B if the limit value is violated:	
	• The motor coasts down to a standstill.	• The converter brakes the motor to a standstill.	
	• The converter signals the following: – C01716 and C30716 (tolerance for safe direction of motion exceeded) – C01700 and C30700 (STOP A triggered)	• The converter signals the following: – C01716 and C30716 (tolerance for safe direction of motion exceeded) – C01701 and C30701 (STOP B triggered) – C01700 and C30700 (STOP A triggered)	
5.	**Acknowledge fault**		
	• Deselect SDI .		
	• Switch the motor off (OFF1 command).		
	• Acknowledge the fault messages with a fail-safe signal.		

4.11.5.7 Acceptance test for F-DI status in PROFIsafe telegram 900

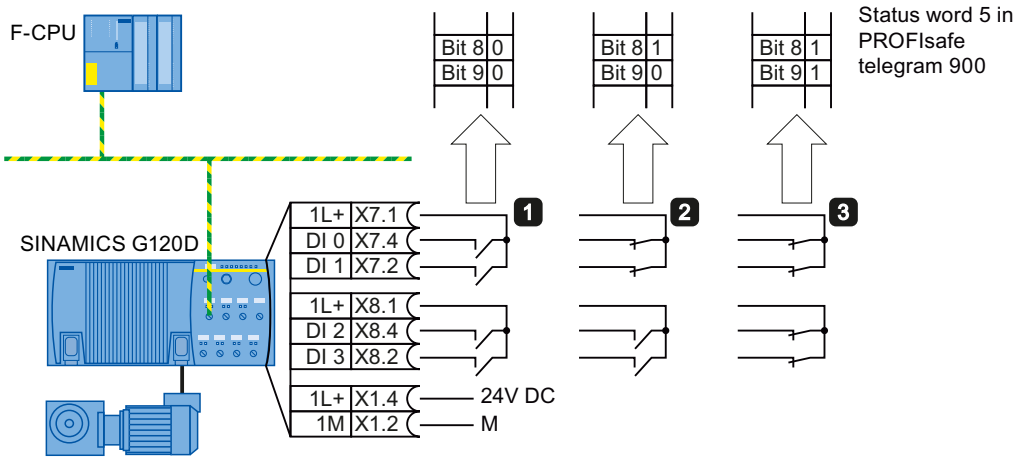


Figure 4-37 Acceptance test for the status of the fail-safe inputs using the example of aSINAMICS G120D

Table 4- 33 Transferring the status of the fail-safe inputs

No.	Description	Status
-	**Initial state**	
	• The converter is "ready" (p0010 = 0).	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
1.	**Check the "Low" status of the fail-safe input in the higher-level control system**	
	• Switch the signal of the fail-safe input to be tested to low.	
	• In status word 5 of the PROFIsafe telegram, check whether the corresponding bit has a value of 0.	
2.	**Check the "High" status of the fail-safe input in the higher-level control system**	
	• Switch the signal of the fail-safe input to be tested to high.	
	• In status word 5 of the PROFIsafe telegram, check whether the corresponding bit has a value of 1.	
3.	**Additional fail-safe inputs**	
	If you transfer the status of additional fail-safe inputs of the converter, check each input as described above.	

Operation

5

Overview

This chapter answers the following questions:

- 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?

Details for setting the functions are described in chapter: Commissioning (Page 65).

5.1 Selecting and deselecting a safety function when the motor is switched on

5.1.1 Safe Torque Off (STO)

Description

- As soon as the machine control selects the STO safety function via a fail-safe input or via PROFIsafe safety-relevant communication, the converter safely switches off the motor torque.
- To switch the motor on again, you have to first deactivate STO and then issue the ON command again.

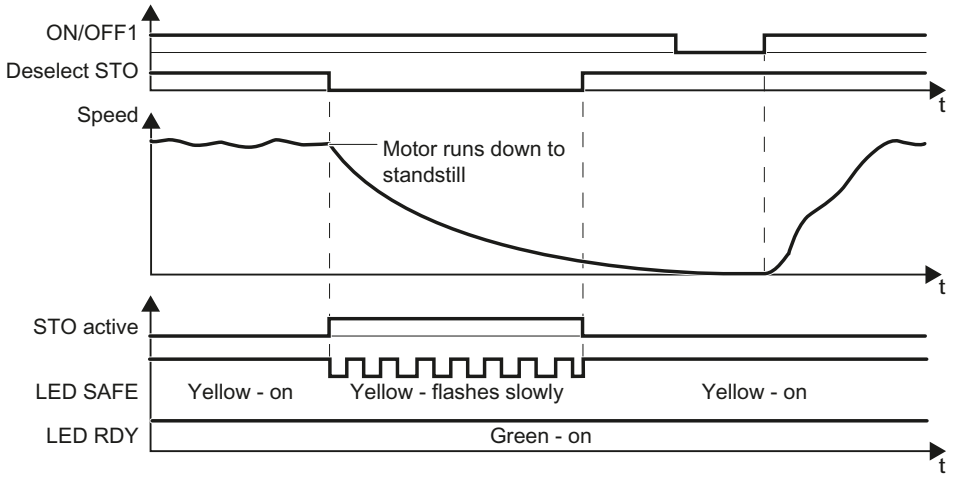


Figure 5-1 Time response of the safety function STO (Safe Torque Off)

5.1.2 Safe Stop 1 (SS1)

5.1.2.1 SS1 with braking ramp monitoring

Description

- As soon as the machine control selects the safety function SS1 via a fail-safe input or via the safe communication PROFIsafe the following happens:
  - If the motor has already been switched off when selecting SS1 , then the converter safely switches off the motor torque with the safety function STO .
  - If the motor is switched on when SS1 is selected, the converter brakes the motor with the OFF3 ramp-down time. The converter monitors whether the load speed decreases using the SBRfunction.
- The converter safely switches off the motor torque using the STO safety function if the load speed reaches the "standstill monitoring".
- To switch the motor on again, you have to first deactivate SS1 and then issue the ON command again.

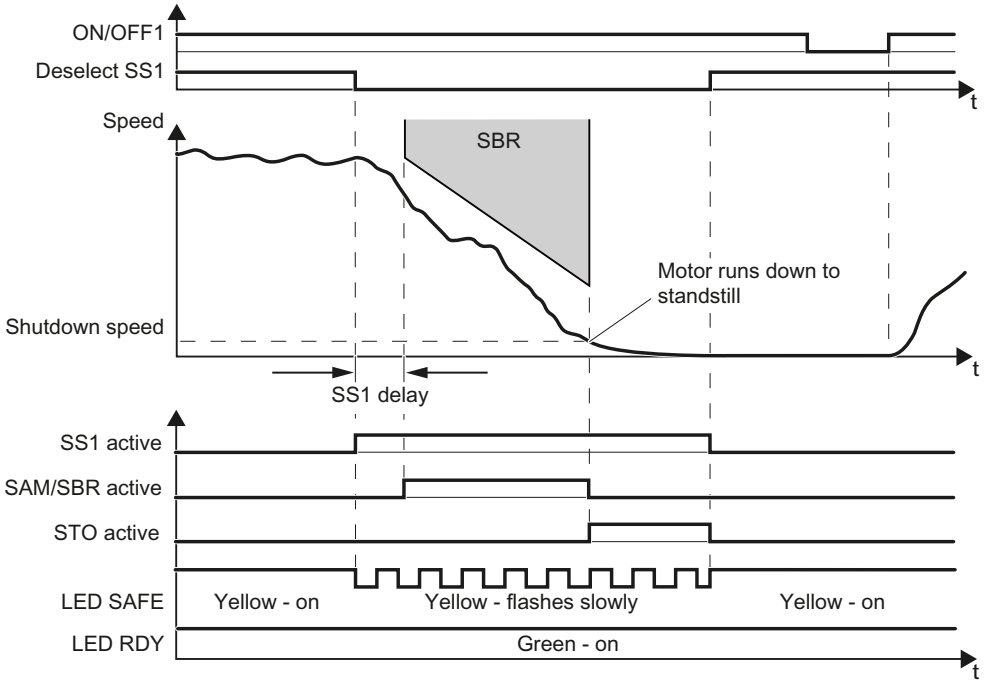


Figure 5-2 Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

5.1.2.2 SS1 with acceleration monitoring

Description

- As soon as the machine control selects the safety function SS1 via a fail-safe input or via the safe communication PROFIsafe the following happens.
  - If the motor has already been switched off when selecting SS1 , then the converter safely switches off the motor torque with the safety function STO .
  - If the motor is switched on when SS1 is selected, the converter brakes the motor with the OFF3 ramp-down time. The converter monitors braking using the SAM function (Safe Acceleration Monitor).
- The converter safely switches off the motor torque using the STO safety function if the load speed reaches the "standstill monitoring".
- To switch the motor on again, you have to first deactivate SS1 and then issue the ON command again.

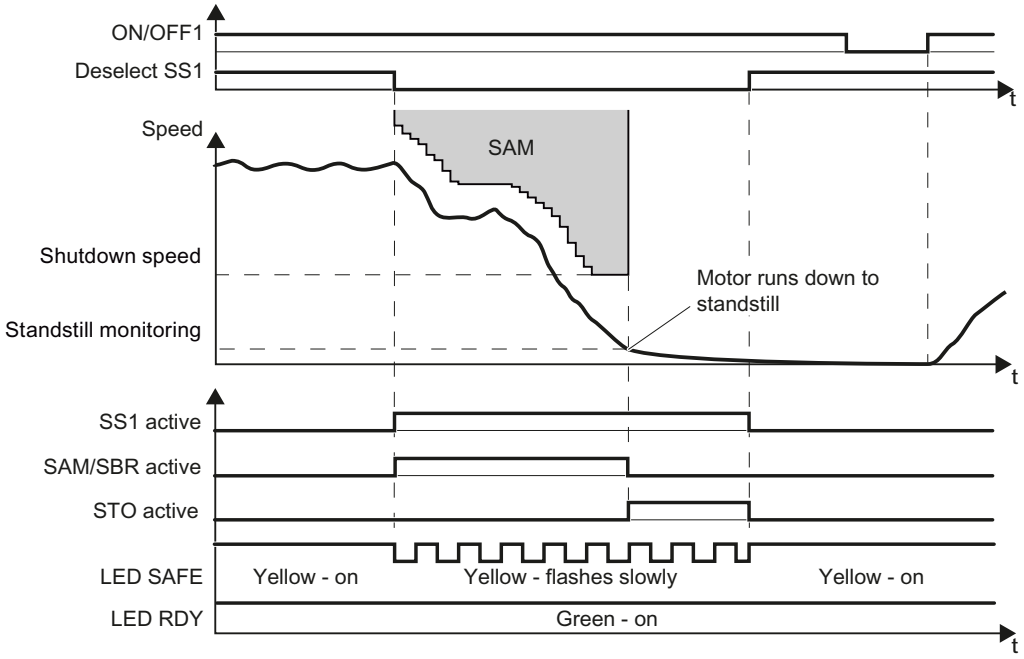


Figure 5-3 Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

5.1.3 Safely Limited Speed (SLS)

5.1.3.1 SLS with braking ramp monitoring

Selecting and deselecting SLS

Description

If the machine control selects the safety function SLS via a fail-safe input or via the safe communication PROFIsafe , 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.

- The motor continues to follow the speed setpoint.
- The converter monitors the speed after the delay time has expired.

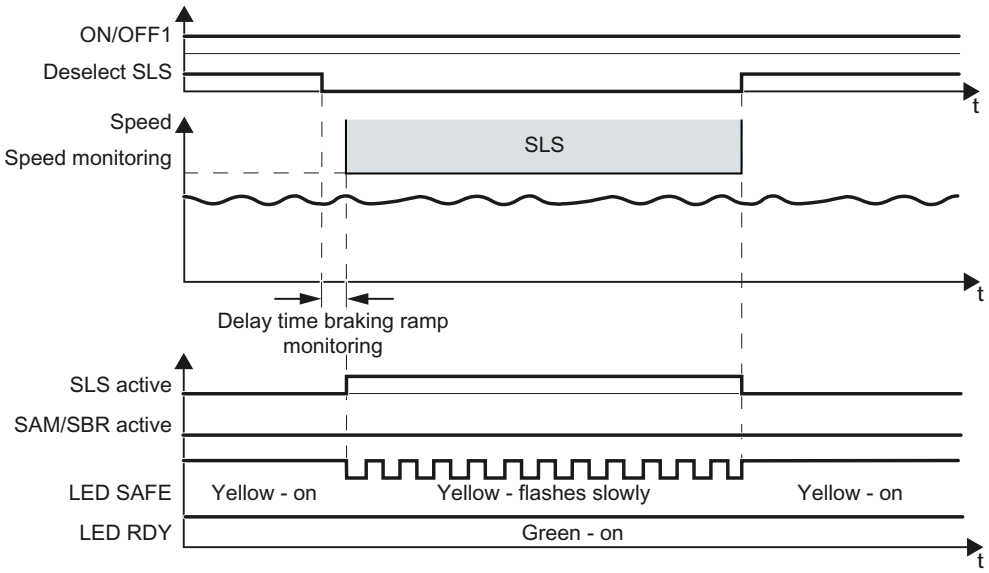


Figure 5-4 Selecting and deselecting the SLS safety function at low speeds

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

- The converter brakes the motor.
- The converter monitors the speed after the delay time has expired.
- If you deselect SLS , then the motor accelerates again up to the speed setpoint.

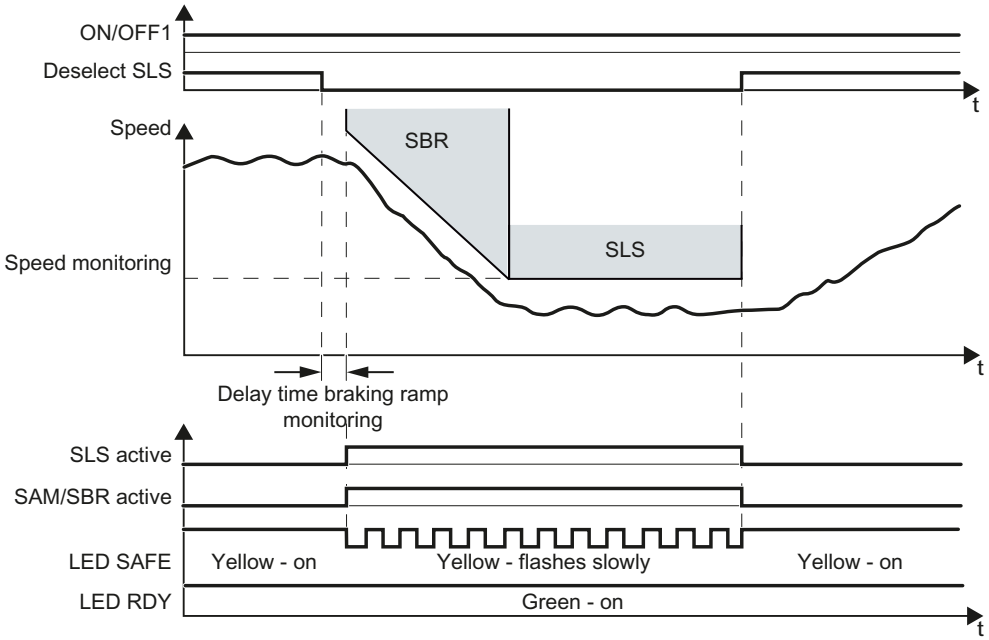


Figure 5-5 Selecting and deselecting the SLS safety function at high speeds

Switching over speed monitoring

When SLS is active, you can switch between four different speed monitoring levels (SLSlevels).

Note

Switching over SLSlevels is only possible via PROFIsafe with control word 1. See also Section: Control word 1 and status word 1 (extended functions) (Page 56).

Description

- If you switch over from a higher to a lower speed monitoring level (SLSlevel), then after the delay time has expired, the converter monitors the motor speed using the SBR (Safe Safe Brake Ramp) function.
- When you switch from one of the lower monitoring limits to a higher speed monitoring limit, then the converter immediately monitors the speed with the higher SLS level.

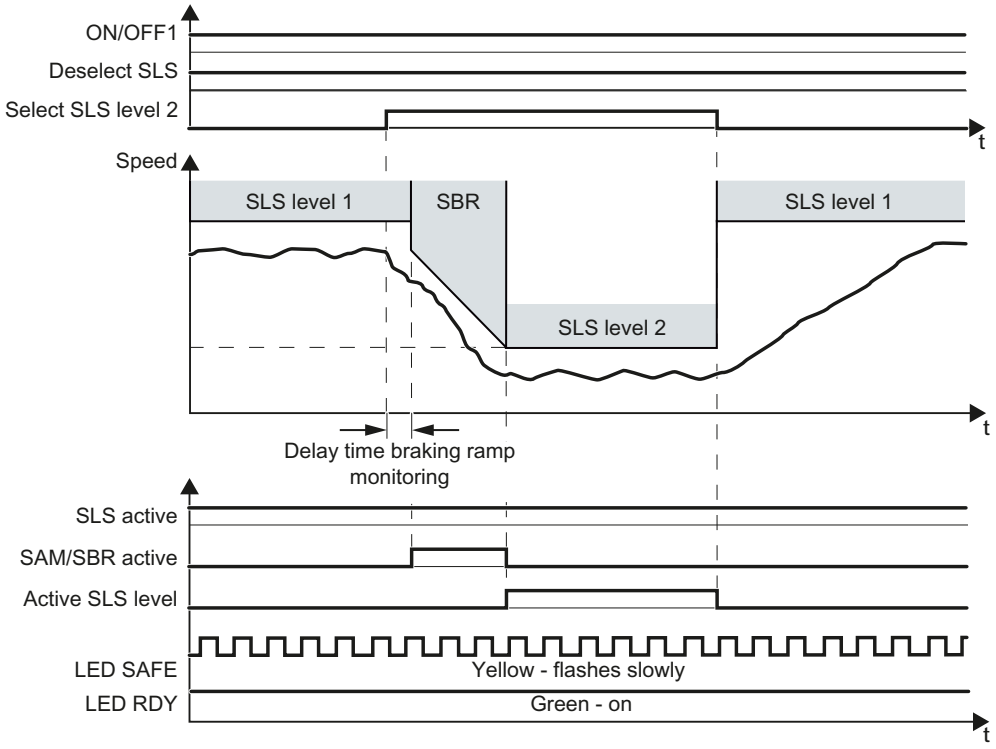


Figure 5-6 Switching between different monitoring thresholds

The converter 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 56).

5.1.3.2 SLS without braking ramp monitoring

Selecting and deselecting SLS

Description

If the machine control selects the safety function SLS via a fail-safe input or via the safe communication PROFIsafe , 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.

- The motor continues to follow the speed setpoint.
- The converter monitors the speed after the delay time has expired.

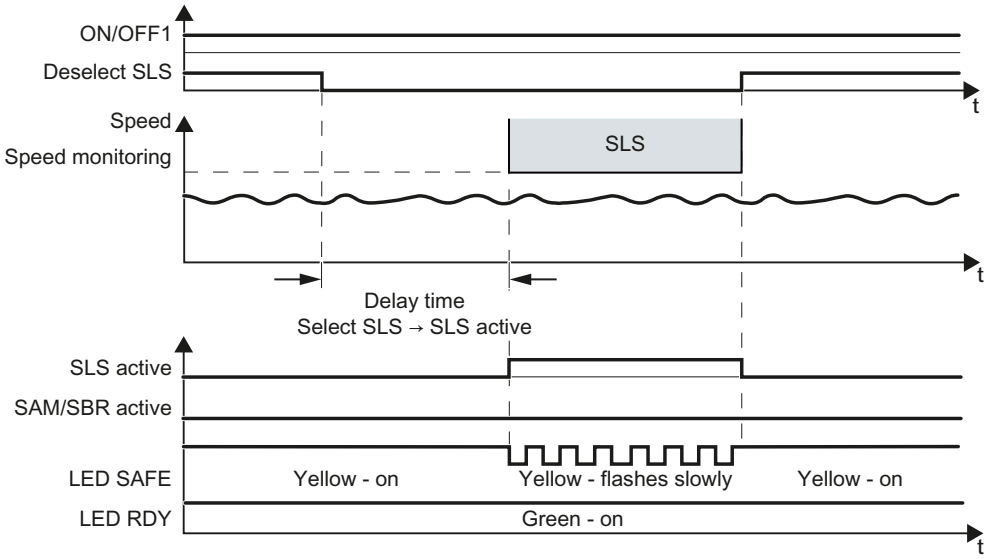


Figure 5-7 Selecting and deselecting the SLS safety function at low speeds

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

- The converter brakes the motor.
- The converter monitors the speed after the delay time has expired.
- If you deselect SLS , then the motor accelerates again up to the speed setpoint.

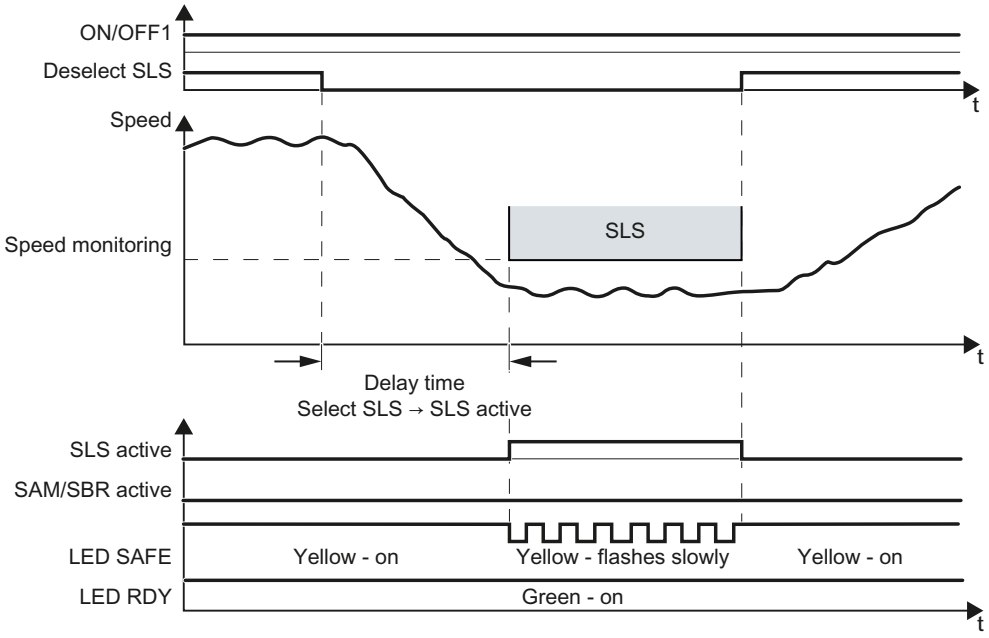


Figure 5-8 Selecting and deselecting the SLS safety function at high speeds

Switching over SLS levels

When SLS is active, you can switch between four different speed monitoring levels (SLSlevels).

Note

Switching over SLSlevels is only possible via PROFIsafe with control word 1. See also Section: Control word 1 and status word 1 (extended functions) (Page 56).

Behavior of SLS when switching over the monitoring

- If you switch from a higher to a lower speed monitoring level (SLSlevel), then the converter monitors the speed with the lower speed level after the delay time has expired.
- When you switch from one of the lower monitoring limits to a higher speed monitoring limit, then the converter immediately monitors the speed with the higher SLS level.

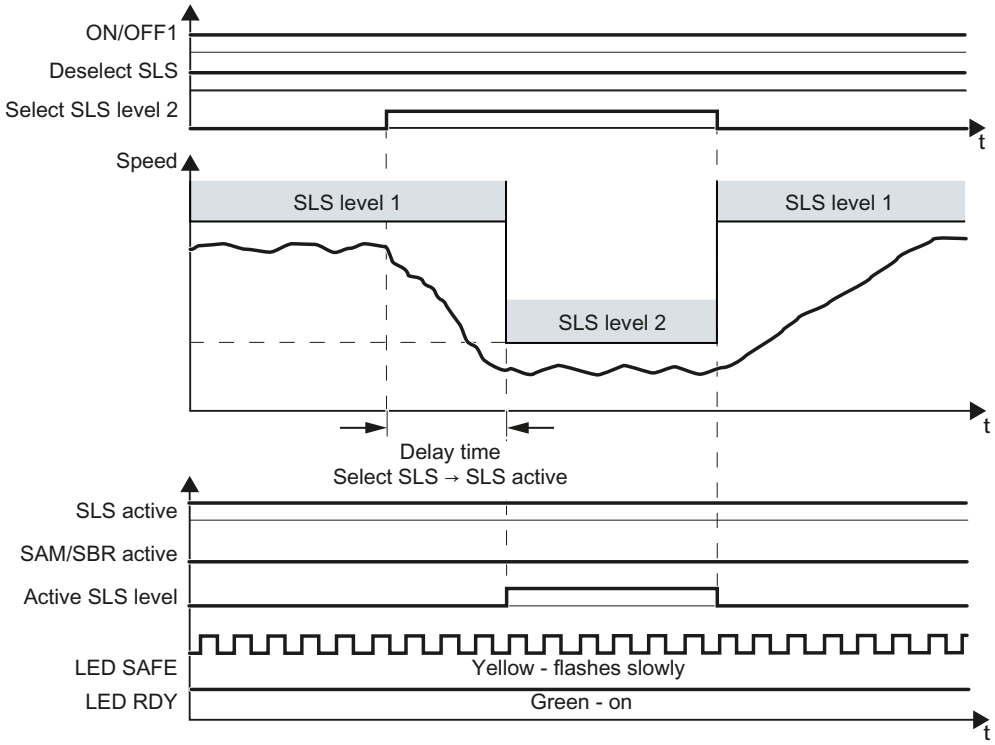


Figure 5-9 Switching between different monitoring thresholds

The converter 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 56).

5.1.4 Safe Direction (SDI)

Description

- As soon as the machine control selects the safety function SDI via a fail-safe input or via the safe communication PROFIsafe , then after the delay time expires, the converter only permits the selected direction of rotation of the motor.
- The converter limits the speed to the permitted direction of rotation. When SDI is selected, if the motor rotates in the impermissible direction, then the converter brakes the motor down to standstill.
- The converter tolerates brief movement in the monitored direction of rotation, by converting the motor speed into an angle.

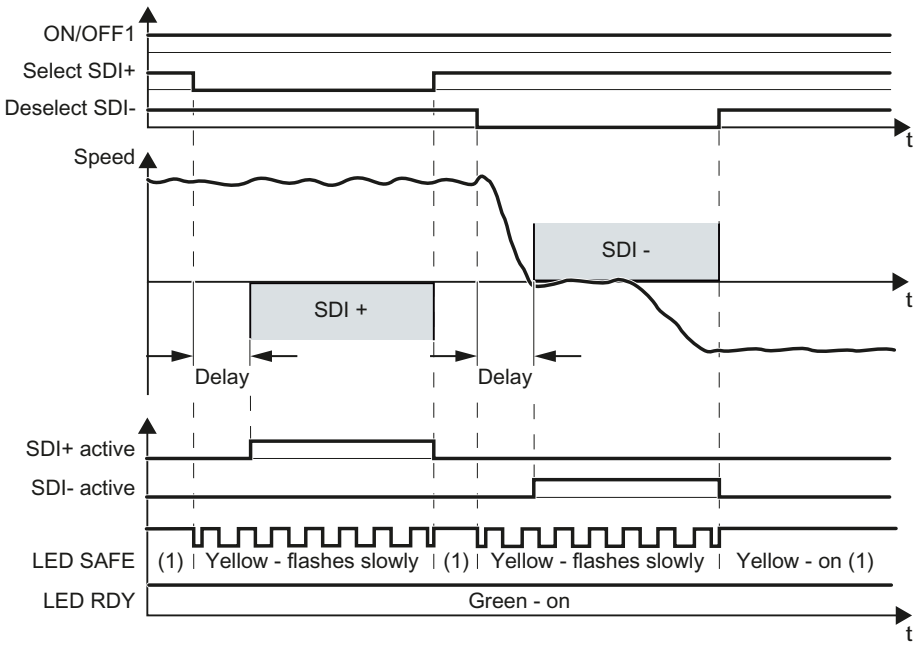


Figure 5-10 Time response of the safety function SDI (Safe Direction)

5.1.5 Safe Speed Monitor (SSM)

Description

- The SSM safety function cannot be selected or deselected using external control signals. SSM is active, if all of the following conditions are fulfilled:
  - You have enabled the SSM safety function.
  - For the SSM function, you have set a monitoring speed > 0.
  - The motor is switched on.
- When the motor is switched on, the converter compares the load speed with the speed limit.

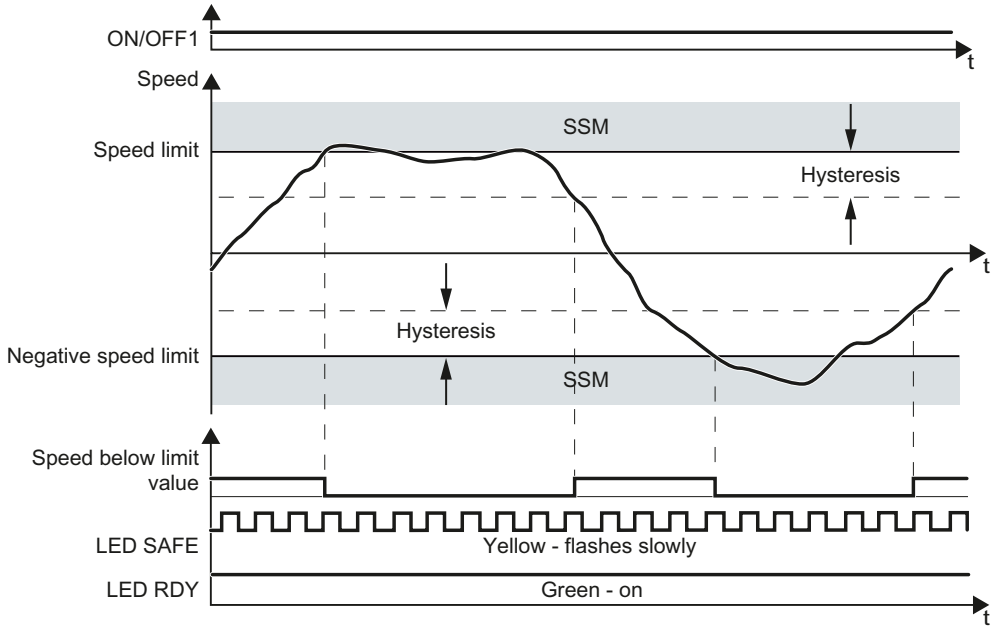


Figure 5-11 Time response of the safety function SSM (Safe Speed Monitor)

5.2 Switching the motor on and off with a safety function active

5.2.1 Switching off the motor when SS1 is active

Description

If you switch off the motor with safety function SS1 active using the OFF1 or OFF3 command, for example when reaching limit switches, then this does not influence the behavior of the motor. SS1 remains active and the converter brakes the motor down to standstill detection with the OFF3 ramp-down time.

If you switch off the motor using the OFF2 command with the SS1 safety function active, then the converter immediately safely switches off the motor torque using the STO safety function. The motor then coasts to a standstill.

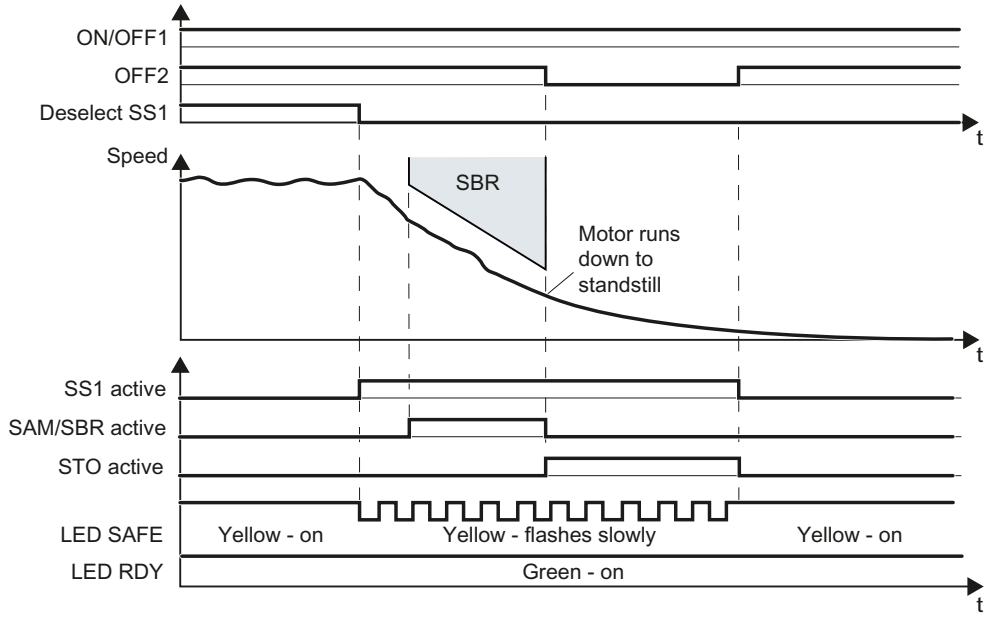


Figure 5-12 OFF2 command when the SS1 safety function is active (example: SS1 with braking ramp monitoring)

To switch the motor on again, you must proceed as follows:

- Deselect the SS1 safety function.
- Deselect the OFF2 command.
- Switch off the motor with the ON/OFF1 command and then switch on again.

5.2.2 Switching off the motor when SLS is active

Description

If you switch off the motor with OFF1 or OFF3, the converter safely switches off the motor torque when reaching the standstill monitoring using the STO safety function. The motor then coasts to a standstill.

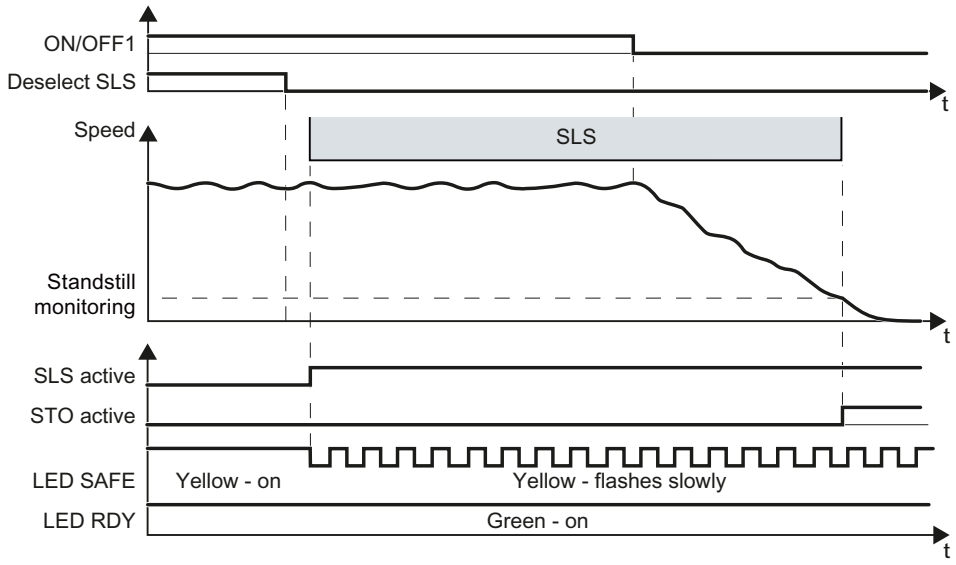


Figure 5-13 OFF1 command when the SLS safety function is active

If you switch off the motor using the OFF2 command, then the converter immediately safely switches off the motor torque using the STO safety function.

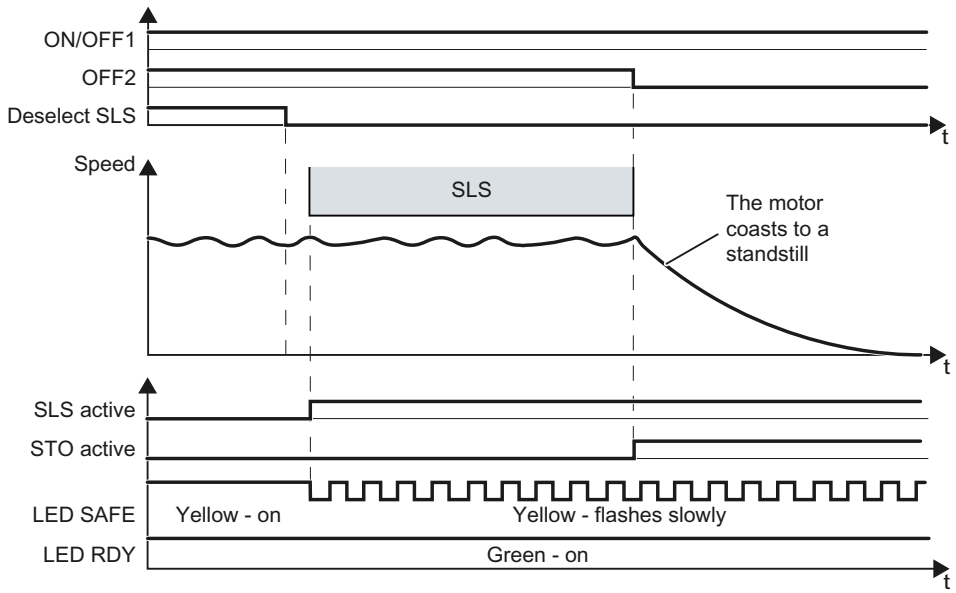


Figure 5-14 OFF2 command while the SLS safety function is active

You must proceed as follows in order to switch on the motor again after the SLS function has been deselected:

- Deselect the SLS safety function.
- If you switched off the motor with one of the OFF2 or OFF3 commands, then deselect the corresponding command.
- Switch off the motor with the ON/OFF1 command and then switch on again.

5.2.3 Switching the motor off and on again when SLS is active

Description

If you switch the motor off with the OFF1 or OFF3 command while the SLS safety function is active, for example, when limit switches are reached, then the inverter brakes the motor with the OFF1 or OFF3 ramp-down time. While braking, the converter monitors the motor speed to determine whether the permissible limit has been exceeded.

Proceed as follows to switch the motor off and on again when SLS is active:

- Switch the motor off when SLS is active.
- When the motor has come to a standstill, select STO .
- Deselect STO before you switch on the motor again.
- Switch on the motor within 5 seconds (ON command).

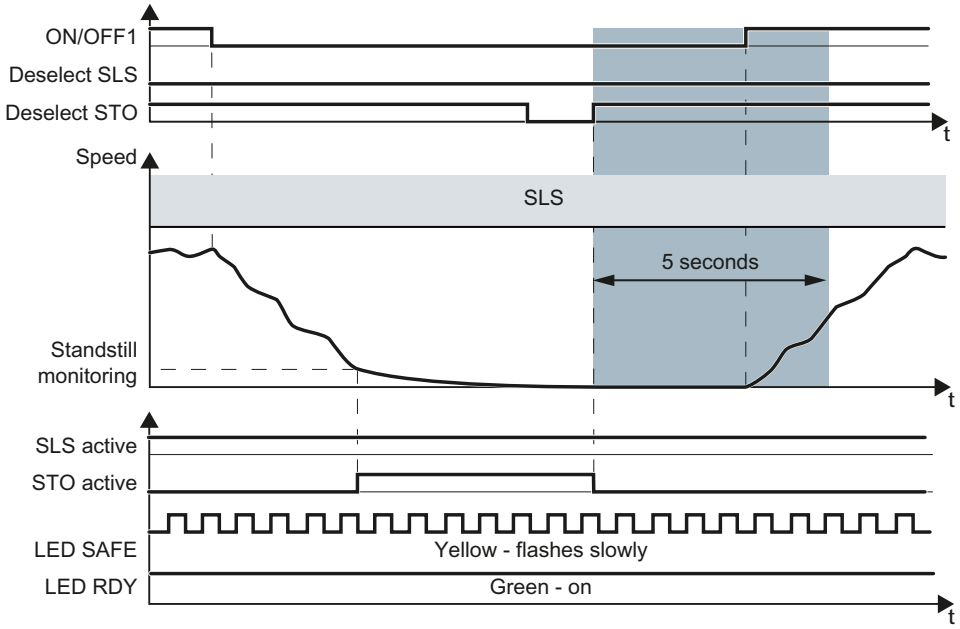


Figure 5-15 Switching the motor off and on (ON/OFF1) when SLS is active

If you do not switch on the motor within 5 seconds, then the converter again goes into the STO state and no longer responds to the ON command. To switch the motor on again, proceed as follows:

- Select STO .
- Deselect STO again.
- Switch on the motor within 5 seconds (ON command).

5.2.4 Switching off the motor when SSM is active

Description

If you switch off the motor with OFF1 or OFF3, the converter brakes the motor and switches it off when standstill monitoring threshold is reached.

You can set the behavior of the converter after switching-off the motor in two different ways:

1. Feedback signal "SSM active" for pulse inhibit *remains active*
   With this setting, the converter safely switches off the motor torque when reaching the standstill monitoring using the STO safety function. The converter ensures that the motor speed remains below the SSMmonitoring.
2. Feedback signal "SSM active" for pulse inhibit *becomes inactive*
   With this setting the converter switches off the motor torque, but not safely. The motor speed is not safely below the SSMmonitoring threshold.

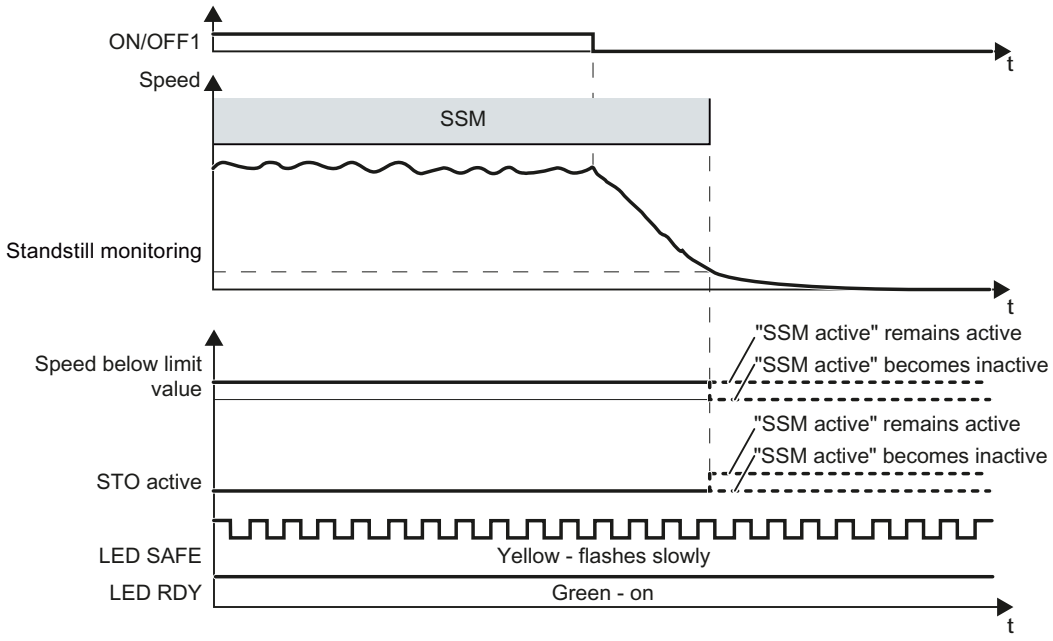


Figure 5-16 OFF1 command when the SSM safety function is active

If you switch off the motor with OFF2, the converter immediately switches off the motor. Depending on the selected setting the converter safely switches off the motor torque with the STO safety function.

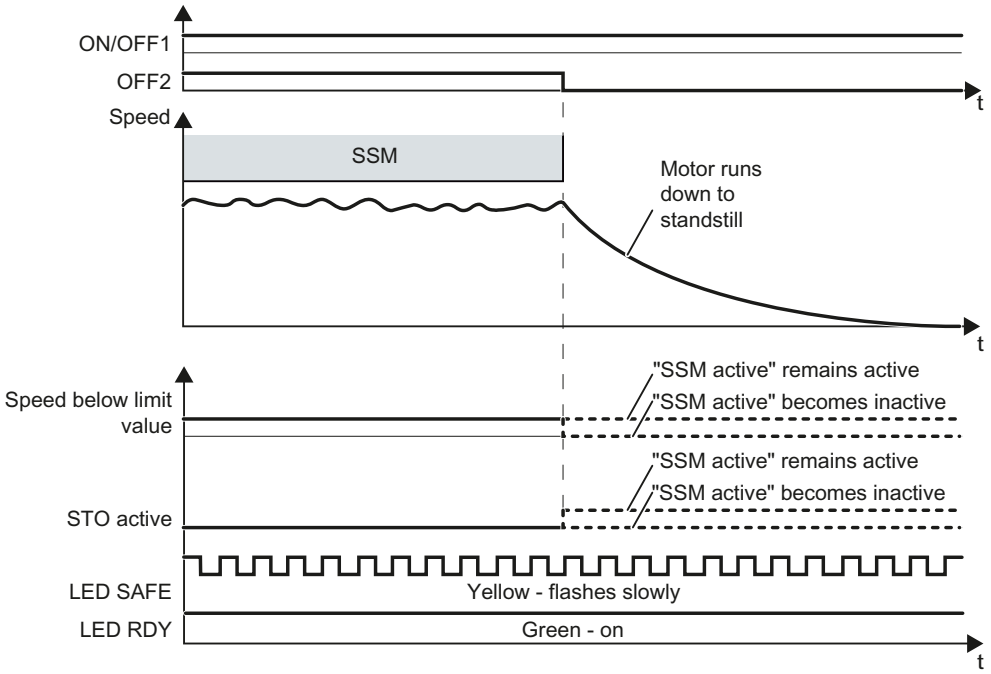


Figure 5-17 OFF2 command while the SSM safety function is active

If the speed is greater than the SSM limit value at the instant when the converter switches off the motor, then the feedback signal "SSM active" remains at 0.

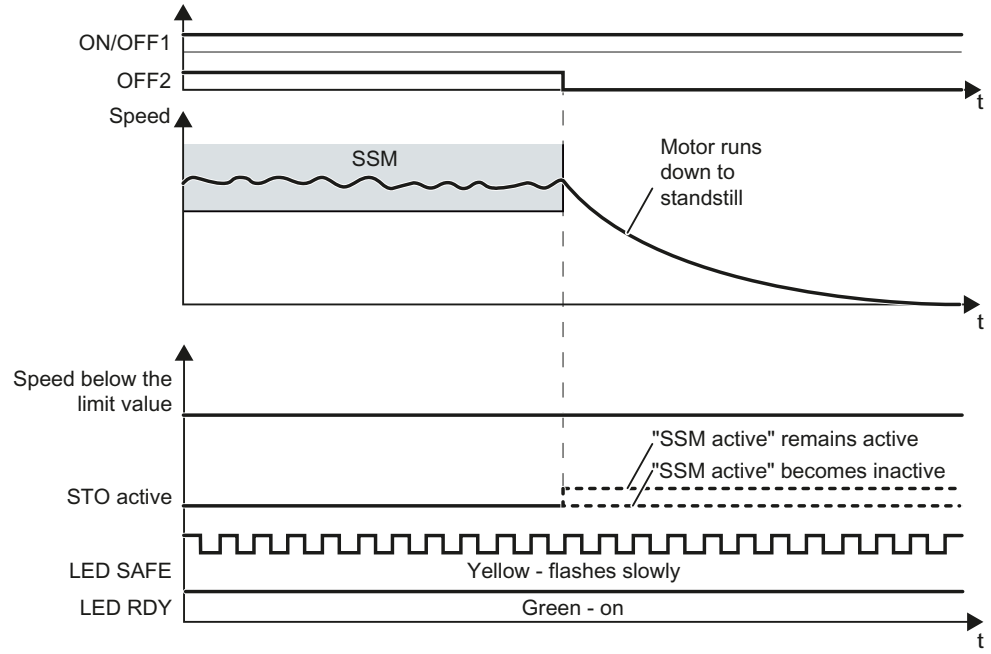


Figure 5-18 The feedback signal from SSM is "frozen" for a motor which has been switched off

5.2.5 Switching the motor off and on again when SSM is active

Description

If you switch the motor off with the OFF1 or OFF3 command while the SSM safety function is active, for example, when limit switches are reached, then the inverter brakes the motor with the OFF1 or OFF3 ramp-down time. Also while braking, the converter monitors the motors speed.

The behavior of SSM when the motor is being switched off, can be defined in two different ways.

The feedback signal "SSM active" for pulse inhibit becomes inactive

If you switch off the motor when SSM is active, then the converter interrupts the speed monitoring and sets the "Status SSM" to "0".

The function SSM becomes active again as soon as you switch on the motor again.

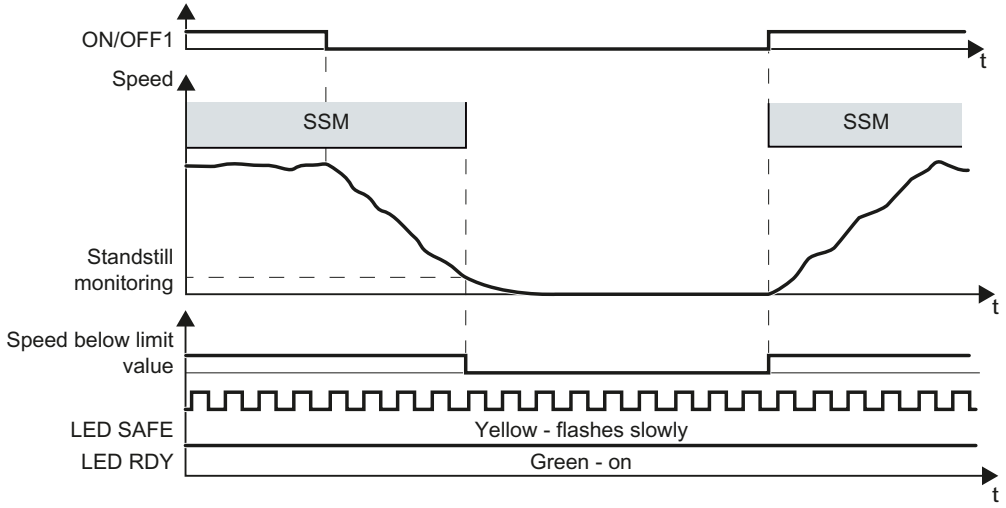


Figure 5-19 Switching the motor on and off with SSMactive, interrupting SSM

The feedback signal "SSM active" for pulse inhibit remains active

After switching off the motor, the converter interrupts the SSMfunction, however by issuing STO prevents the motor from accelerating.

Proceed as follows to switch the motor off and on again when SSM is active:

- Select STO after the motor has been switched off.
- Deselect STO again before you switch on the motor.
- Switch on the motor within 5 seconds.

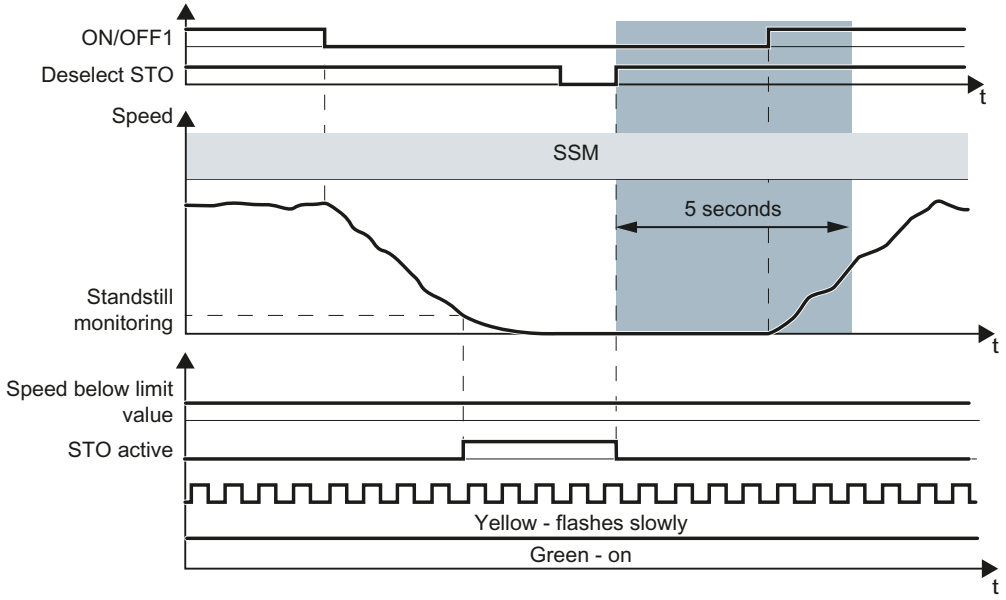


Figure 5-20 Switching the motor off and on with SSM active

If you do not switch on the motor within 5 seconds, then the converter again goes into the STO state and no longer responds to the ON command. To switch the motor on again, proceed as follows:

- Select STO .
- Deselect STO again.
- Switch on the motor within 5 seconds.

5.2.6 Switching off the motor when SDI is active

Description

If you switch off the motor with OFF1 or OFF3, the converter switches off the motor.

You can set the behavior of the converter after switching-off the motor in two different ways:

1. Feedback signal "SDI active" for pulse inhibit *remains active*
   With this setting, the converter safely switches off the motor torque when reaching the standstill monitoring using the STO safety function. The converter 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 converter switches off the motor torque, but not safely. The system does not safely prevent that the motor actively accelerates. Therefore, the converter sets the "SDI active" signal to 0 when the motor is switched off.

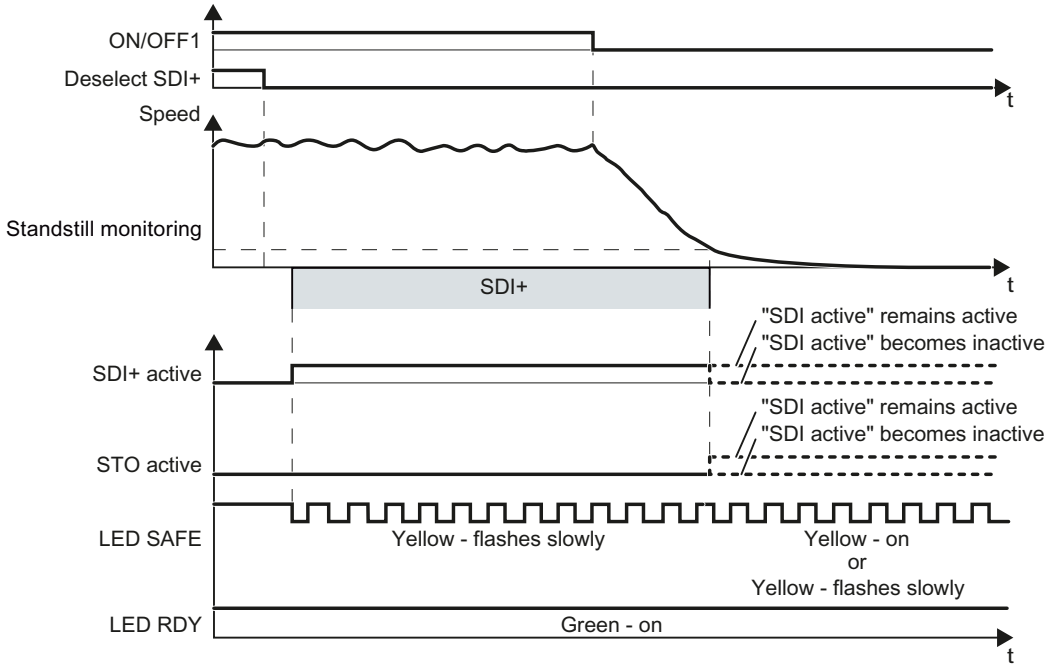


Figure 5-21 OFF1 command when the SDI safety function is active

If you switch the motor off with the OFF2 command when the SDI safety function is active, the converter immediately switches off the motor. Depending on the selected setting, the converter immediately switches off the motor torque with the STO safety function.

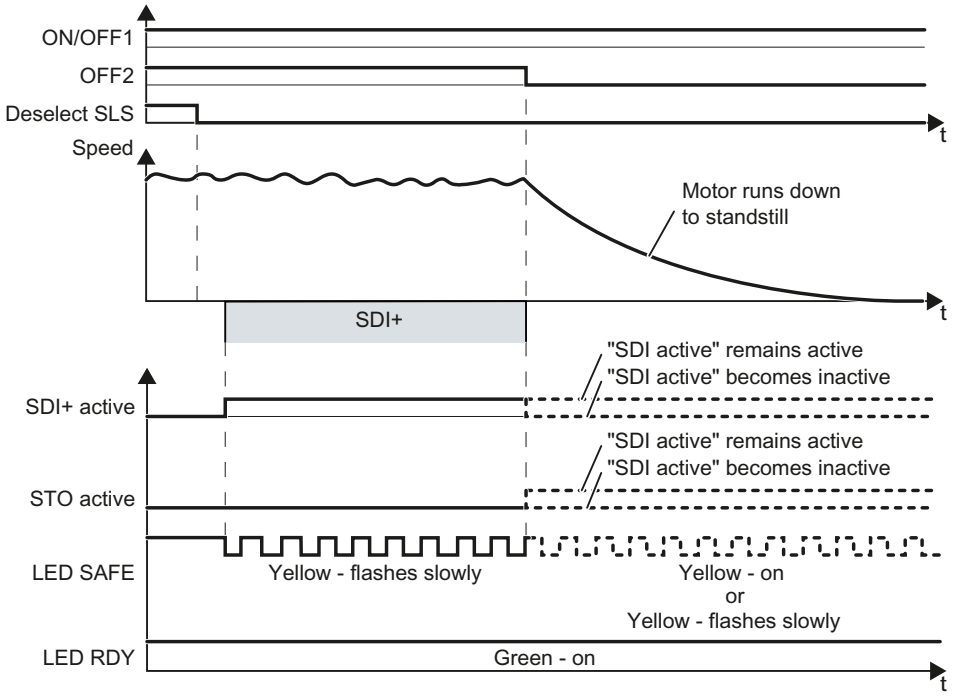


Figure 5-22 OFF2 command while the SDI safety function is active

You must proceed as follows in order to switch on the motor again after the SDI function has been deselected:

- Deselect the SDI safety function.
- If you switched off the motor with one of the OFF2 or OFF3 commands, then deselect the corresponding command.
- Switch off the motor with the ON/OFF1 command and then switch on again.

5.2.7 Switching the motor off and on again when SDI is active

Description

If you switch the motor off with the OFF1 or OFF3 command while the SDI safety function is active, for example, when limit switches are reached, then the converter brakes the motor with the OFF1 or OFF3 ramp-down time. Also while braking, the converter monitors the direction of rotation.

The behavior of SDI after the motor has been switched off can be defined in two different ways.

The feedback signal "SDI active" for pulse inhibit becomes inactive

If you switch off the motor when SDI is active, then the converter interrupts the speed monitoring and sets the "SDI " signal to 0.

The function SDI becomes active again as soon as you switch on the motor again.

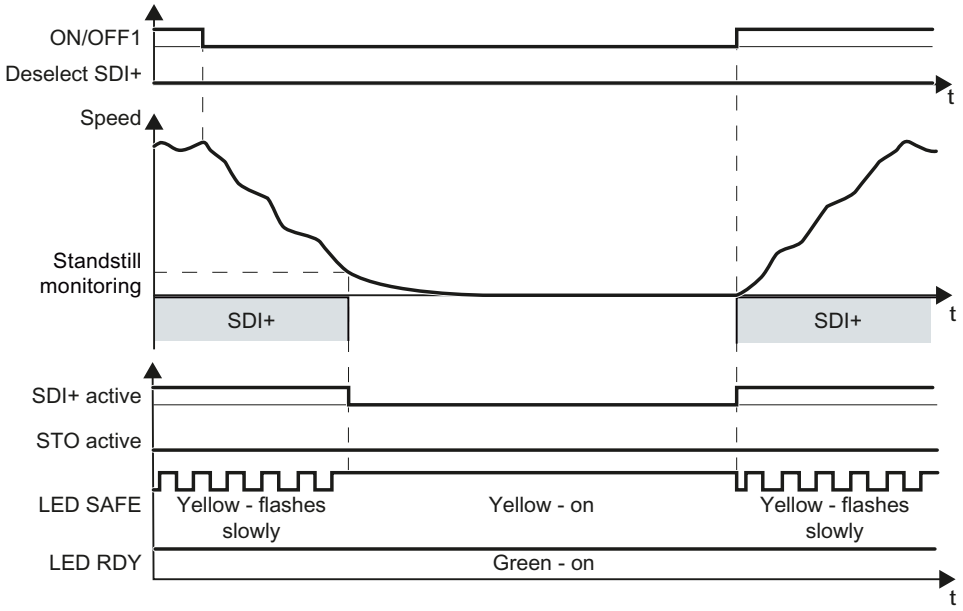


Figure 5-23 Switching the motor off and on again with SDI, active, interrupting the feedback signal from SDI

The feedback signal "SDI active" for pulse inhibit remains active

After switching off the motor, the converter interrupts the SDIfunction, however by issuing STO safely prevents the motor from accelerating.

Proceed as follows to switch the motor off and on again when SDI is active:

- Select STO after the motor has been switched off.
- Deselect STO again before you switch on the motor.
- Switch on the motor within 5 seconds.

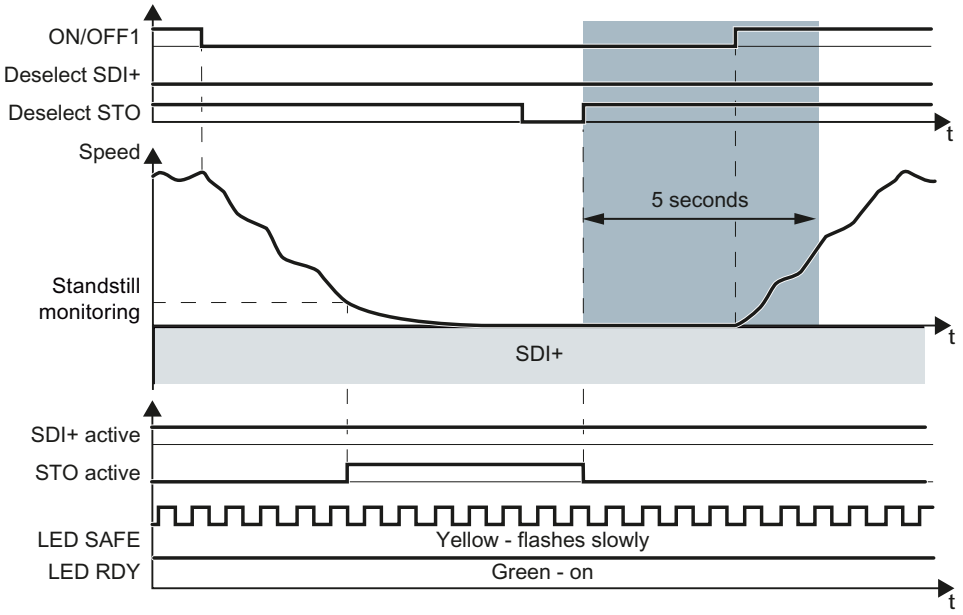


Figure 5-24 Switching the motor off and on with SDI active

If you do not switch on the motor within 5 seconds, then the converter again goes into the STO state and no longer responds to the ON command. To switch the motor on again, proceed as follows:

- Select STO .
- Deselect STO again.
- Switch on the motor within 5 seconds.

5.3 Selecting safety function when a safety function is active

5.3.1 Overview

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 5- 1 Interaction between two safety functions

Active safety function 1	With safety function 1 active, additionally control safety function 2:			
	STO	SS1	SLS	SDI
STO	---	No effect	No effect	No effect
SS1	Selecting STO when SS1 is active (Page 180)	---	No effect	No effect
SLS	Selecting STO when SLS is active (Page 181)	Selecting SS1 when SLS is active (Page 184)	---	Selecting SDI when SLS is active (Page 189)
SDI	Selecting STO when SDI is active (Page 182)	Selecting SS1 when SDI is active (Page 185)	Selecting SLS when SDI is active (Page 187)	---
SSM	Selecting STO when SSM is active (Page 183)	Selecting SS1 when SSM is active (Page 186)	Selecting SLS when SSM is active (Page 188)	Selecting SDI when SSM is active (Page 190)

5.3.2 Selecting STO when SS1 is active

Description

Table 5- 2 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	**STO select when active SS1**	---	---	---
SLS	---	---	---	---
SDI	---	---	---	---
SSM	---	---	---	---

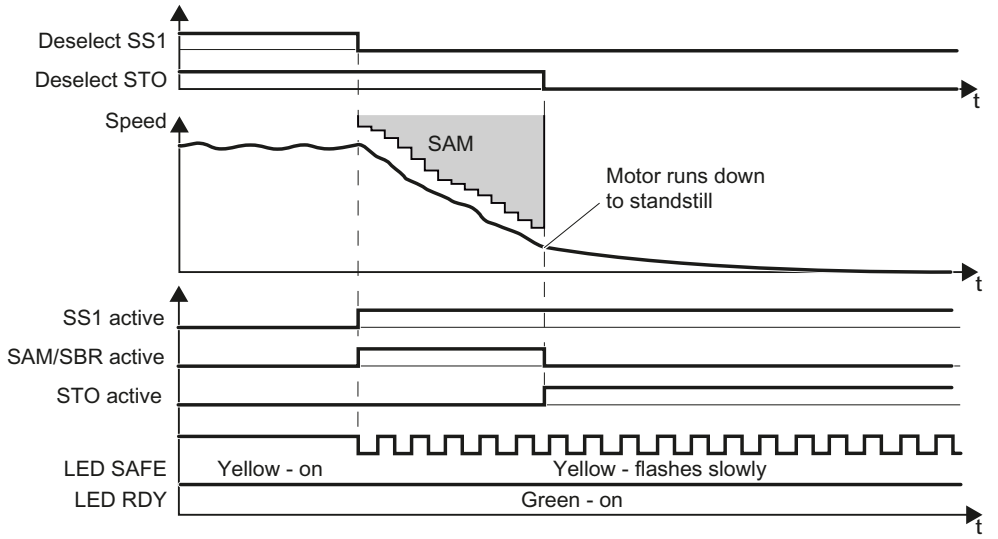


Figure 5-25 Select STO when SS1 is active (as example: SS1 with acceleration monitoring)

5.3.3 Selecting STO when SLS is active

Description

Table 5- 3 Interaction between two safety functions

	STO	**SS1**	**SLS**	**SDI**
STO	---	---	---	---
SS1	---	---	---	---
SLS	**STO select when active SLS**	---	---	---
SDI	---	---	---	---
SSM	---	---	---	---

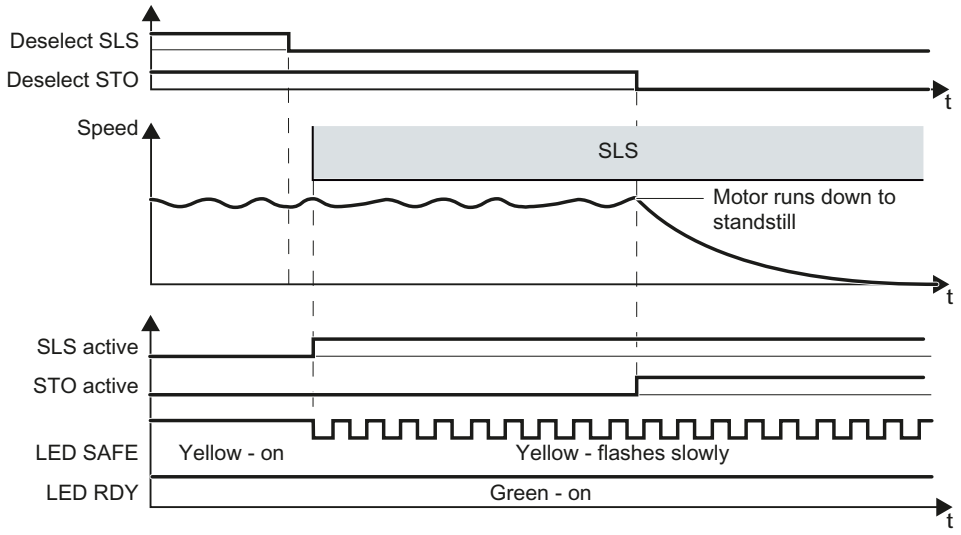


Figure 5-26 STO select when active SLS

5.3.4 Selecting STO when SDI is active

Description

Table 5- 4 Interaction between two safety functions

	STO	**SS1**	**SLS**	**SDI**
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	**STO select when active SDI**	---	---	---
SSM	---	---	---	---

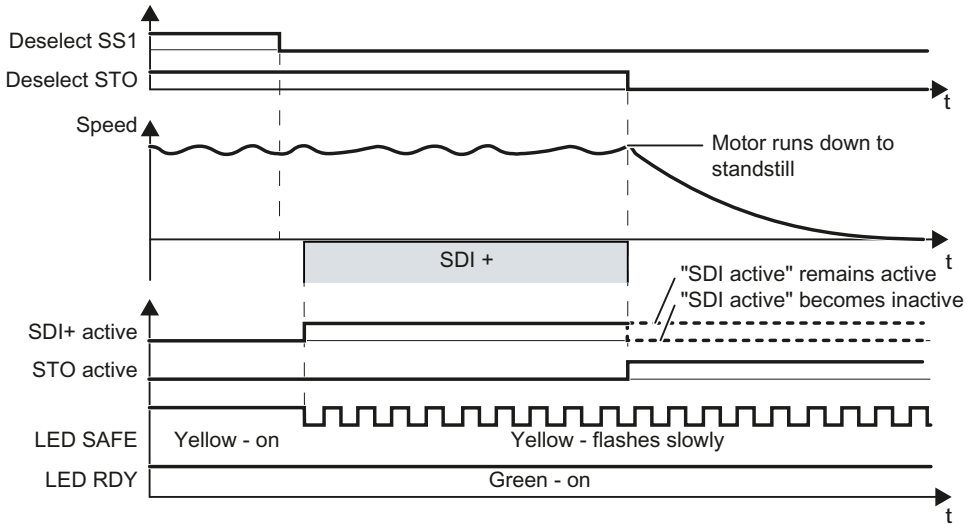


Figure 5-27 STO select when active SDI

5.3.5 Selecting STO when SSM is active

Description

Table 5- 5 Interaction between two safety functions

	STO	**SS1**	**SLS**	**SDI**
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	---	---	---
SSM	**STO select when active SSM**	---	---	---

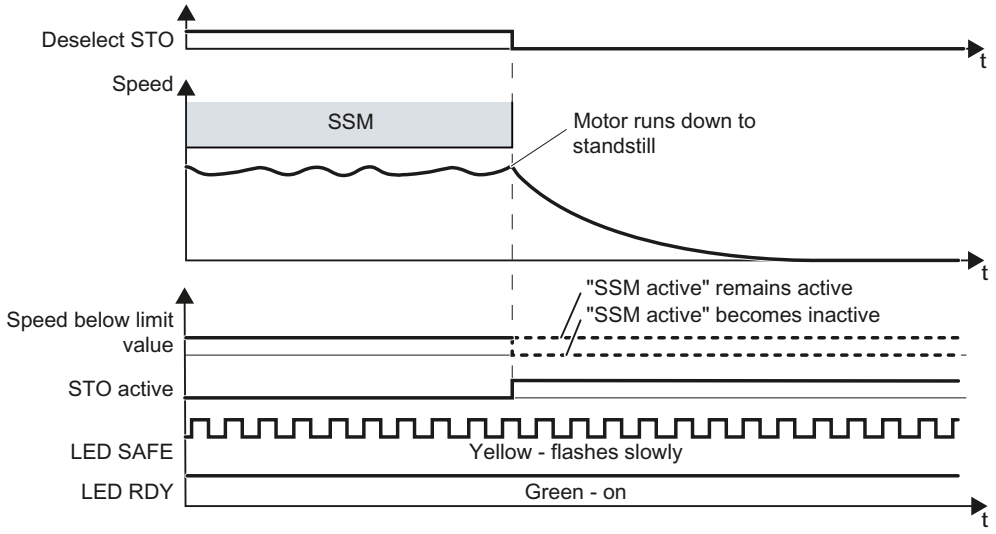


Figure 5-28 STO select when active SSM

5.3.6 Selecting SS1 when SLS is active

Description

Table 5- 6 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	**SS1 select when active SLS**	---	---
SDI	---	---	---	---
SSM	---	---	---	---

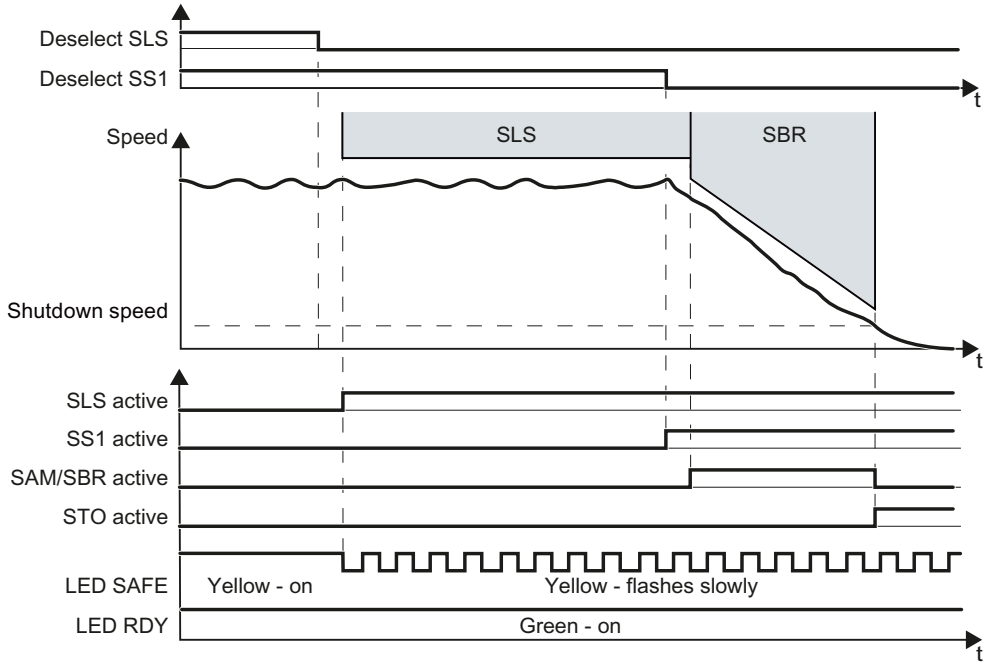


Figure 5-29 SS1 select when SLS is active (as example SS1 with braking ramp monitoring)

5.3.7 Selecting SS1 when SDI is active

Description

Table 5- 7 Interaction between two safety functions

	STO	**SS1**	**SLS**	**SDI**
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	**SS1 select when active SDI**	---	---
SSM	---	---	---	---

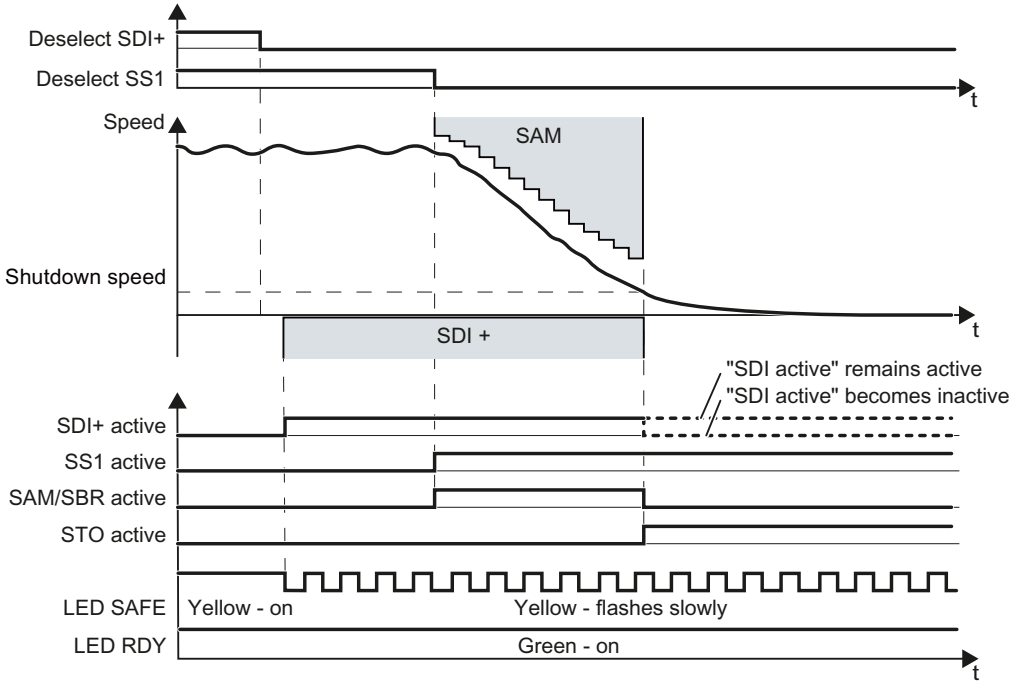


Figure 5-30 SS1 select when active SDI

5.3.8 Selecting SS1 when SSM is active

Description

Table 5- 8 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	---	---	---
SSM	---	**SS1 select when active SSM**	---	---

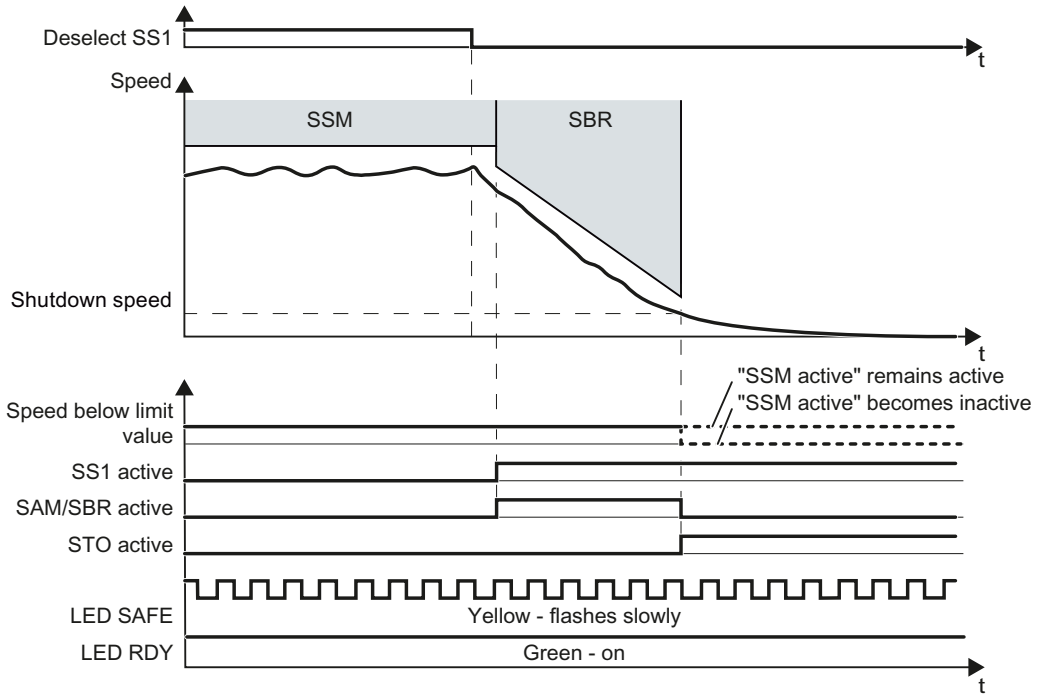


Figure 5-31 SS1 select when active SSM

5.3.9 Selecting SLS when SDI is active

Description

Table 5- 9 Interaction between two safety functions

	STO	**SS1**	**SLS**	**SDI**
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	---	**SLS select when active SDI**	---
SSM	---	---	---	---

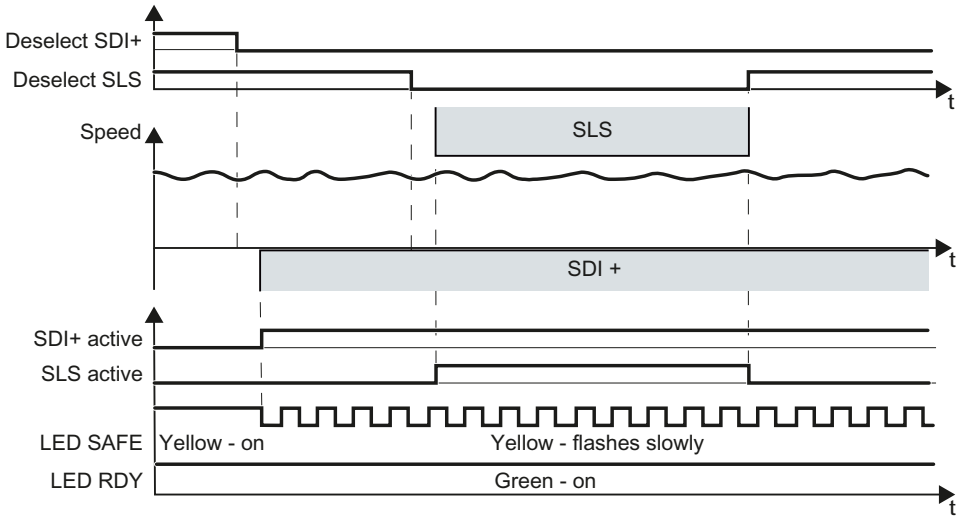


Figure 5-32 SLS select when active SDI

5.3.10 Selecting SLS when SSM is active

Description

Table 5- 10 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	---	---	---
SSM	---	---	**SLS select when active SSM**	---

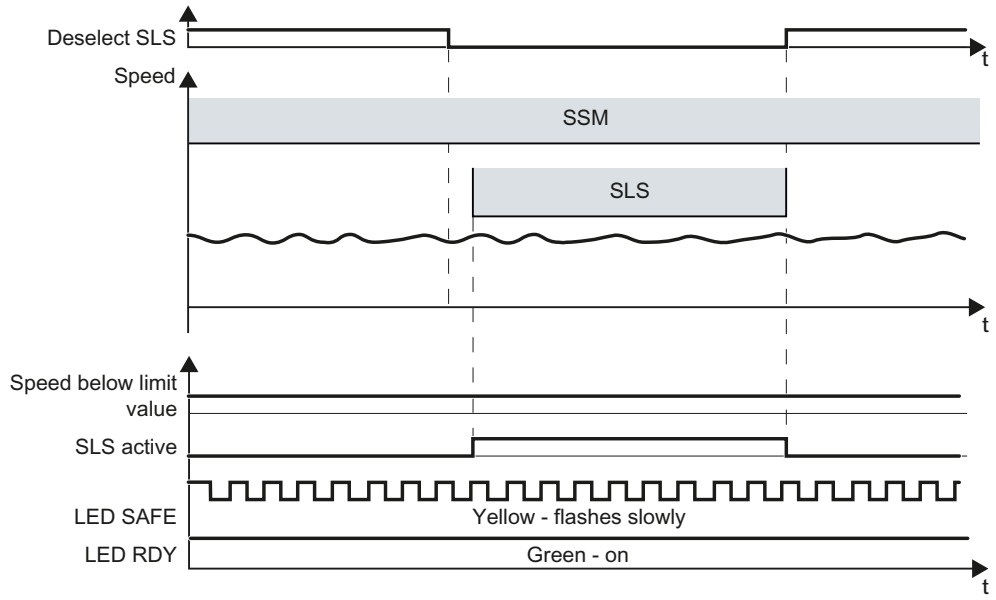


Figure 5-33 SLS select when active SSM

5.3.11 Selecting SDI when SLS is active

Description

Table 5- 11 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	**SDI select when active SLS**
SDI	---	---	---	---
SSM	---	---	---	---

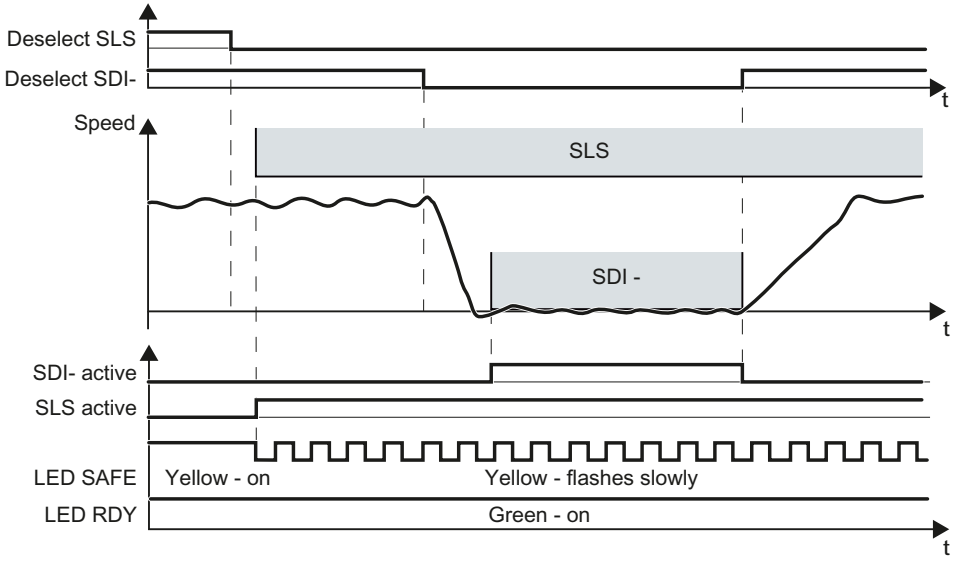


Figure 5-34 SDI select when active SLS

5.3.12 Selecting SDI when SSM is active

Description

Table 5- 12 Interaction between two safety functions

	STO	SS1	SLS	SDI
STO	---	---	---	---
SS1	---	---	---	---
SLS	---	---	---	---
SDI	---	---	---	---
SSM	---	---	---	**SDI select when active SSM**

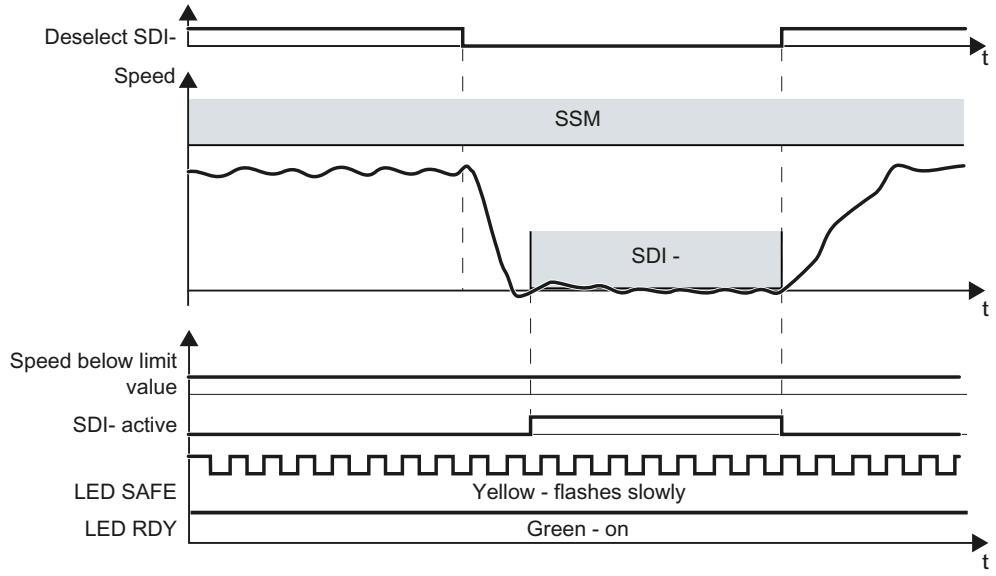


Figure 5-35 SDI select when active SSM

5.4 Faults of the safety functions

The response of the converter to internal faults and limit violations of the safety functions is subject to specific rules.

The following sections provide an overview of the causes, reaction and acknowledgement of safety function faults. This will be followed by a detailed description of the drive behavior for active safety functions.

5.4.1 Cause of fault

Depending on the cause of the fault, the safety function faults trigger various different reactions from the converter.

General faults

These are faults that are assigned to the converter's safety functions, which however do not compromise the fail-safe operation of the converter. For example, these faults may have been caused by any of the following:

- Impermissible parameter value settings (F01659)
- Message "Acceptance test required" (F01650)

General faults do not require any special acknowledgment.

Discrepancy

A discrepancy is a fault in the external wiring of the fail-safe inputs (see Section Response to a discrepant input signal (Page 194)). When a discrepancy occurs, the converter no longer evaluates the F-DI (=zero).

The F-DI remains in the safe state until you acknowledge the converter using a fail-safe signal or using a power-on reset.

Internal event

An "internal event" is a major fault that causes the converter 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 converter detects an internal fault in its hardware or its firmware on the basis of a data cross-check (F01611).
- The converter identifies when a limit value is violated as a result of an inadmissible motor speed (C01714).

An "internal event" can only be acknowledged in a fail-safe manner.

5.4.2 Stop responses

For an "internal event", the converter responds with a STOP (STOP A, STOP B or STOP F).

Response of the motor in the event of a STOP

STOP A

For a STOP A, the converter safely switches off the torque of the connected motor immediately.

STOP B

For a STOP B, the converter 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 converter switches over the control mode to speed control.

The converter monitors the braking of the motor. The monitoring type corresponds to the monitoring mode of SS1, also see Section Safe Stop 1 (SS1) (Page 17).

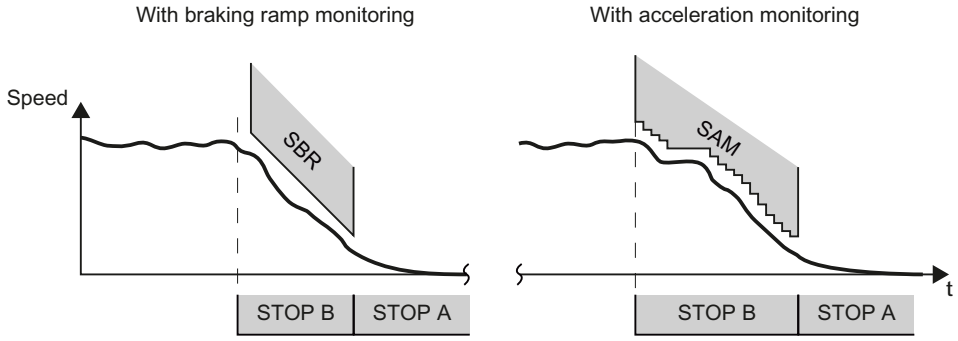


Figure 5-36 Monitoring the speed for a STOP B

If the motor does not follow the defined braking ramp, the converter interrupts the braking of the motor and responds with a STOP A.

STOP F

A STOP F either initiates a STOP A or a STOP B:

- If fault F01611 is the cause of the STOP F, then the converter immediately initiates a STOP A.
- If alarm C01711 is the cause of the STOP F, then the converter response depends on the active safety function:
  - If no safety function is active, the alarm stops and does not affect motor operation.
  - If STO is active, then the converter initiates aSTOP A.
  - In all other cases, the converter initiates a STOP B.

5.4.3 Fail-safe acknowledgment

You must acknowledge the majority of safety function faults using a fail-safe signal. There are several possibilities that allow you to do so, which are described below.

Fail-safe acknowledgment via digital input

Once you have interconnected a fail-safe input F-DI with an acknowledgement signal, proceed as follows:

- Acknowledge the fault with F-DI = 0 → 1 → 0.
- Then, acknowledge the converter with the "standard" acknowledgement signal.

Fail-safe acknowledgment via PROFIsafe

If you use the PROFIsafe telegram, proceed as follows:

- Acknowledge the fault with bit 7 of the control word 0: Bit 7 = 0 → 1 → 0.
- Then, acknowledge the converter with the "standard" acknowledgement signal.

Acknowledge by selecting and deselecting Safe Torque Off (STO) or Safe Stop 1 (SS1)

Acknowledge safety function faults by selecting and deselecting STO or SS1. This functions both via a fail-safe input F-DI as well as also the PROFIsafetelegram. The procedure is as follows:

- Select the STO or SS1 safety function and then deselect again:
  - F-DI = 1 → 0 → 1
    or
  - PROFIsafe control word 1, bit 0 or 1 = 1 → 0 → 1
- Then, acknowledge the converter with the "standard" acknowledgement signal.

Other acknowledgement options: Power on reset

You can acknowledge faults by temporarily shutting off the power supply to the converter and then switching it on again.

5.5 Response to a discrepant input signal

5.5.1 Discrepancy for Safe Torque Off (STO)

Prerequisite

The converter is set so that the safety function STO is selected via a fail-safe input of the converter.

Description

A discrepancy at the fail-safe input immediately selects the safety functionSTO .

The behavior of the drive depends on the setting of the converter:

1. Case: 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
2. Case: You have selected the following setting:
   - Extended Functions via onboard terminals

1. Case

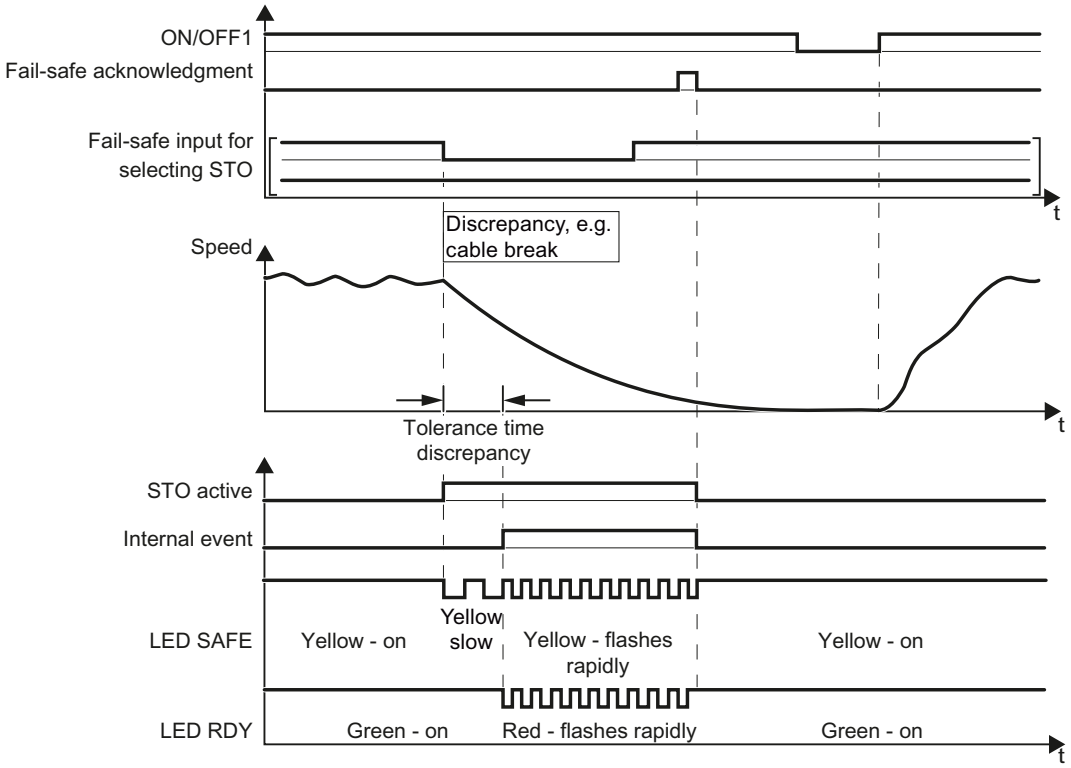


Figure 5-37 Discrepancy for safety function STO (example: Cable break in the channel of processor P1)

After the tolerance time has expired, the converter signals the discrepancy with fault F01611 or F30611.

Via PROFIsafestatus word 1, bit 7, the converter signals an internal event.

To switch the motor on again, you must proceed as follows:

1. Remove the discrepancy.
2. Acknowledge the messages present:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
   - See also section: Options for acknowledging the discrepancy signal (Page 200).
3. Issue an OFF1 command.
4. Switch on the motor (ON command).

2. Case

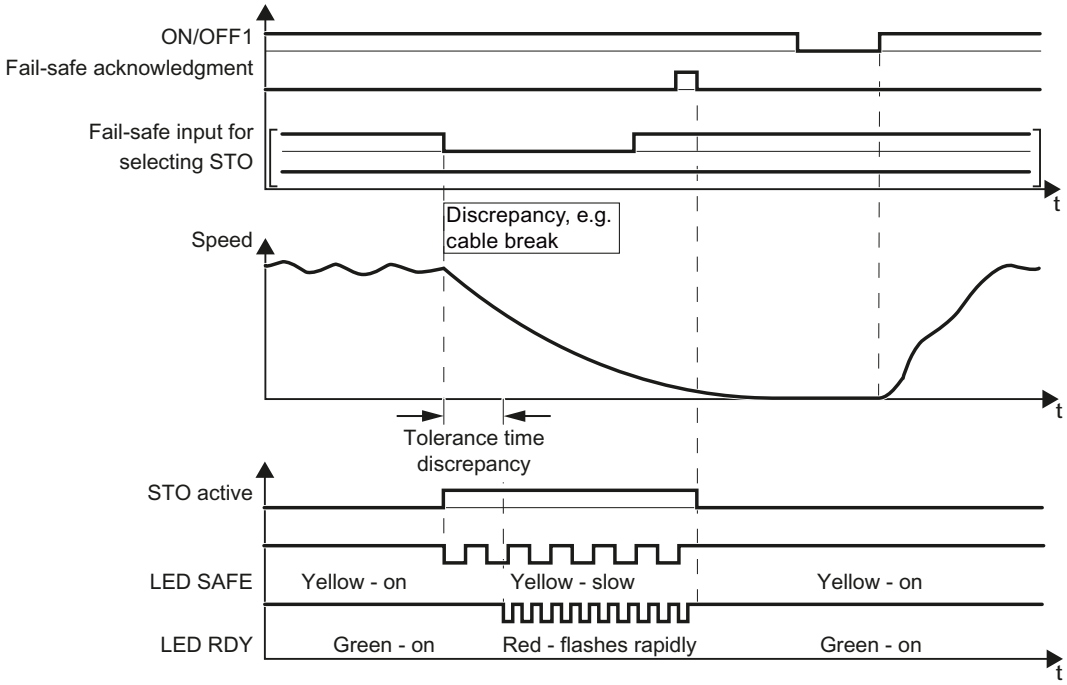


Figure 5-38 Response of safety function STO in the event of a discrepancy

After the tolerance time has expired, the converter signals the discrepancy with alarm C01770 or C30770.

To switch the motor on again, you must proceed as follows:

1. Remove the discrepancy.
2. Acknowledge the messages present:
   - F-acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - See also section: Options for acknowledging the discrepancy signal (Page 200)).
3. Issue an OFF1 command.
4. Switch on the motor (ON command).

5.5.2 Discrepancy with Safe Stop 1 (SS1)

Prerequisite

The converter is set so that the safety function SS1 is selected via a fail-safe input of the converter.

Description

A discrepancy at a fail-safe input immediately selects the safety functionSS1. After the tolerance time has expired, the converter signals the discrepancy (C01770 or C30770) but does not interrupt the braking operation for the motor.

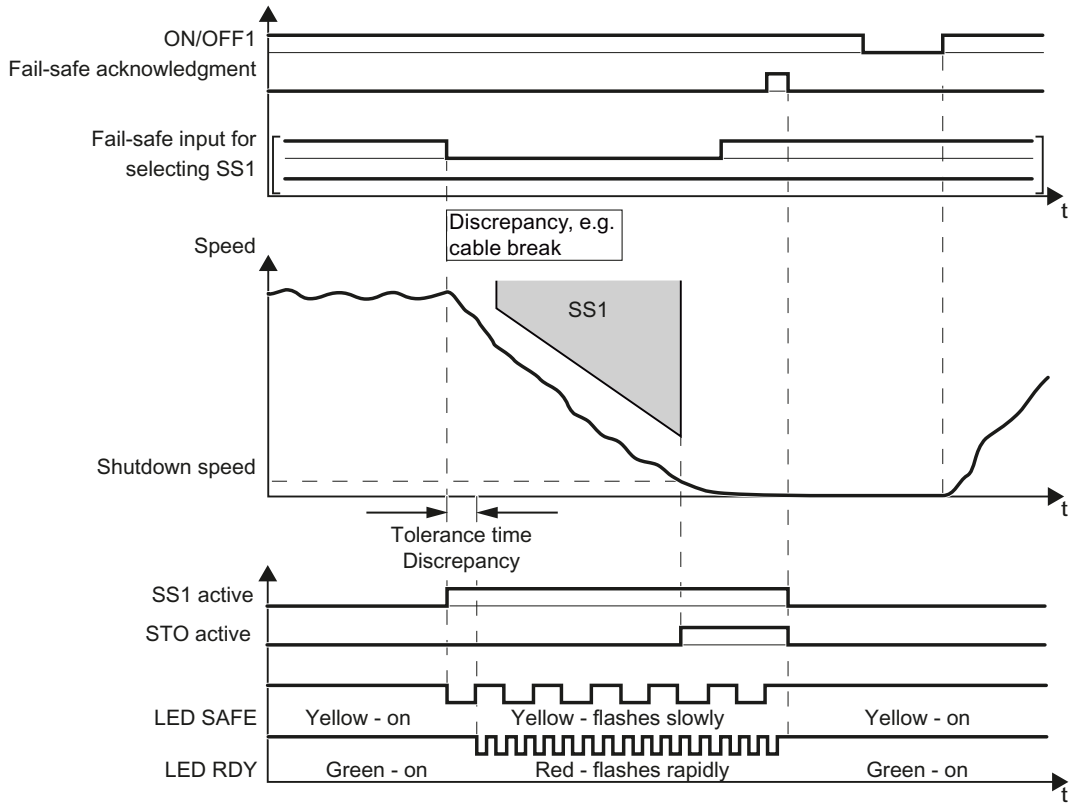


Figure 5-39 Response of safety function SS1 in the event of a discrepancy (as example: SS1 with braking ramp monitoring)

To switch the motor on again, you must proceed as follows:

1. Remove the discrepancy.
2. Acknowledge the messages present:
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - See also section: Options for acknowledging the discrepancy signal (Page 200).
3. Issue an OFF1 command.
4. Switch on the motor (ON command).

5.5.3 Discrepancy with Safely Limited Speed (SLS)

Prerequisite

The converter is set so that the safety function SLS is selected via a fail-safe input of the converter.

Description

A discrepancy at the fail-safe input immediately selects the safety function SLS . After the tolerance time expires, the converter signals the discrepancy (alarm C01770 or C30770), however, it does not interrupt the SLS function.

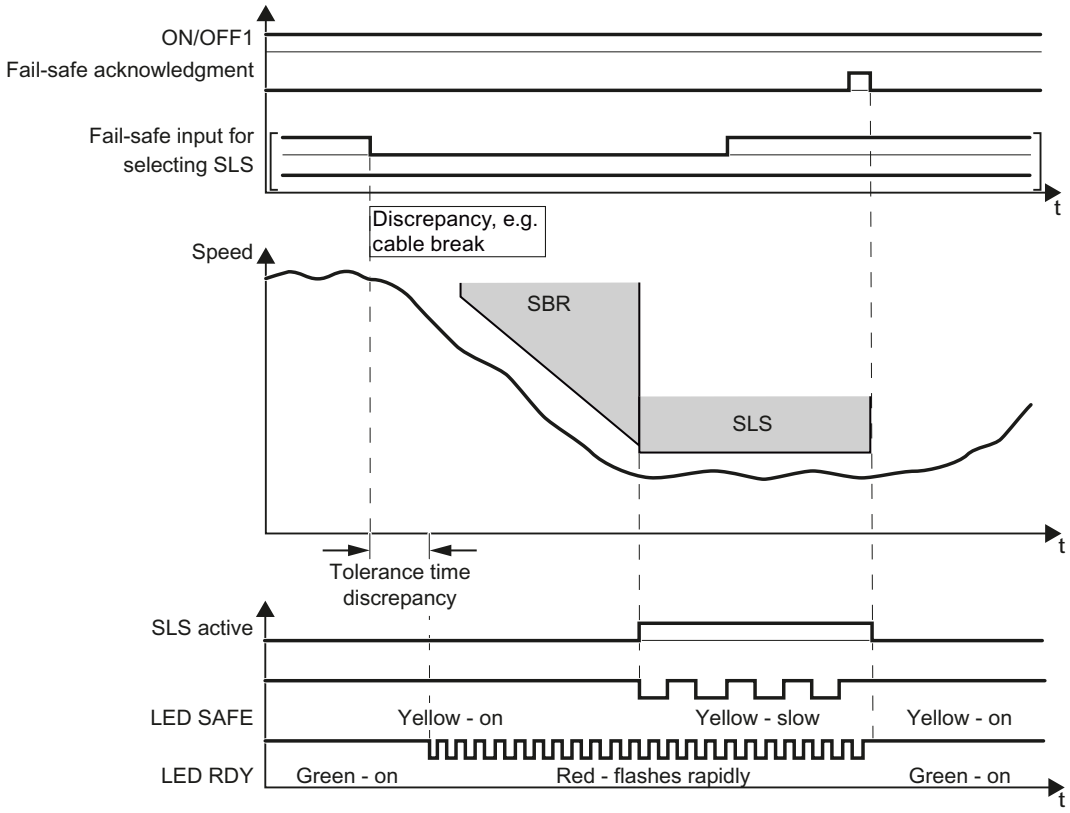


Figure 5-40 Response of safety function SLS in the event of a discrepancy

To deselect SLS you must remove the discrepancy and acknowledge the message:

- Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
- See also section: Options for acknowledging the discrepancy signal (Page 200).

5.5.4 Discrepancy for Safe Direction (SDI)

Prerequisite

The converter is set so that the safety function SDI is selected via a fail-safe input of the converter.

Description

A discrepancy at the fail-safe input immediately selects the safety functionSDI . After the tolerance time has expired, the converter signals the discrepancy (C01770 or C30770) but does not switch off the motor.

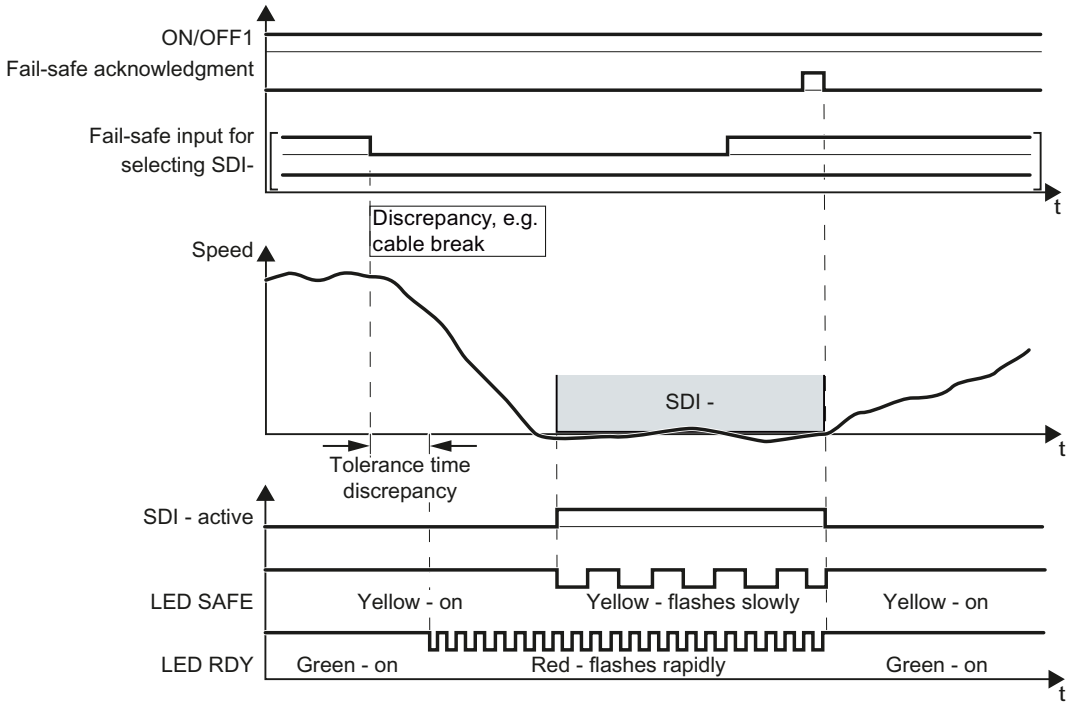


Figure 5-41 Response of safety function SDI in the event of a discrepancy

To deselect SDI , you must remove the discrepancy and acknowledge the message:

- Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
- See also section: Options for acknowledging the discrepancy signal (Page 200).

5.5.5 Options for acknowledging the discrepancy signal

Description

You must acknowledge a discrepancy signal in a fail-safe manner. The following table shows all of the options that the converter offers for this purpose:

Table 5- 13 Acknowledging a discrepancy signal

Setting of the converter	Discrepancy of the F-DI for the control of	How can the discrepancy signal be acknowledged?		
		F-DI	PROFIsafe	Power on reset
Basic Functions via onboard terminals	STO	Selecting and deselecting STO	---	Yes
Basic Functions via PROFIsafe and onboard terminals	STO	Selecting and deselecting STO	• Selecting and deselecting STO • PROFIsafe control word 1, bit 7	Yes
Extended Functions via onboard terminals	• STO [1] • SS1 [1]	Fail-safe acknowledgment	---	Yes
	• SLS • SDI • Fail-safe acknowledgment	• Selecting and deselecting STO • Selecting and deselecting SS1 • Fail-safe acknowledgment		
Extended functions via PROFIsafe and basic functions via onboard terminals	STO	Selecting and deselecting STO	• Selecting and deselecting STO • Selecting and deselecting SS1 • PROFIsafe control word 1, bit 7	Yes

[1] Acknowledgment by selecting and deselecting STO or SS1 is not possible in this case.

See also Section: Fail-safe acknowledgment (Page 193).

5.6 Response to an internal event

5.6.1 Internal event when Safe Torque Off (STO) is active

Description

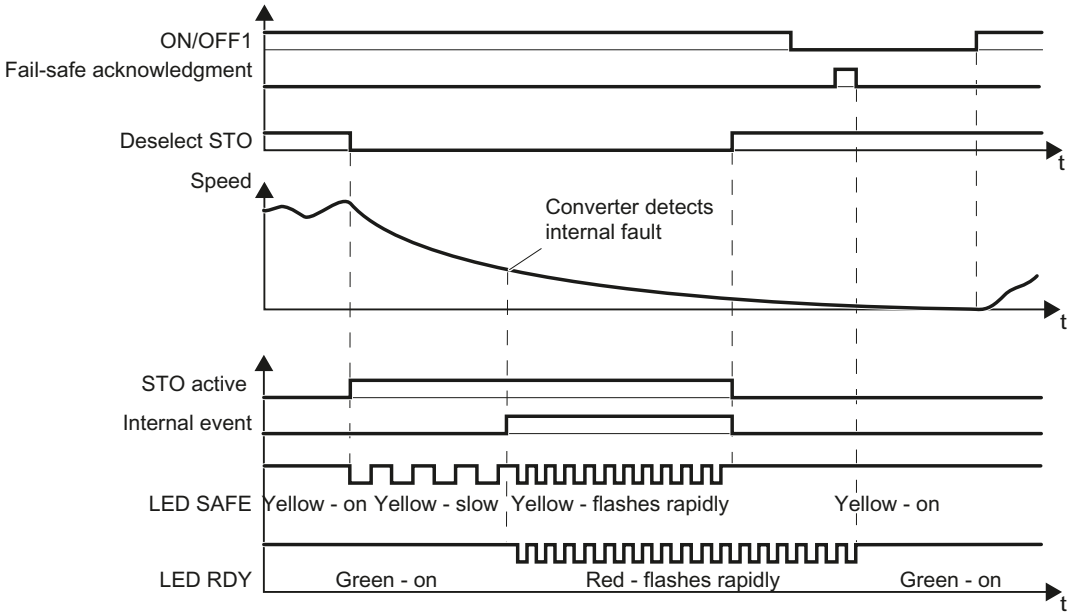


Figure 5-42 Internal event when the STO safety is active

To switch the motor on again, you must proceed as follows:

1. Deselect the STO function.
2. Issue an OFF1 command.
3. Acknowledge the internal event:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
     or
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - Further acknowledgment options: Also see Section Fail-safe acknowledgment (Page 193).
4. Switch on the motor (ON command).

5.6.2 Internal event when Safe Speed Monitoring (SSM) is active

Description

If an active safety function with motion monitoring (SS1, SSL, SDI or SSM) is interrupted with an internal event, the converter responds with a STOP F.

Example

The motor behavior is explained using the SSM function and a STOP B with acceleration monitoring as an example:

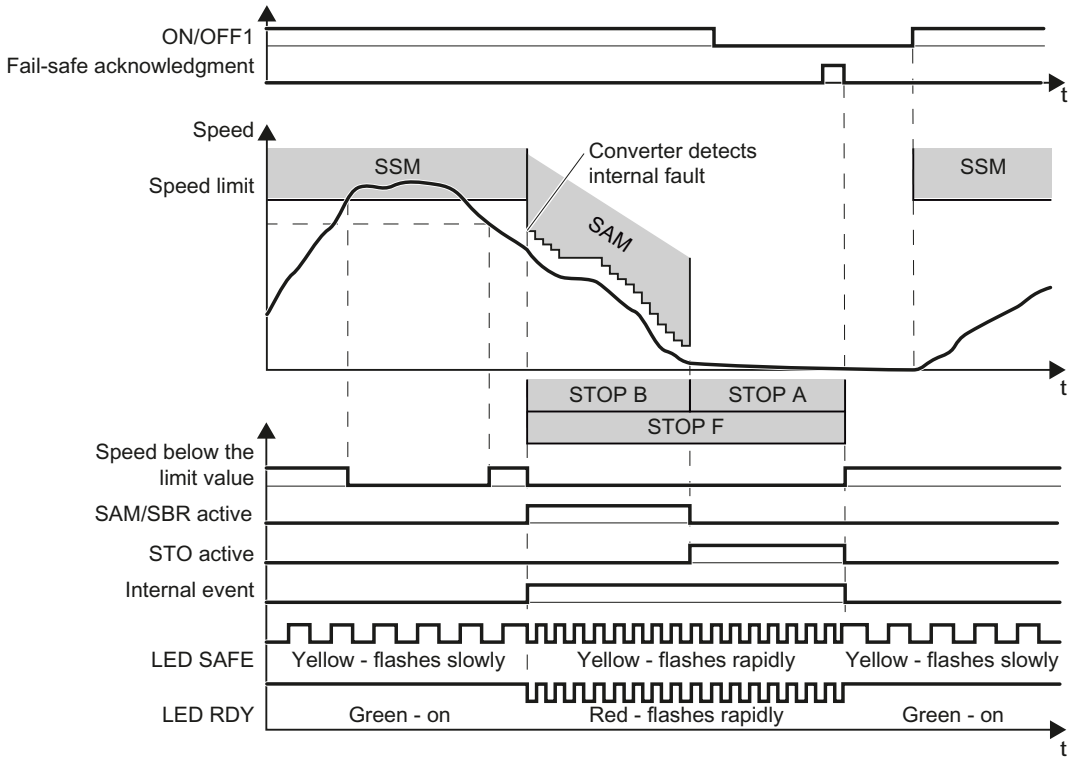


Figure 5-43 Reaction of the SSM safety function to an internal event

To switch the motor on again, you must proceed as follows:

1. Issue an OFF1 command.
2. Acknowledge the internal event:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
     or
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - Further acknowledgment options: Also see Section Fail-safe acknowledgment (Page 193).
3. Switch on the motor. See also Section: Switching the motor off and on again when SSM is active (Page 173).

5.6.3 Limit value violation when Safe Stop 1 (SS1) is active

Description

If the motion monitoring identifies a fault when SS1 is active, then the converter safety switches off the motor torque (STOP A).

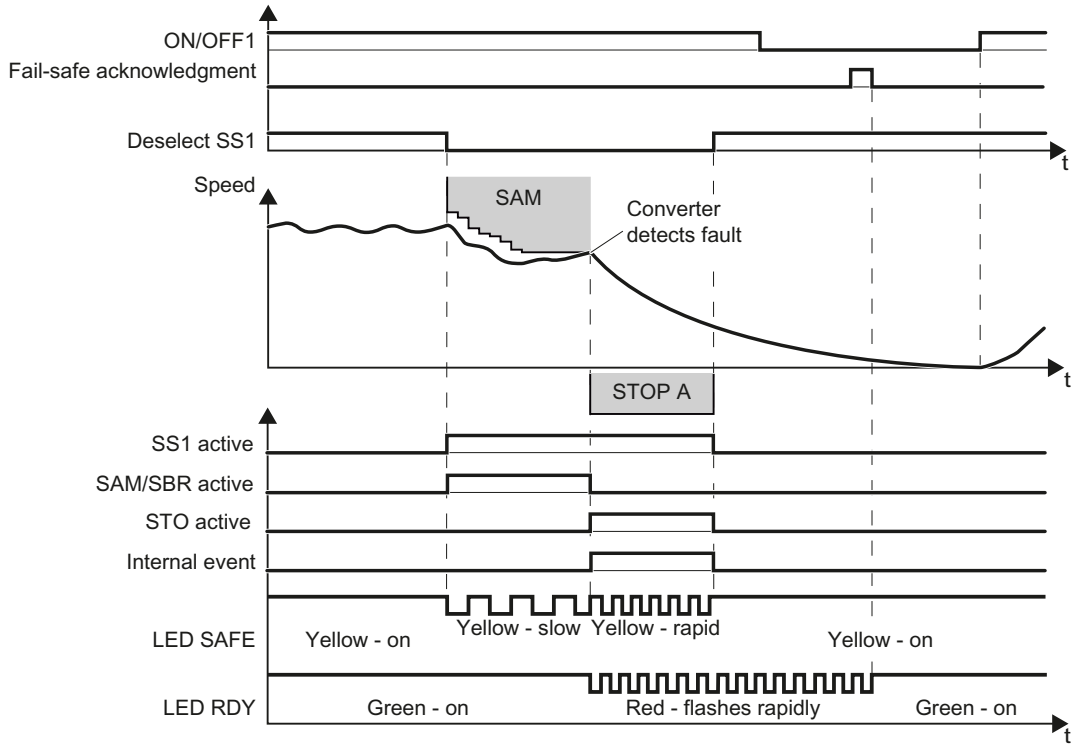


Figure 5-44 General fault response of safety function SS1 (as example: SS1 with acceleration monitoring)

To switch the motor on again, you must proceed as follows:

1. Deselect the SS1 function.
2. Issue an OFF1 command.
3. Acknowledge the internal event:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
     or
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - Further acknowledgment options: Also see Section Fail-safe acknowledgment (Page 193).
4. Switch the motor on again (ON command).

5.6.4 Limit value violation when Safely Limited Speed (SLS) is active

Description

If the motion monitoring identifies an error when SLS is active, then the converter either responds with a STOP A or a STOP B. You select the converter response when commissioning the drive You can find the different STOPversions in Section Stop responses (Page 192).

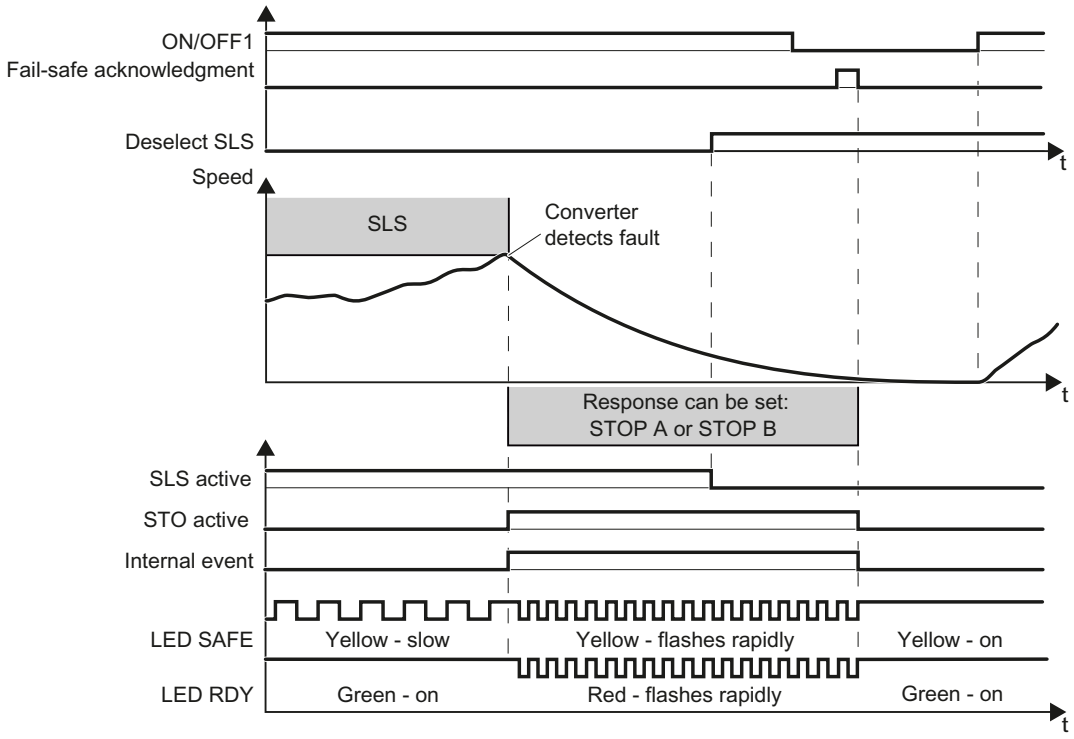


Figure 5-45 Fault response of the SLSsafety function

To switch the motor on again, you must proceed as follows:

1. Deselect the SLS function.
2. Issue an OFF1 command.
3. Acknowledge the internal event:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
     or
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - Further acknowledgment options: Also see Section Fail-safe acknowledgment (Page 193).
4. Switch on the motor (ON command).

5.6.5 Limit value violation when Safe Direction (SDI) is active

Description

If the motion monitoring identifies an error when SDI is active, then the converter either responds with a STOP A or a STOP B. You select the converter response when commissioning the drive You can find the different STOPversions in Section Stop responses (Page 192).

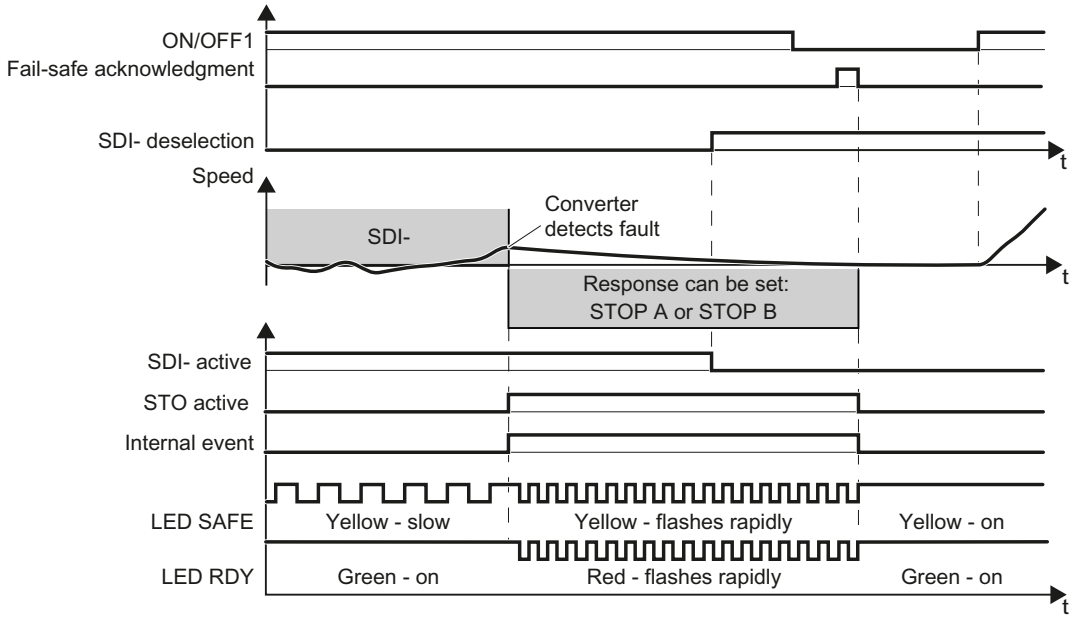


Figure 5-46 Fault response of the SDI safety function

To switch the motor on again, you must proceed as follows:

1. Deselect the SDI function.
2. Issue an OFF1 command.
3. Acknowledge the internal event:
   - Fail-safe acknowledgment via PROFIsafe: Control word 0, bit 7 = 0 → 1 → 0.
     or
   - Fail-safe acknowledgment via a fail-safe input: F-DI = 0 → 1 → 0.
   - Further acknowledgment options: Also see Section Fail-safe acknowledgment (Page 193).
4. Switch on the motor (ON command).

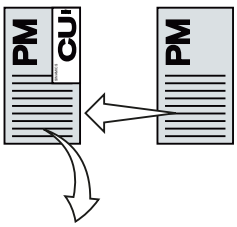
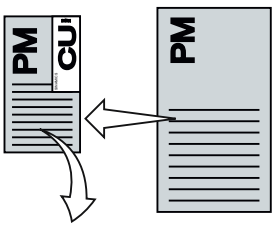
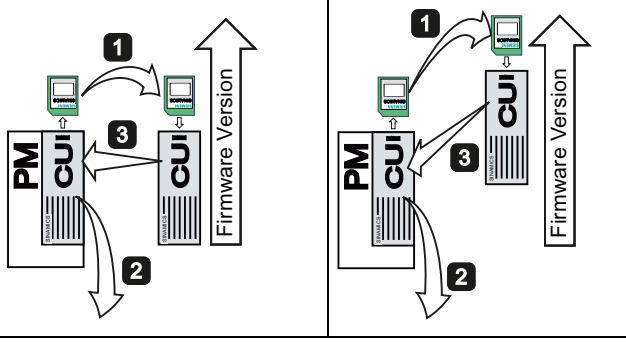
Servicing and maintenance

6

6.1 Replacing components of the modular SINAMICS G120/G120D converter

6.1.1 Overview of replacing converter components

In the event of a permanent function fault, you can replace the converter's Power Module or Control Unit independently of one another. In the following cases, you may immediately switch on the motor again after the replacement.

<table>
<tr><td colspan="2">Replacing the Power Module</td><td colspan="2">Replacing the Control Unit with external backup of the settings, e.g. on a memory card</td></tr>
<tr><td>Replacement:
• Same type
• Same power rating</td><td>Replacement:
• Same type
• Higher power rating</td><td>Replacement:
• Same type
• Same firmware version</td><td>Replacement:
• Same type
• higherfirmware version (e.g. replace FW V4.2 by FW V4.3)</td></tr>
<tr><td> 
</td><td> 
</td><td colspan="2"> 
</td></tr>
<tr><td></td><td>Power Module and motor must be adapted to one another (ratio of motor and Power Module rated power > 1/8)</td><td colspan="2">The converter automatically loads the settings on the memory card into the new CU.
If you have saved the settings of your converter on another medium, e.g. on an operator panel or on a PC, then after the replacement, the settings must be loaded into the converter.</td></tr>
</table>

⚠ WARNING

In all other cases, you must recommission the drive.

6.1.2 Replacing the Control Unit

After commissioning has been completed, we recommend that you back up your settings on an external storage medium, e.g.: on a memory card or the operator panel.

If you do not back up your data, you have to recommission the drive when you replace the Control Unit.

Procedure for replacing a Control Unit with a memory card

- 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.
- Remove the signal cables from the Control Unit.
- Remove the defective CU.
- Mount the new CU onto the Power Module. The new CU must have the same order number and the same or a higher firmware version as the CU that was replaced.
- Remove the memory card from the old Control Unit and insert it in the new Control Unit.
- Reconnect the signal cables of the Control Unit.
- Connect up the line voltage again.
- The converter adopts the settings from the memory card, saves them (protected against power failure) in its internal parameter memory, and switches to "ready to start" state.
- Switch on the motor and check the function of the drive.

Procedure for replacing a Control Unit without a memory card

- 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.
- Remove the signal cables of the Control Unit.
- Remove the defective CU.
- Mount the new CU onto the Power Module.
- Reconnect the signal cables of the Control Unit.
- Connect up the line voltage again.
- The converter goes into the "ready-to-switch-on" state.

- If you have backed up your settings:
  - Load the settings from the operator panel or via STARTER into the converter.
  - For converters of the same type and the same firmware version, you can now switch-on the motor. Check the function of the drive.
  - For a different type of converter, the converter outputs alarm A01028. The alarm indicates that the settings that have been loaded are not compatible with the converter. In this case, clear the alarm with p0971 = 1 and recommission the drive.
- If you have not backed up your settings, then you must recommission the drive.

Inverter with enabled safety functions

If you replace an inverter with enabled safety functions, then you also need to confirm the safety function settings on the new inverter. You will find the procedure in Section: Downloading parameters (Page 123).

Acceptance test

If you activated the safety functions in the inverter, after replacing the inverter you must perform an acceptance test for the safety functions.

- Switch off the inverter supply voltage.
- Wait until all LEDs on the inverter go dark. Now switch on the inverter power supply again (power on reset).
- If you commissioned the inverter for the first time, carry out a **complete** acceptance test, see Full acceptance tests (Page 126).
- In all other cases, after downloading the parameters into the inverter, carry-out a **reduced** acceptance test. The reduced acceptance test is described in Section Reduced acceptance (Page 127).

6.1.3 Replacing the Power Module

Procedure for replacing a Power Module

- Disconnect the Power Module from the line supply.
- If being used, switch off the 24 V supply of the Control Unit.

⚠DANGER

Risk of electrical shock!

Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.

It is not permissible to carry out any installation work before this time has expired!

- Remove the connecting cables of the Power Module.
- Remove the Control Unit from the Power Module.
- Replace the old Power Module with the new Power Module.
- Mount the Control Unit onto the new Power Module.
- Connect up the new Power Module using the connecting cables.
- Switch on the line supply and, if being used, the 24 V supply for the Control Unit.
- If necessary, recommission the drive (also see Overview of replacing converter components (Page 207)).

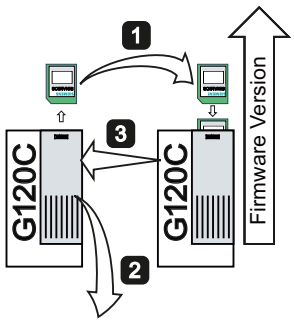
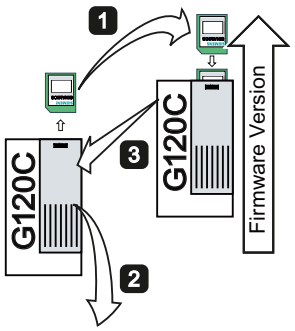
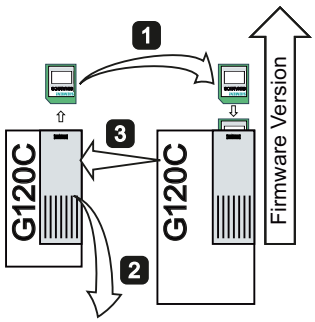
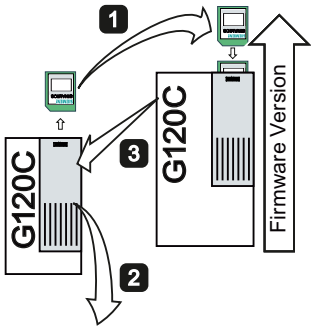
Acceptance test

- Acknowledge the fault code issued by the inverter.
- Perform a reduced acceptance test. The necessary measures are described in Chapter Reduced acceptance (Page 127).

6.2 Replacing the SINAMICS G120C inverter

6.2.1 Overview of how to replace an inverter

You must replace the inverter if it continually malfunctions. In the following cases, you may immediately switch on the motor again after the replacement.

<table>
<tr><td colspan="4">Replacing the inverter with external backup of the settings, e.g. on a memory card.</td></tr>
<tr><td colspan="4">The inverter automatically loads the settings on the memory card.
If you have saved the settings of your inverter on another medium, e.g. on an operator panel or on a PC, then after the replacement, the settings must be loaded into the inverter.</td></tr>
<tr><td>Replacement:
• Same type
• Same power rating
• Same firmware version</td><td>Replacement:
• Same type
• Same power rating
• higher firmware version (e.g. replace FW V4.2 by FW V4.3)</td><td>Replacement:
• Same type
• Higher power rating
• Same firmware version</td><td>Replacement:
• Same type
• Higher power rating
• higher firmware version (e.g. replace FW V4.2 by FW V4.3)</td></tr>
<tr><td> 
</td><td> 
</td><td> 
</td><td> 
</td></tr>
<tr><td colspan="2"></td><td colspan="2">Inverter and motor must be adapted to one another (ratio of the motor and inverter rated power > 1/8)</td></tr>
</table>

⚠ WARNING

In all other cases, you must recommission the drive.

6.2.2 Replacing the inverter

After commissioning has been completed, we recommend that you back up your settings on an external storage medium, e.g.: on a memory card or the operator panel.

Without a data backup, you must recommission the drive after replacing the inverter.

Procedure to replace an inverter with memory card

- Disconnect the line voltage to the inverter.

⚠DANGER

Risk of electrical shock!

Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.

It is not permissible to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the inverter.
- Remove the signal cables of the inverter.
- Remove the defective inverter.
- Mount the new inverter.
- Remove the memory card from the old inverter and insert it in the new inverter.
- Reconnect the signal cables of the Control Unit.
- Reconnect the connectors for line, motor and braking resistor of the inverter.
- Connect up the line voltage again.
- The inverter adopts the settings from the memory card, saves them (protected against power failure) in its internal parameter memory, and switches to "ready to start" state.
- For inverters of the same type and an equal or higher firmware version, you can switch on the inverter without any additional commissioning.
  Alarm A01028 will be output for inverters of different types. This alarm indicates that the parameter settings are not compatible with the inverter. In this case, delete the message using p0971 = 1 and recommission the drive.

Procedure for replacing the inverter without a memory card

- Disconnect the line voltage of the inverter.

⚠DANGER

Risk of electrical shock!

Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.

It is not permissible to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the inverter.
- Remove the signal cables of the inverter.
- Remove the defective inverter.
- Mount the new inverter.
- Reconnect the signal cables of the inverter.
- Reconnect the connectors for line, motor and braking resistor of the inverter.
- Connect up the line voltage again.
- The inverter goes into the "ready-to-switch-on" state.
- If you have saved your settings:
  - Load the settings from the Operator Panel or via the STARTER in your inverter.
  - For inverters of the same type and an equal or higher firmware version, you can now switch on the motor. Check the function of the motor.
    Alarm A01028 will be output for inverters of different types. This alarm indicates that the parameter settings are not compatible with the inverter. In this case, delete the message using p0971 = 1 and recommission the drive.
- If you did not save the parameter setting, you have to recommission the drive.

Inverter with enabled safety functions

If you replace an inverter with enabled safety functions, then you also need to confirm the safety function settings on the new inverter. You will find the procedure in Section: Downloading parameters (Page 123).

Acceptance test

If you activated the safety functions in the inverter, after replacing the inverter you must perform an acceptance test for the safety functions.

- Switch off the inverter supply voltage.
- Wait until all LEDs on the inverter go dark. Now switch on the inverter power supply again (power on reset).
- If you commissioned the inverter for the first time, carry out a **complete** acceptance test, see Full acceptance tests (Page 126).
- In all other cases, after downloading the parameters into the inverter, carry-out a **reduced** acceptance test. The reduced acceptance test is described in Section Reduced acceptance (Page 127).

System events

7

7.1 Operating states indicated on LEDs

The LED RDY (Ready) is temporarily orange after the power supply voltage is switched-on. As soon as the color of the LED RDY changes to either red or green, the LEDs signal the inverter state.

Signal states of the LED

In addition to the signal states "on" and "off" there are two different flashing frequencies:

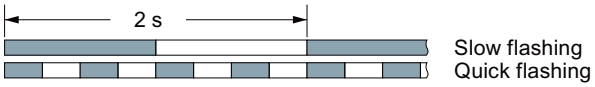


Table 7- 1 Diagnostics of the safety functions

SAFE LED	Meaning
YELLOW - on	One or more safety functions are enabled, but not active.
YELLOW - slow	One or more safety functions are active; no safety function faults have occurred.
YELLOW - rapid	The converter has detected a safety function fault and initiated a STOP response.

7.2 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 converter, detailed causes and remedial measures can be found in the List Manual.

Alarm or fault	Cause	Remedy
	For further information, please refer to the List Manual.	
F01600	STOP A initiated. Fault value r0949 provides more detailed information.	Select STO and then deselect again. If the fault cannot be acknowledged, replace the Control Unit.
F01611	Defect in a monitoring channel. More detailed information is supplied by fault value r0949.	Check the F-DI wiring and set the signal filter (discrepancy, contact bounce or bit pattern test). Switch the Control Unit power supply off and then on again if the fault cannot be acknowledged. Replace the CU if the fault cannot be acknowledged.
A01620, F01620	Safe Torque Off active.	Depends on the triggering message.
F01625	Sign-of-life error in the safety data.	Select STO and then deselect again. Replace the CU if the fault cannot be acknowledged.
F01649	Internal software error	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
F01650	Acceptance test required	Perform a function test, generate an acceptance report and acknowledge the fault.
F01651	Synchronization, safety time slices unsuccessful.	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
F01653	PROFIBUS configuration error	Check the PROFIBUS configuration of the safety slot on the master side and on the Control Unit, and correct if necessary.
F01656	Motor Module parameter error.	Recommission the safety functions. If unsuccessful, replace the CU.
F01659	Write request for parameter rejected.	Check the following: - Password - Reset to the factory setting only when the safety functions have been disabled.
F01665	System is defective.	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
A01666, F01666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI to a logical 0 signal for acknowledging the safety function.
F01680	Checksum error safe monitoring functions.	Check the safety-relevant parameters. Switch the Control Unit power supply off and then on again.

Alarm or fault	Cause	Remedy
	For further information, please refer to the List Manual.	
F01692	Parameter value not permitted for encoderless safety functions.	Correct the parameter value and acknowledge the fault.
A01693, F01693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Then switch the Control Unit power supply off and then on again.
A01697, F01697	Forced checking procedure of the extended functions is required.	Carry out forced checking procedure. The signal source to initiate this is parameterized in p9705.
A01698	Commissioning mode active.	Not necessary.
A01699	Forced checking procedure of the basic functions is required.	Deselect STO and then select again.
C01700 (fault)	STOP A initiated.	Remove the cause that the speed monitoring was exceeded (SLS limit or SDI). Acknowledge fault.
C01701 (fault)	STOP B initiated.	Remove the cause that the speed monitoring was exceeded (SLS limit or SDI). Acknowledge fault.
C01706 (alarm or fault) [1]	SAM/SBR limit exceeded.	Check the braking behavior of the motor and, if necessary, modify the tolerance for parameterizing the "safe braking ramp". [1] Acknowledge the fault.
C01711 (alarm)	Defect in a monitoring channel.	Check the safety function parameters. Increase the actual value tolerance (see SectionSetting the gear ratio and tolerance (Page 87)). Carry out an acceptance test. [1]
C01712 (alarm)	Defect during F-IO processing.	Check the F-DI wiring. Check the safety function parameter assignment. Carry out an acceptance test. [1]
C01714 (alarm)	Safely limited speed exceeded.	Check the speed setpoint from the control. Check and, if necessary, modify the SLS limits. [1]
C01716 (fault)	Tolerance for safe direction of motion exceeded.	Check the tolerance for the "SDI" function and adapt if necessary.
A01772	Test stop fail-safe inputs/outputs active.	The alarm automatically disappears after successfully ending or canceling (error) the forced checking procedure (test stop).
F01773	Test stop error.	Check the fail-safe output wiring and start the forced checking procedure again (test stop). The fault is withdrawn if the test stop was successfully completed.
A01774	Test stop required.	The time to carry out the forced checking procedure (test stop) has expired (p10003). Start the forced checking procedure of the fail-safe output.
C01770 (fault)	Discrepancy error of the fail-safe inputs or outputs.	Check the F-DI wiring. Perform a fail-safe acknowledgement.
F30600	STOP A triggered. More detailed information is provided by fault value r0949.	Select and then deselect STO. Replace the CU if the fault cannot be acknowledged.
F30611	Defect in a monitoring channel. More detailed information is supplied by fault value r0949.	Check the F-DI wiring (discrepancy error). Switch the Control Unit power supply off and then on again if the fault cannot be acknowledged. Replace the CU if the fault cannot be acknowledged.
A30620, F30620	Safe Torque Off active.	Not necessary.

Alarm or fault	Cause	Remedy
	For further information, please refer to the List Manual.	
F30625	Sign-of-life error in the safety data.	Select STO and then deselect again. Replace the CU if the fault cannot be acknowledged.
F30649	Internal software error.	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
F30650	Acceptance test required.	Perform a function test, generate an acceptance report and acknowledge the fault.
F30651	Synchronization with Control Unit unsuccessful.	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
F30656	Motor Module parameter error.	Recommission the safety functions. If unsuccessful, replace the CU.
F30659	Write request for parameter rejected.	Check the following: - Password - Reset to the factory setting only when the safety functions have been disabled.
F30665	System is defective.	Switch the Control Unit power supply off and then on again. Replace the CU if the fault cannot be acknowledged.
A30666, F30666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI to a logical 0 signal for acknowledging the safety function.
F30680	Checksum error safe monitoring functions.	Check the safety-relevant parameters. Switch the Control Unit power supply off and then on again.
F30692	Parameter value not permitted for encoderless safety functions.	Correct the parameter value and acknowledge the fault.
A30693, F30693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Then switch the Control Unit power supply off and then on again.
C30700 (fault)	STOP A initiated.	Remove the cause that the speed monitoring was exceeded (SLS limit or SDI). Acknowledge fault.
C30701 (fault)	STOP B initiated.	Remove the cause that the speed monitoring was exceeded (SLS limit or SDI). Acknowledge fault.
C30706 (alarm or fault) [1]	SAM/SBR limit exceeded.	Check the braking behavior of the motor and, if necessary, modify the tolerance for parameterizing the "safe braking ramp". [1]
C30711 (alarm)	Defect in a monitoring channel.	Check the safety function parameters. Increase the actual value tolerance (see SectionSetting the gear ratio and tolerance (Page 87)). Carry out an acceptance test. [1]
C30712 (alarm)	Defect during F-IO processing.	Check the F-DI wiring. Check the safety function parameter assignment. Carry out an acceptance test. [1]
C30714 (alarm)	Safely limited speed exceeded.	Check the speed setpoint from the control. Check and, if necessary, modify the SLS limits. [1]
C30716 (fault)	Tolerance for safe direction of motion exceeded	Check the tolerance for the "SDI" function and adapt if necessary.
C30770 (fault)	Discrepancy error of the fail-safe inputs or outputs.	Check the F-DI wiring. Perform a fail-safe acknowledgement.

[1] If the safety functions of the converter have been enabled, then this alarm initiates a STOP response and a converter fault.

System properties

8

Response times following activation

The following table contains the response times from when the fail-safe input signal changes or the PROFIsafe telegram is received to initiation of the response.

Table 8- 1 Response times of the basic functions

Function	Response	when activated via ...			
				Typical	Worst case
STO	Motor torque is switched off	… PROFIsafe:		10 ms	10 ms
		… fail-safe input F-DI:		4 ms + t_E [1]	14 ms + t_E [1]
		… PROFIsafe as well as also F-DI			
			PROFIsafe:	10 ms	10 ms
			F-DI:	4 ms + t_E [1]	14 ms + t_E [1]

Table 8- 2 Response times of the extended functions

Function	Response	when activated via ...			
				Typical	Worst case
STO	Motor torque is switched off	… PROFIsafe:		50 ms	54 ms
		… fail-safe input F-DI:		50 ms + t_E [1]	54 ms + t_E [1]
		… PROFIsafe as well as also F-DI			
			PROFIsafe:	50 ms	54 ms
			F-DI:	4 ms + t_E [1]	14 ms + t_E [1]

[1] t_E = debounce time + 1 ms (if debounce time > 0)
t_E = 2 ms (if debounce time = 0)
A description of the debounce time is provided in Section Setting the filter for fail-safe inputs (Page 90).

Response times when limit values are violated

Table 8- 3 Response times until a response is initiated

Function	Response	Typical	Worst case
SLS	STOP A or STOP B	67 ms [2]	113 ms [2]
SDI	STOP A or STOP B		
SSM	Signal change into the "Status SSM"		

[2] If you switch on the motor when a safety function is active, the converter 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 88).

Certifications

The safety functions of the converter fulfill the following requirements:

- Category 3 to EN 954-1 and ISO 13849-1
- Performance level (PL) d according to EN ISO 13849-1
- Safety integrity level 2 (SIL 2) to IEC 61508

Probability of failure

The probability of failure of safety functions must be specified by the machine manufacturer in the form of a PFH value (Probability of Failure per Hour) in accordance with IEC 61508, IEC 62061, and ISO 13849-1.

The integrated converter 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.
- A converter for safely stopping (SS1) a motor on account of the open protective door.

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.

The following applies for the integrated converter safety function:

Safety function	PFH_D
STO, SS1, SLS, SDI, SSM	5×10^{-8}

In the Internet we provide a free tool to calculate the PFH_D value of a complete machine: Safety Evaluation Tool (www.siemens.com/safety-evaluation-tool).

Duration of use

You may not operate converters with integrated safety functions for longer than 20 years. The period of 20 years starts from the delivery date and, for example, cannot be extended by a proof test; this also applies if at some stage you decommission the converter.

Test interval

You must test the safety-relevant circuits of the converter at least once every year. This process is also known as "forced dormant error detection".

Information on the procedure can be found in Section Setting forced dormant error detection (Page 84).

Appendix

A

A.1 Documentation for acceptance

A.1.1 Machine documentation

Machine or system description

Designation	…
Type	…
Serial number	…
Manufacturer	…
End customer	…
Block diagram of the machine or system: … … … … … … …	

Converter data

Table A- 1 Hardware version of the safety-related converter

Labeling the drive	Order number and hardware version of the converter
…	…
…	…

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 active	*Conveyor belt*	*STO*	
Setting up	*Protective door closed*	*Conveyor belt*	*---*	*---*
	Protective door open	*Conveyor belt*	*SLS level 1 (300 rpm)*	
	Emergency Stop button active	*Conveyor belt*	*STO*	

Logging the settings

File name of the log:
…
…

Data backup

Data	Storage medium			Holding area
	Archiving type	Designation	Date	
Logs	…	…	…	…
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.1.2 Log of the settings for the basic functions, firmware V4.4 and V4.5

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 target checksum SI parameters	p9799	<p9799_v>

Table A- 6 Settings of the safety function

Name	Number	Value
SI enable, functions integrated in the drive	p9601	<p9601_v>
SI PROFIsafe address	p9610	<p9610_v>
SI F-DI changeover, tolerance time	p9650	<p9650_v>
SI STO debounce time	p9651	<p9651_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.1.3 Log of the settings for the extended functions, firmware V4.4 and V4.5

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 target checksum SI parameters	p9799	<p9799_v>
SI motion, reference checksum, SI parameters	p9729[0]	<p9729[0]_v>
	p9729[1]	<p9729[1]_v>
	p9729[2]	<p9729[2]_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 cancellation	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>
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>

Name		Number	Value
SI Motion pulse cancellation 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 cancellation shutdown speed		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>
SI PROFIsafe address		p9610	<p9610_v>
SI F-DI changeover, tolerance time		p9650	<p9650_v>
SI STO debounce time		p9651	<p9651_v>
SI forced dormant error detection timer		p9659	<p9659_v>
SI discrepancy monitoring 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>
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

Name		Number	Value
From firmware V4.5	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>

A.2 Standards and specifications

A.2.1 General information

A.2.1.1 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. To ensure this, companies describe in the various standards the current state of the art covering all aspects relevant to safety. When the relevant Standards are observed, this ensures that state-of-the-art technology has been utilized and, in turn, the erector/builder of a plant 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, which is it is important that rules and regulations that have been internationally harmonized are applied. This is also designed to avoid distortions in the competition 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.2.1.2 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 achieve functional safety are based on the following basic goals:

- Avoiding systematic faults
- Controlling 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 minimizing systematic faults. This is expressed in the Standards using different terms. In IEC/EN 61508, IEC/EN 62061, IEC/EN 61800-5-2 "Safety Integrity Level" (SIL) and EN ISO 13849-1 "Categories" and "Performance Level" (PL).

A.2.2 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.2.2.1 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.2.2.2 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 12100-1 (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.2.2.3 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 the safety functions failing is sufficiently minimized. EN ISO 13849-1 (formerly EN 954-1) and EN 62061 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.

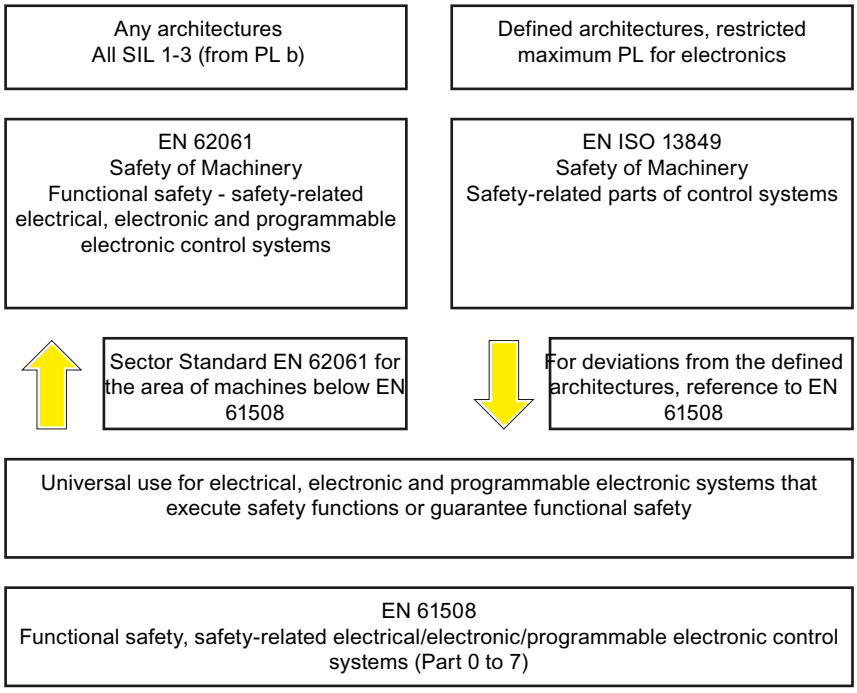


Figure A-1 Standards for implementing safety-related controllers

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.2.2.4 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).

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. In the event of any deviations from this, EN ISO 13849-1 refers to EN 61508.

When combining several safety-related parts to form a complete system, the Standard explains how to determine the resulting PL.

Note

Since May 2007, DIN EN ISO 13849-1 has been harmonized as part of the Machinery Directive.

A.2.2.5 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 lifecycle, 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 requirements regarding the implementation of 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 EN 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 EN 61508 or EN 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. EN ISO 13849-1 must be applied for non-electric systems.

Note

Details of simple sub-systems that have been implemented and integrated are now available as "functional examples".

Note

IEC 62061 has been ratified as EN 62061 in Europe and harmonized as part of the Machinery Directive.

A.2.2.6 Series of standards EN 61508 (VDE 0803)

This series of standards describes the current state of the art.

EN 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 EN 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 case, the manufacturer can use EN 61508, although no presumption of conformity exists here.
- A harmonized European standard (e.g. EN 62061, EN ISO 13849, EN 60204-1) references EN 61508. This ensures that the appropriate requirements of the directives are fulfilled ("standard that is also applicable"). When manufacturers apply EN 61508 properly and responsibly in accordance with this reference, they can use the presumption of conformity of the referencing standard.

EN 61508 covers all the aspects that must be taken into account when E/E/PES systems (**e**lectrical, **e**lectronic, and **p**rogrammable **e**lectronic **S**ystem) 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, as in EN ISO 13849, not part of the standard.

EN 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 EN 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.2.2.7 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 12100-1 "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 14121-1 (previously EN 1050, Paragraph 5) "Safety of machinery - Risk assessment"

EN ISO 12100-1 focuses on the risks to be analyzed and the design principles for minimizing risk. EN ISO 14121-1 describes the iterative process for assessing and minimizing risk to achieve the required level of safety.

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
  - Determining the limits of the machine (EN ISO 12100-1, EN ISO 14121-1 Paragraph 5)
  - Identifying the hazards (EN ISO 12100-1, EN ISO 14121-1 Paragraph 6)
  - Estimating the level of risk (EN 1050 Paragraph 7)
- Risk assessment (EN ISO 14121-1 Paragraph 8)

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.

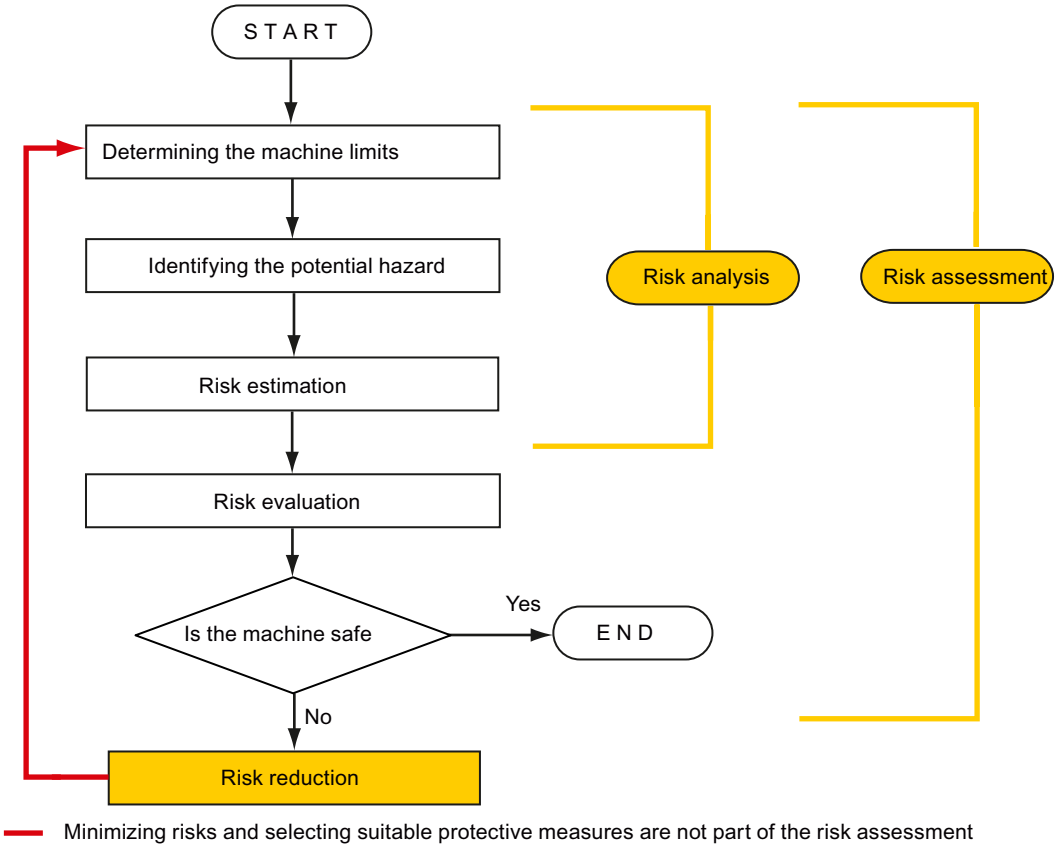


Figure A-2 Iterative process to achieve the required level of safety to ISO 14121-1

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 in accordance with EN ISO 13849-1. For electrical and electronic controls, EN 62061 can be used as an alternative to EN ISO 13849-1. Electronic controls and bus systems must also comply with IEC/EN 61508.

A.2.2.8 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 graph, which can be used instead of the categories to create hierarchical 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 to ISO 14121 (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.2.2.9 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 12100-2).

A.2.3 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.2.3.1 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.2.3.2 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.

A.2.3.3 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). Like 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) cause the system to switch 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 → 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.2.3.4 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.2.4 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
ISO12100-1	JIS B 9700-1	Earlier designation TR B 0008
ISO12100-2	JIS B 9700-2	Earlier designation 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.2.5 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.2.6 Other safety-related issues

A.2.6.1 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.2.6.2 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.

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):

http://www.bg-metall.de/

First select the menu item "Service and Contact", then the Link "Downloads" and finally the category "Information sheets of the specialist committees".

A.3 Additional information on the inverter

A.3.1 Manuals for your inverter

Table A- 15 Manuals for your converter

Information depth	Manual	Contents	Available languages	Download or order number
++	**Getting Started Guide** for the following converters: • SINAMICS G120 with Control Units CU230P-2; CU240B-2; CU240E-2 • SINAMICS G120C • SINAMICS G120D	Installing and commissioning the converter.	Chinese, English, French, German, Italian, Spanish	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 converters: • SINAMICS G120 with the Control Units CU240B-2; CU240E-2 • SINAMICS G120C • SINAMICS G120D with the Control Units CU240D-2 • SINAMICS G120D with the Control Units CU250D-2	Installing and commissioning the converter. Description of the converter functions.		
+++	**Function Manual for Safety Integrated**	(this manual)	English, German	
+++	**List Manual** for the following converters: • SINAMICS G120 with the Control Units CU240B-2; CU240E-2 • SINAMICS G120C • SINAMICS G120D with the Control Units CU240D-2, CU250D-2	Complete list of all parameters, alarms and faults. Graphic function diagrams.	Chinese, English, German	
+	**Getting Started Guide** for the following SINAMICS G120 Power Modules: • PM240, PM250 and PM260 • PM240-2 • PM230	Installing the Power Module	English	

Information depth	Manual	Contents	Available languages	Download or order number
+	**Installation Instructions** for reactors, filters and braking resistors	Installing components		
+++	**Hardware Installation Manual** for the following SINAMICS G120 Power Modules: • PM230 IP20 • PM230 IP55 • 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 kit for IOP		

A.3.2 Configuring support

Table A- 16 Support when configuring and selecting the converter

Manual or tool	Contents	Languages	Download or order number
Catalog D 31	Ordering data and technical information for the standard SINAMICS G converters	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)
Configuration Manual	Selecting geared motors, motors, converters and braking resistor based on calculation examples	English, German	Configuration Manual (http://support.automation.siemens.com/WW/view/en/37728795)

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.3.3 Product Support

If you have further questions

You can find additional information on the product and more in the Internet under: Product support (http://support.automation.siemens.com/WW/view/en/4000024).

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.4 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:documentation.standard.drives@siemens.com)

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