

SINAMICS G120

Frequency inverter
with Control Units

CU240E-2

CU240E-2 DP

CU240E-2 F

CU240E-2 DP-F

Function Manual Safety Integrated · 07/2010



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SINAMICS G120 Safety Integrated Function Manual, SINAMICS G120

Function Manual

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07/2010 Edition, Firmware V4.3.2

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 corresponding 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 for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Introduction

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. It describes the integrated safety functions of the SINAMICS G120 inverter and enables the target groups specified to parameterize and commission the integrated safety functions of the inverter correctly.

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 inverter functions. An overview of the documentation available and the associated applications is provided in the section Overview of documentation (Page 10).

Mistakes and improvements

If you encounter mistakes when reading this manual or if you have any suggestions for how it can be improved, please contact us at the following address or send your suggestion by E-mail:

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Drive Technologies
Motion Control Systems
Postfach 3180
91050 Erlangen, Germany

E-mail (<mailto:documentation.standard.drives@siemens.com>)

If you have further questions

Further information is provided in the STARTER PC tool's online help, the parameter manual and the installation instructions. In addition, you will find Internet product support: Product support (<http://support.automation.siemens.com/WW/view/en/4000024>).

1.2 Guide through this manual

Chapter	Why do you need this information?
Description (Page 15)	This chapter contains detailed information on the safety functions of the inverter.
Activation (Page 43)	If you use the fail-safe inputs of the inverter, this chapter contains a series of wiring examples to help you. Refer to the relevant example for the wiring you require for your particular application. Read the description in this chapter if you want to configure PROFIsafe communication.
Commissioning (Page 69)	This chapter describes the different commissioning methods and helps you choose the most appropriate method for your application.
Alarms, faults and system messages (Page 133)	This chapter contains information on the diagnostics and troubleshooting procedures for the safety functions.
System properties (Page 151)	This chapter provides an overview of all the key properties and data of the safety functions.
Appendix (Page 153)	The appendix contains an overview of the standards and regulations that you, the machine manufacturer or operator, must observe when using the safety functions.

1.3 Overview of documentation

Manuals and software are available for every inverter application:

Table 1- 1 Documentation for SINAMICS G120

Planning and configuring	Installation and connection	Commissioning	Service and maintenance
SIZER engineering tool	---	---	---
Configuration Manual Selecting geared motors, motors and inverters using calculation examples	---	---	---
Hardware Installation Manual, Power Modules Comprehensive information on every Power Module. Available for: <ul style="list-style-type: none"> • PM230 • PM240 • PM250 • PM260 	---	---	Hardware Installation Manual, Power Modules (refer to the lefthand column)

Planning and configuring	Installation and connection	Commissioning	Service and maintenance
Function Manual, Safety Integrated Comprehensive information about the integrated safety functions of the CU240E-2 Control Unit			
Operating instructions Contains extensive information for most applications. Available for the following Control Units: <ul style="list-style-type: none"> • CU230P-2 • CU240B-2 and CU240E-2 • CU240E and CU240S 			
---	---	STARTER Commissioning tool	
Getting Started For entry level personnel to switch on the motor for the first time. Available for Control Units: <ul style="list-style-type: none"> • CU230P-2 • CU240B-2 and CU240E-2 • CU240E • CU240S 			---
---	---	Parameter Manual Contains detailed lists of all parameters, alarms and faults as well as graphic function block diagrams. Available for the following Control Units: <ul style="list-style-type: none"> • CU230P-2 • CU240B-2 and CU240E-2 • CU240E and CU240S 	

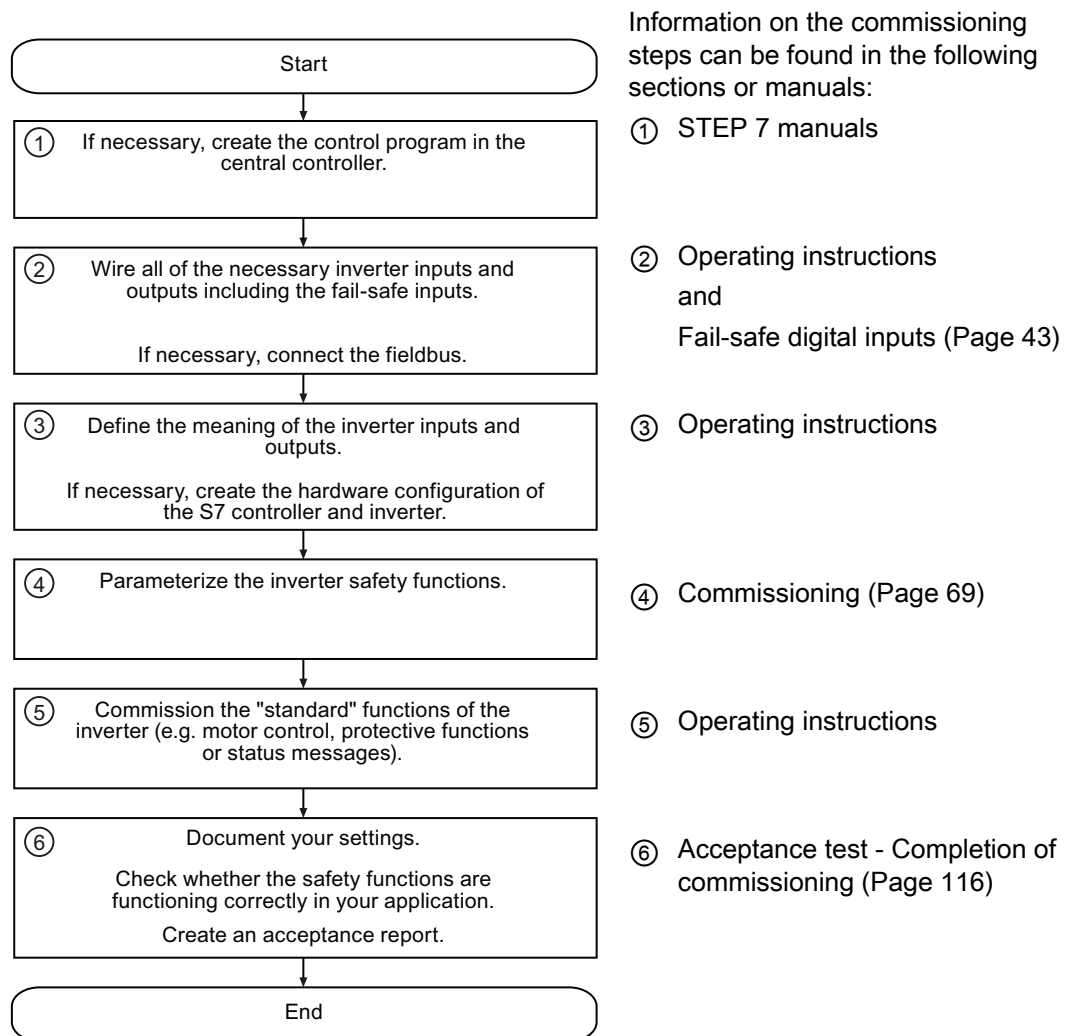
This is how you find the software and the manuals

SIZER	You obtain SIZER on a DVD (Order number: 6SL3070-0AA00-0AG0) and can be downloaded from the Internet: SIZER (http://support.automation.siemens.com/WW/view/en/10804987/130000)
Configuration Manual	You can obtain the Configuration Manual from your local sales office
STARTER	You obtain STARTER on a DVD (Order number: 6SL3072-0AA00-0AG0) and can be downloaded from the Internet: STARTER (http://support.automation.siemens.com/WW/view/en/10804985/130000)
Getting Started	A paper copy of "Getting Started" is provided with each Control Unit
Operating instructions and manuals	All of the manuals can be downloaded from the Internet: Customer support (http://support.automation.siemens.com/WW/view/en/22339653/133300) and are also available on DVD: SD Manual Collection - all of the manuals on low-voltage motors, geared motors and low-voltage inverters, 5 languages <ul style="list-style-type: none"> • Order number: 6SL3298-0CA00-0MG0 (supplied once) • Order number: 6SL3298-0CA10-0MG0 (update service for 1 year; supplied 4 times)

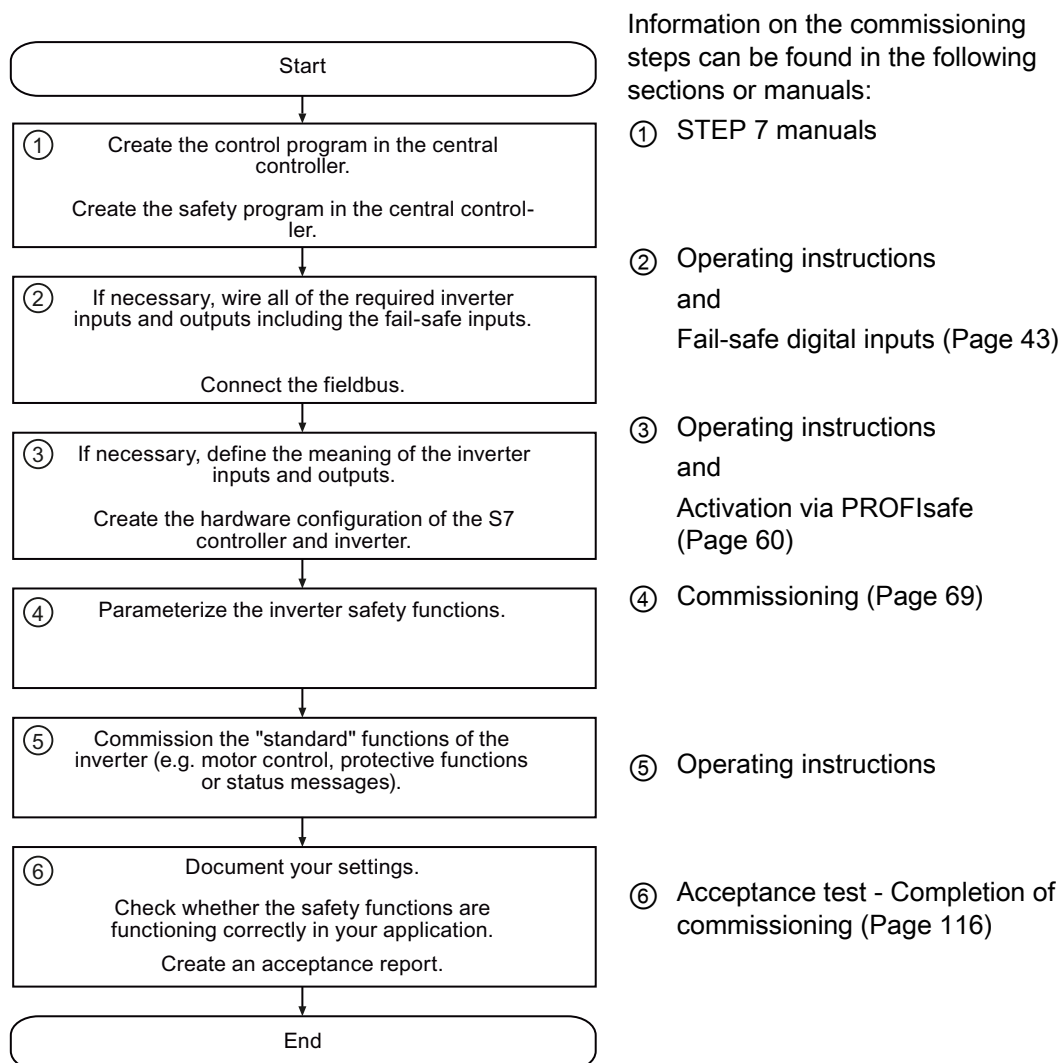
1.4 Commissioning guidelines

The steps for commissioning the safety functions form part of the activities for commissioning the entire drive. Depending on whether you activate the safety functions via fail-safe inputs or connect the inverter to PROFIsafe, we recommend that you use one the following two commissioning procedures.

Activation via fail-safe digital inputs (F-DI)



Activation via PROFIsafe (and, where appropriate, via F-DI)



1.5 Notation

The following notation is used in this documentation:

Notation for parameters:

p0918	Adjustable parameter 918
r1024	Display parameter 1024
p1070[1]	Adjustable parameter 1070, index 1
p2098[1].3	Adjustable parameter 2098, index 1 bit 3
p0099[0...3]	Adjustable parameter 99, indices 0 to 3
p0795.4	Adjustable parameter 795, bit 4

Notation for faults and alarms:

F12345	Fault 12345
A67890	Alarm 67890
C01700	Message 1700 for safety functions

These messages can be faults or alarms, see the sections List of alarms (Page 145) and List of faults (Page 147).

Description

2

	Applications with fixed speed				Applications with variable speed						High-performance and motion control applications				Numeric control in machine tools	
	SIMATIC ET 200S Motorstarter	SIMATIC ET 200pro Motorstarter	SIMATIC ET 200S FC	SIMATIC ET 200pro FC	SINAMICS G120	SINAMICS G120D	SINAMICS G130	SINAMICS G150	SINAMICS S110	SINAMICS S120	SINAMICS S150	SINUMERIK 840D sl	SINUMERIK 840D powerline			
Integrated safety functions (to IEC 61800-5-2)																
STO	Yes				Yes					Yes				Yes		
Safe Torque Off																
SS1	-				Yes					Yes				Yes		
Safe Stop 1																
SFC	-		-		Yes		Yes			Yes				Yes		
Safe Brake Control																
SBT	-		-		-		-			-				Yes		
Safe Brake Test																
SLS	-				Yes					Yes				Yes		
Safely Limited Speed																
SSM	-		-		-		Yes			Yes				Yes		
Safe Speed Monitor																
SOS	-		-		-		Yes			Yes				Yes		
Safe Operating Stop																
SS2	-		-		-		Yes			Yes				Yes		
Safe Stop 2																
SCA	-		-		-		-			-				Yes		
Safe Cam																
SLP	-		-		-		-			-				Yes		
Safely Limited Position																
Fail-safe communication																
PROFIBUS with PROFIsafe profile	Yes				Yes					Yes				Yes		
PROFINET with PROFIsafe profile	Yes				Yes									Yes	-	
Safety Local via F-DI	Yes, external components required		Yes, external components required		Yes		Yes			Yes, external components required in certain cases				Yes	-	
Certification																
EN 954-1	Cat. 4 / PL e				Cat. 3					Cat. 3				Cat. 3		
EN ISO 13849-1	-				Cat. 3 / PLd					Cat. 3 / PL d				Cat. 3 / PL d		
EN 61508	SIL 3				SIL 2					SIL 2				SIL 2		
NFPA 79	Yes				-					Yes				Yes		
NRTL listed	Yes				-					Yes				Yes		

1) only for SINAMICS S120 Booksize

Content of this manual

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

2.1 SINAMICS G120 safety functions

Note

The entries in italics in the following tables apply for Control Units CU240S DP-F and CU240S PN-F. These Control Units are not described in this manual. Information on these Control Units can be found in Function Manual: SINAMICS G120, SINAMICS G120D, SIMATIC ET200S FC, SIMATIC ET200pro FC (<http://support.automation.siemens.com/WW/view/en/31676845>).

Table 2- 1 SINAMICS G120 safety functions

Abbreviation	Description (DE/EN)	Function	Available with Control Unit
STO	Sicher abgeschaltetes Moment Safe Torque Off	The motor is switched safely to zero torque.	CU240E-2 CU240E-2 DP CU240E-2 F CU240E-2 DP-F <i>CU240S DP-F</i> <i>CU240S PN-F</i>
SS1	Sicherer Stopp 1 Safe Stop 1	The motor is shutdown safely. An encoder for measuring the motor speed is not required.	CU240E-2 F CU240E-2 DP-F <i>CU240S DP-F</i> <i>CU240S PN-F</i>
SLS	Sicher begrenzte Geschwindigkeit Safely Limited Speed	The speed of the motor is limited safely. An encoder for measuring the motor speed is not required.	CU240E-2 F CU240E-2 DP-F <i>CU240S DP-F</i> <i>CU240S PN-F</i>
<i>SBC</i>	<i>Sichere Bremsenansteuerung</i> <i>Safe Brake Control</i>	<i>Activation of the motor holding brake is controlled safely.</i>	<i>CU240S DP-F</i> <i>CU240S PN-F</i>

Table 2- 2 Fail-safe communication with SINAMICS G120

Communication	Available with Control Unit
PROFIsafe via PROFIBUS	CU240E-2 DP CU240E-2 DP-F <i>CU240S DP-F</i>
<i>PROFIsafe via PROFINET</i>	<i>CU240S PN-F</i>

Table 2- 3 Certification of SINAMICS G120 safety functions

Standard		Available with Control Unit
<i>EN 954-1</i>	<i>Cat. 3</i>	<i>CU240S DP-F</i> <i>CU240S PN-F</i>
EN ISO 13849-1	Cat. 3 / PL d	CU240E-2 CU240E-2 DP CU240E-2 F CU240E-2 DP-F <i>CU240S DP-F</i> <i>CU240S PN-F</i>
EN 61508	SIL 2	CU240E-2 CU240E-2 DP CU240E-2 F CU240E-2 DP-F <i>CU240S DP-F</i> <i>CU240S PN-F</i>

2.2 Examples of how the safety functions can be applied

Description of problem	Suitable safety function	Solution
When the emergency stop button is pressed, a stationary motor must not start unintentionally.	STO	Activate the inverter via terminals using an emergency stop button.
A central emergency stop button is designed to prevent more than one drive from starting unintentionally.	STO	Evaluate the emergency stop button in a central control, activate the inverter via PROFIsafe.
Having opened a protective door, the machine operator must enter the hazardous zone around a machine and run a conveyor belt at low speed.	SLS	Activate the inverter via terminals using a button to move the conveyor belt.
When a protective door is opened, the motor must be stationary.	SS1	Activate the SS1 function in the inverter and enable the protective door as soon as the inverter signals back "Power removed".

2.3 Preconditions and constraints

2.3.1 General conditions

Prerequisites for using fail-safe functions

1. The machine risk assessment (e.g. in compliance with EN ISO 1050, "Safety of machinery - Risk assessment - Part 1: Principles") allows inverter safety functions to be used in accordance with SIL 2 or PL d.
2. The closed-loop speed control of the inverter 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 inverter operates below its limit values (for current, temperature, voltage, etc.). The drive train comprises an inverter, motor, brake and driven machine. The performance and parameters of the inverter 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 fail-safe inverter 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.


2.3.2 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, encoderless safety functions SS1 and SLS must not be used. 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 and SLS must not be used.
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 and SLS 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 and SLS can be used without restriction.

 WARNING
Synchronous motors
If you operate the inverter with a synchronous motor, encoderless safety functions SS1 and SLS must not be used.

 WARNING
PM240 FSGX Power Module
Encoderless safety functions SS1 and SLS must not be used in conjunction with the PM240 FSGX Power Module.

2.3.3 Impermissible functions

NOTICE
Certain inverter functions can cause significant fluctuations in the motor speed. When safety function SS1 or SLS is active, the monitoring mechanism of the function may be activated or the inverter triggers a STOP F response.
The following inverter functions must not be used when safety function SS1 or SLS is active:
<ul style="list-style-type: none"> • Torque control • Motor identification • Flying restart • DC braking • Compound braking

Furthermore, the control mode must not be switched (either via p1300 or via the DDS changeover function) when SS1 and SLS are active.

More detailed information on the abovementioned inverter functions can be found in the operating instructions.

2.4 Safe Torque Off, STO

STO functions as follows:

- The operator activates the STO safety function via a fail-safe input or via PROFIsafe (safe bus communication).
- The inverter cuts off the motor torque.
- To switch the motor on again, you have to first deactivate STO and then specify the ON command again.

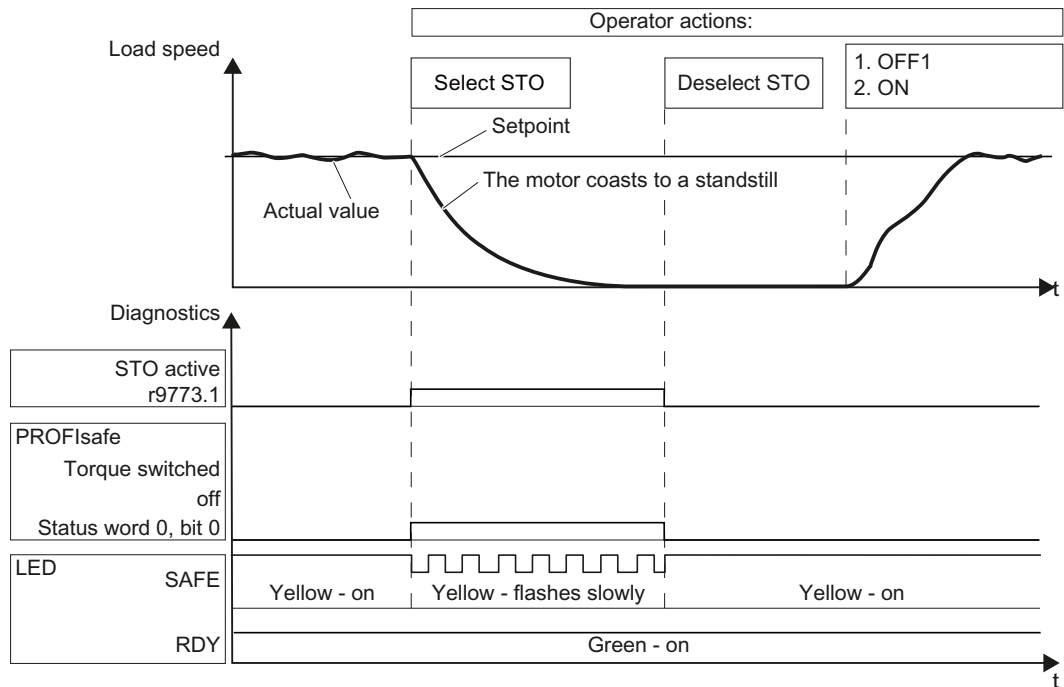


Figure 2-2 Dynamic response of STO (Safe Torque Off)

Diagnostics of the safety functions

- Bit r9773.1 indicates the status of the motor. Bit 0 in PROFIsafe status word 0 has the same function.
- The yellow "SAFE" LED on the front of the Control Unit indicates that one of the safety functions (in this case, STO) has been enabled.
- When the "SAFE" LED flashes slowly, this indicates that one of the safety functions (in this case, STO) is currently active.

2.5 Safe Stop 1, SS1

2.5.1 Basic principle of operation

Safety function SS1 brakes the motor until it virtually reaches a standstill and monitors load speed during the braking operation using the SBR function (Safe Brake Ramp). If the speed is low enough, the inverter cuts off the motor torque.

SS1 monitors the speed but not the direction of rotation.

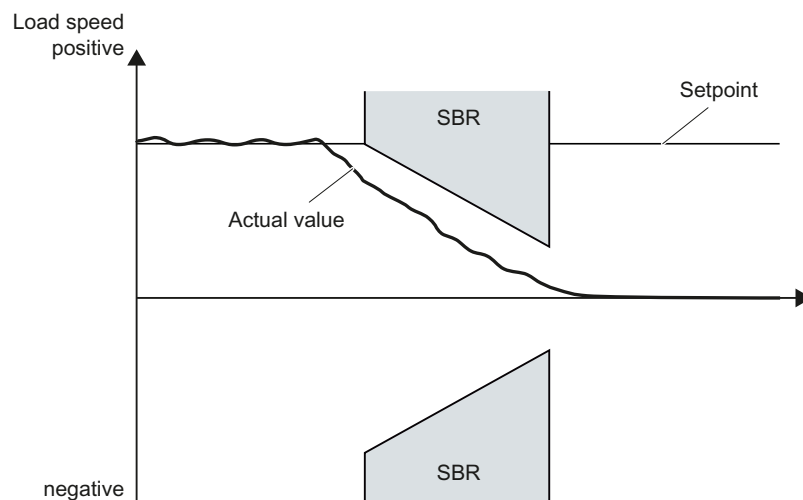


Figure 2-3 Basic principle of operation of SS1

2.5.2 Dynamic response of SS1

The inverter monitors the load speed. To enable the inverter to calculate the load speed from the motor speed, you have to parameterize the gear ratio and the number of motor pole pairs.

SS1 functions as follows:

- The operator selects the SS1 safety function via a fail-safe input or via PROFIsafe (safe bus communication).
 - If the motor torque has already been cut off when SS1 is selected, the inverter safely switches off the motor torque (STO).
 - If the motor is switched on when SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time. The OFF3 ramp-down time is set with parameter P1135.

Note

The motor is decelerated until it reaches a standstill. The braking of the motor cannot be interrupted by deselecting SS1 during braking.

Braking behavior

- During the braking operation, the inverter monitors whether the load speed decreases using the SBR function.
- The inverter uses the values set for the reference speed and SS1 monitoring time parameters for this purpose.
- The SBR function does not start until a definable time (SS1 delay) has elapsed. To begin with, the inverter monitors the speed setpoint that applied when SS1 was selected.
- Once the motor speed has reached a definable threshold ("standstill monitoring"), the inverter safely switches off the motor torque (STO) and the motor coasts to a standstill. Standstill monitoring, which is set via parameters P1226 and P1227, is also active. The motor is always switched off immediately with STO irrespective of how motor standstill is first detected.

Switch on the motor

- To switch the motor on again, you have to first deactivate SS1 and then specify the ON command again.

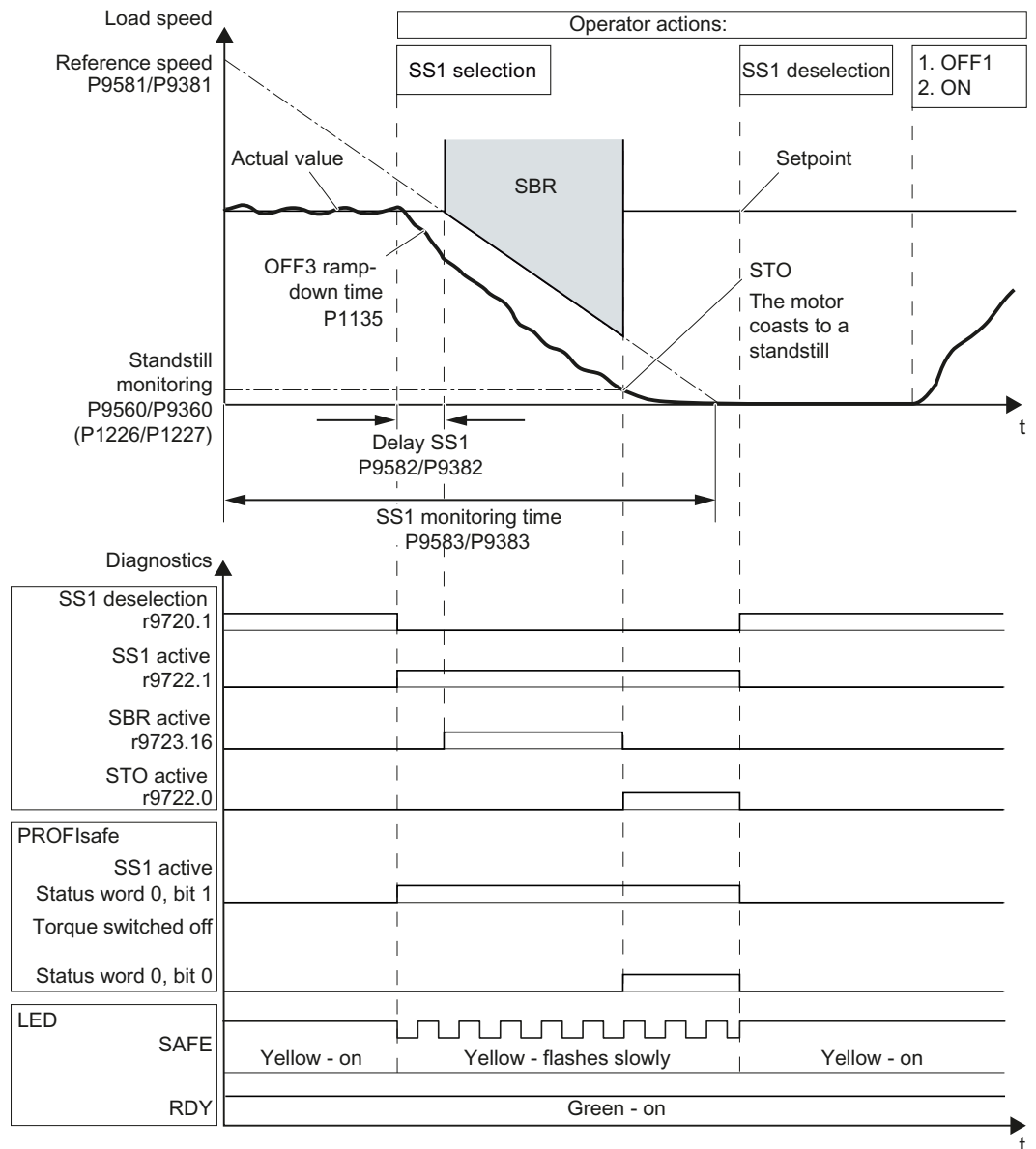


Figure 2-4 Braking behavior and diagnostics of the safety function SS1 (Safe Stop 1)

Diagnostics of SS1:

- When monitoring is active, bit r9722.1 and bit 1 of the PROFIsafe status word 0 are set to "1".
- When the motor or load speed reach the "standstill monitoring" threshold, bit r9722.0 and bit 0 of the PROFIsafe status word 0 (STO active) are set to "1".
- The yellow "SAFE" LED on the Control Unit indicates that one of the safety functions (in this case, SS1) has been enabled.
- When the "SAFE" LED flashes slowly, this indicates that one of the safety functions (in this case, SS1) is currently active.

2.6 Safely Limited Speed, SLS

2.6.1 Basic principle of operation

The SLS safety function continuously monitors the load speed.

SLS also limits the motor speed setpoint internally to ensure that the load speed remains within the monitoring thresholds.

SLS does not monitor the direction of rotation.

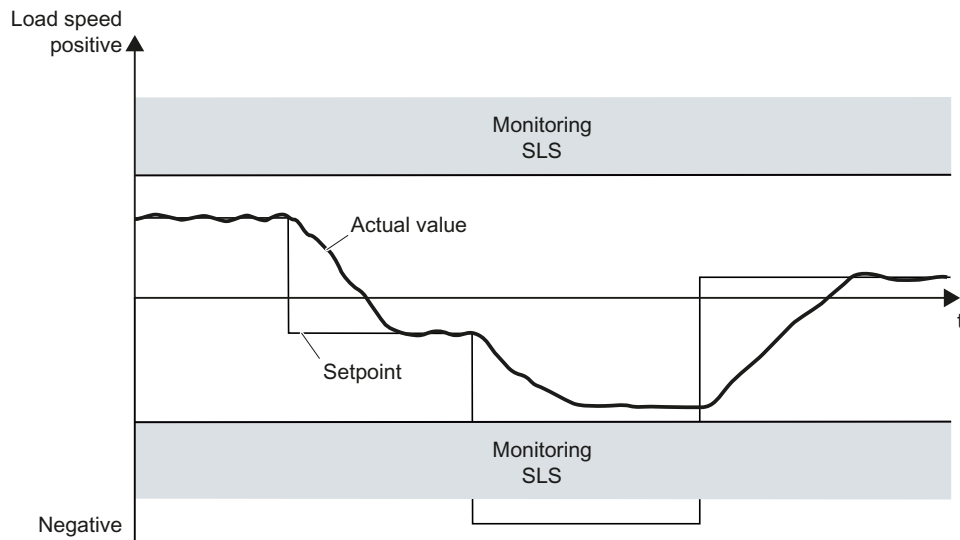


Figure 2-5 Basic principle of operation of SLS

2.6.2 Selecting SLS when the motor is switched on

The inverter monitors the load speed. To enable the inverter to calculate the load speed from the motor speed, you have to parameterize the gear ratio and the number of motor pole pairs.

SLS functions as follows:

- The operator selects the SLS safety function via a fail-safe input or via PROFIsafe (safe bus communication).
 - If the motor torque has already been cut off when SLS is selected, you must switch on the motor within 5 seconds. Further information can be found in the section Switching on the motor when SLS is active (Page 27).
 - If the motor has already been switched on when SLS is selected, the motor behaves differently depending on the load speed. These two scenarios are described below.

Scenario 1: The load speed is below the monitoring threshold.

- The motor speed continues to follow the setpoint as long as the load speed does not overshoot the upper speed limit.
- The inverter does not start monitoring the load speed until a definable time (SS1 delay) has elapsed. The delay is the same as that for the SS1 function.
- When you deselect SLS, the motor continues following its speed setpoint.

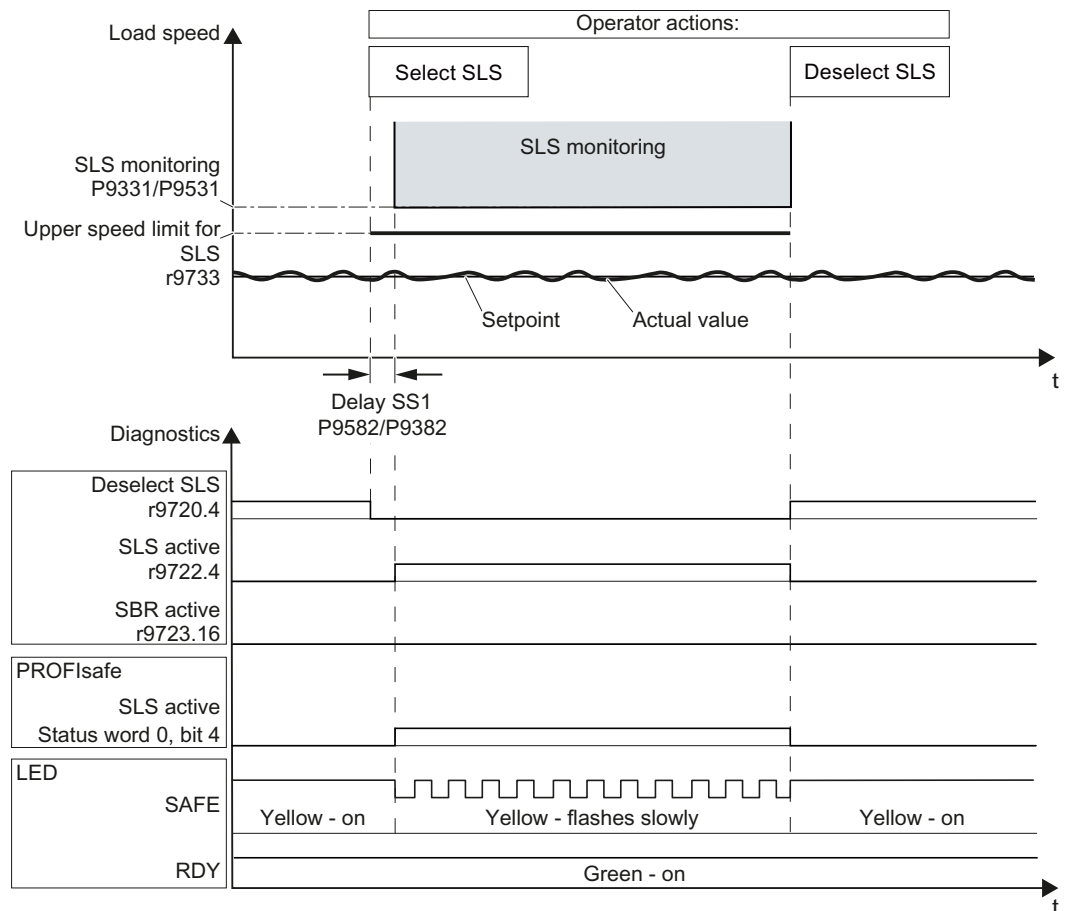


Figure 2-6 Selecting and deselecting the SLS safety function at low speeds

Diagnostics of the safety functions

- Bit r9722.4 and bit 4 of the PROFIsafe status word 0 indicate whether load speed monitoring is active.
- The yellow "SAFE" LED on the front of the Control Unit indicates that one of the safety functions (in this case, SLS) has been enabled.
- When the "SAFE" LED flashes slowly, this indicates that one of the safety functions (in this case, SLS) is active.

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

- After SLS has been selected, the inverter brakes the motor immediately with the OFF3 ramp-down time.
- After a definable "SS1 delay" has elapsed, the inverter uses the SBR (Safe Brake Ramp) function to determine whether the load speed has decreased. The delay is the same as that for the SS1 function.
- The inverter switches from SBR monitoring to "SLS monitoring" as soon as one of the following two conditions is fulfilled:
 - The SBR ramp has reached the "SLS monitoring" value.
 - The load speed has decreased to the "SLS monitoring" value and the "SS1 delay" has elapsed. This case is illustrated in the diagram below.
- When you deselect SLS, the motor continues following its speed setpoint.

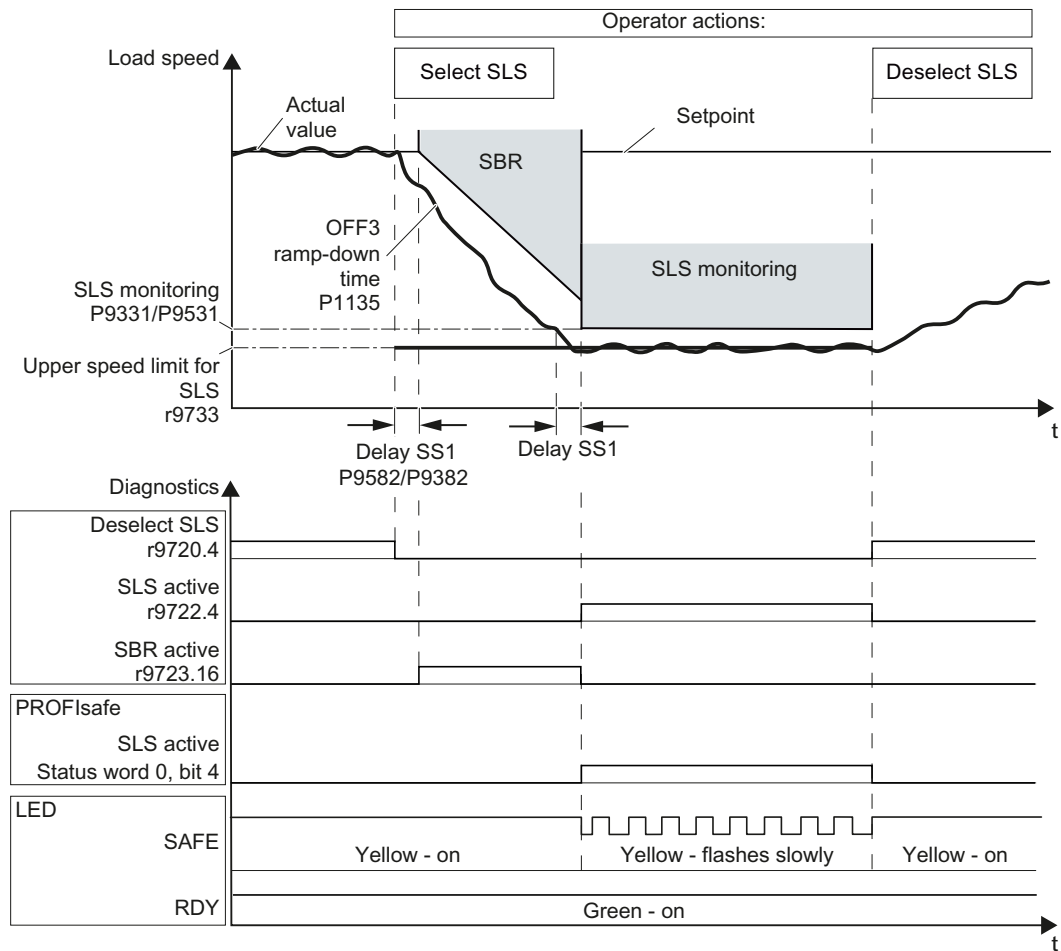


Figure 2-7 Selecting and deselecting the SLS safety function at high speeds

Diagnostics of the safety functions

- Bit r9722.4 and bit 4 of the PROFIsafe status word 0 indicate whether load speed monitoring is active.
- The yellow "SAFE" LED on the front of the Control Unit indicates that one of the safety functions (in this case, SLS) has been enabled.
- When the "SAFE" LED flashes slowly, this indicates that one of the safety functions (in this case, SLS) is active.

2.6.3 Switching on the motor when SLS is active

In certain applications, the motor may only be switched on when SLS is active, for example, when a machine operator runs a conveyor belt in the hazardous zone.

Since the safety functions are implemented without an encoder, the inverter does not have any information on the current speed when the motor torque has been cut off. To switch on the motor when the SLS safety function is active, you have to issue commands to the inverter in a specific chronological order.

Dynamic response

- Activate SLS.
- Switch on the motor within 5 seconds (ON command).

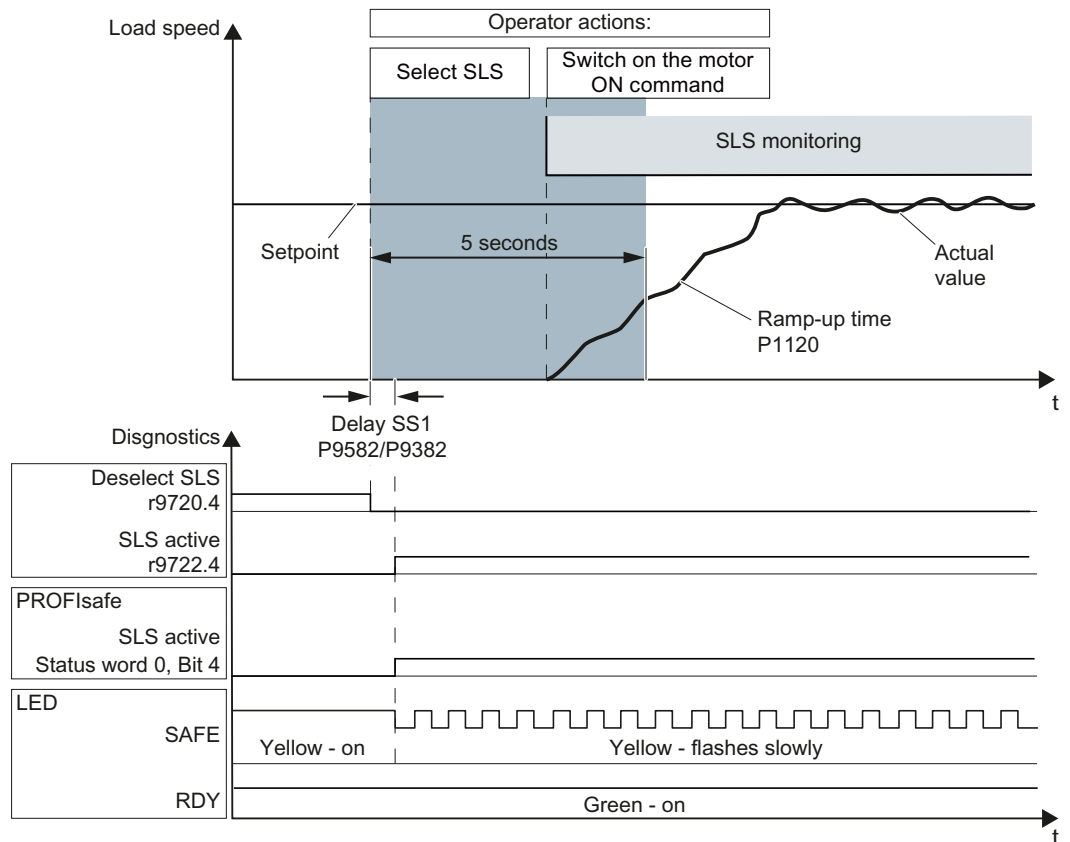


Figure 2-8 Switching on the motor when SLS is active

If you do not switch on the motor within 5 seconds, the inverter switches to the STO status and does not respond to the ON command. To switch the motor on again, proceed as follows:

- Activate STO.
- Deactivate STO.
- After you have deactivated STO, switch on the motor within 5 seconds (ON command).

Further information on switching the motor off and on when SLS is active can be found in the following sections:

- Switching off the motor when SLS is active (Page 37)
- Switching the motor on and off when SLS is active (Page 39)

2.6.4 Switching between monitoring thresholds

When SLS is active, you can switch between four different monitoring thresholds.

Note

This is only possible via PROFIsafe.

PROFIsafe control word 0		Active monitoring threshold
Bit 9	Bit 10	
0	0	P9331[0], P9531[0]
1	0	P9331[1], P9531[1]
0	1	P9331[2], P9531[2]
1	1	P9331[3], P9531[3]

Behavior of SLS when the monitoring thresholds are switched

The drive behaves as follows when you switch from a higher to a lower monitoring threshold:

- The inverter switches the speed setpoint limit (r9733) to a lower value.
- The inverter brakes the motor with the OFF3 ramp-down time.
The OFF3 ramp-down time is set with parameter P1135.
- Once the delay (SS1 delay) has elapsed, the inverter starts monitoring the braking operation (Safe Brake Ramp (SBR)).
- The inverter switches from SBR monitoring to "SLS monitoring" as soon as one of the following two conditions is fulfilled:
 - The SBR ramp has reached the "SLS monitoring" value.
 - The load speed has decreased to the "SLS monitoring" value and the "SS1 delay" has elapsed. This case is illustrated in the diagram below.

The drive behaves as follows when you switch from a lower to the higher monitoring threshold:

- The inverter switches the speed setpoint limit (r9733) to the higher value.
- The inverter immediately switches the monitoring threshold to the higher value.

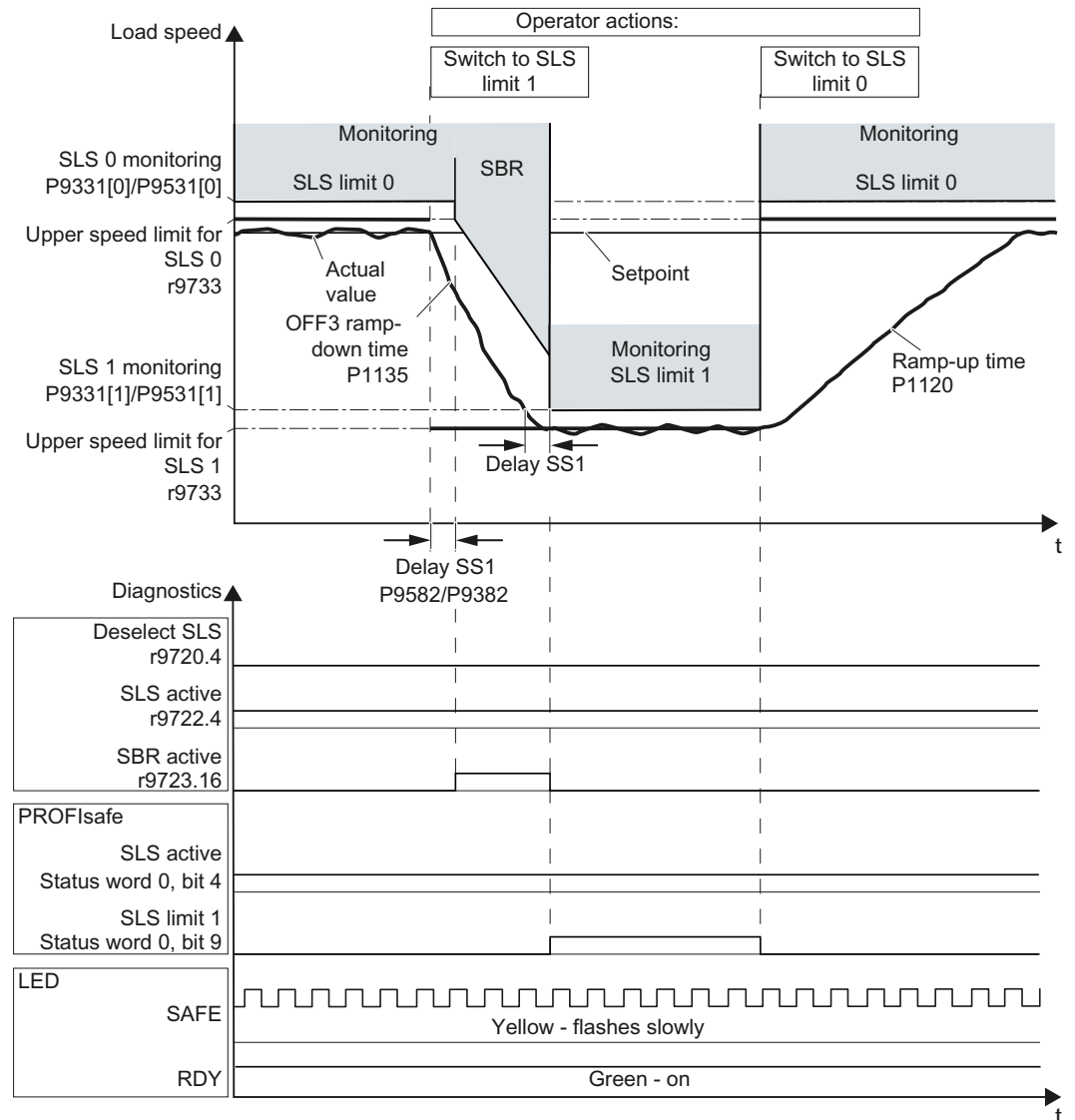


Figure 2-9 Switching between different monitoring thresholds

Diagnostics of the safety functions

- Bit r9723.16 indicates the status of the SBR function for the monitored braking operation.
- As soon as the load speed falls below the monitoring threshold, the relevant bit is set in PROFIsafe status word 0.
The selected SLS monitoring threshold is confirmed by bits 9 and 10 in PROFIsafe status word 0.

PROFIsafe status word 0		Active SLS limit
Bit 9	Bit 10	
0	0	P9331[0], P9531[0]
1	0	P9331[1], P9531[1]
0	1	P9331[2], P9531[2]
1	1	P9331[3], P9531[3]

- When the "SAFE" LED flashes slowly, this indicates that one of the safety functions (in this case, SLS) is currently active.

2.7 Interrupting safety functions

2.7.1 Selecting STO when SS1 is active

If you select the safety function STO when SS1 is already active, the inverter cuts off the motor torque immediately. The motor then coasts to a standstill.

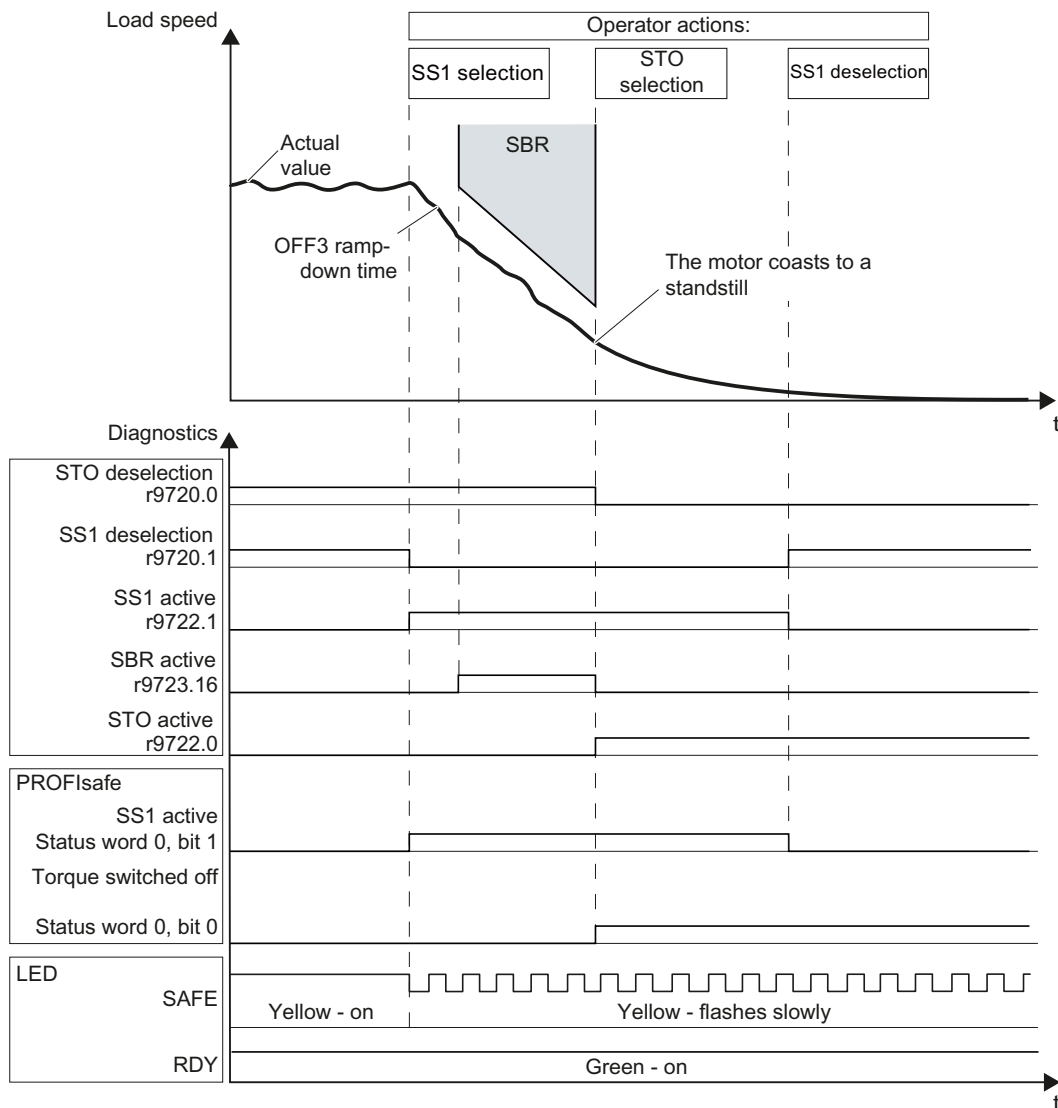


Figure 2-10 Selecting STO when SS1 is active

To switch the motor on again, proceed as follows:

- Deselect the STO and SS1 safety functions.
- Specify the OFF1 command.
- Switch on the motor (ON command).

2.7.2 Selecting STO when SLS is active

If you select the safety function STO when SLS is already active, the inverter cuts off the motor torque immediately. The motor then coasts to a standstill.

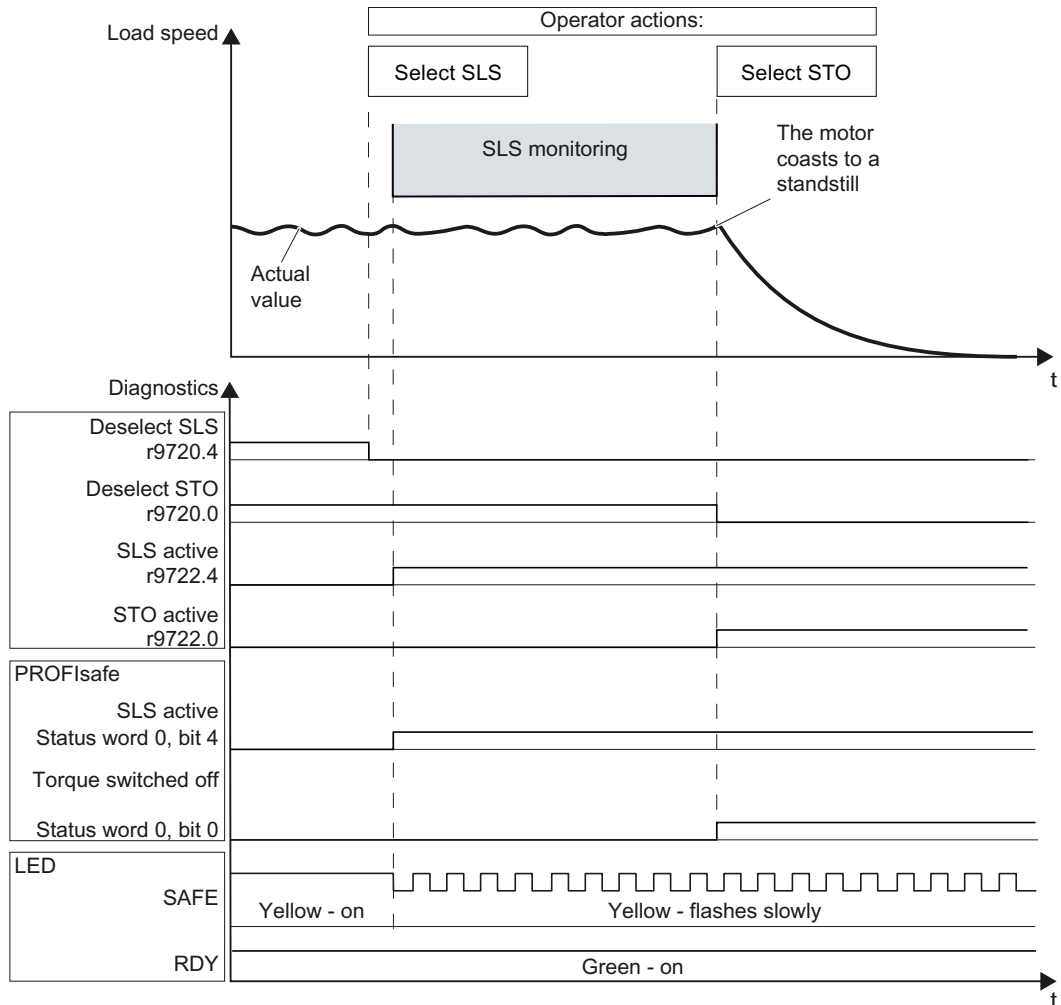


Figure 2-11 Selecting STO when SLS is active

You can switch the motor on again in one of two ways:

Proceed as follows if you want to deselect SLS:

- Specify the OFF1 command.
- Deselect the STO and SLS safety functions.
- Switch on the motor (ON command).

Proceed as follows if SLS is to remain active when the motor is switched on:

- Specify the OFF1 command.
- Deselect STO.
- Switch on the motor within 5 seconds (ON command).
Further information can be found in the section Switching on the motor when SLS is active (Page 27).

2.7.3 Selecting SS1 when SLS is active

If you select the safety function SS1 when SLS is already active, the inverter brakes the motor with the OFF3 ramp-down time and monitors the braking operation. When the standstill detection threshold is reached, the inverter cuts off the motor torque. The motor then coasts to a standstill.

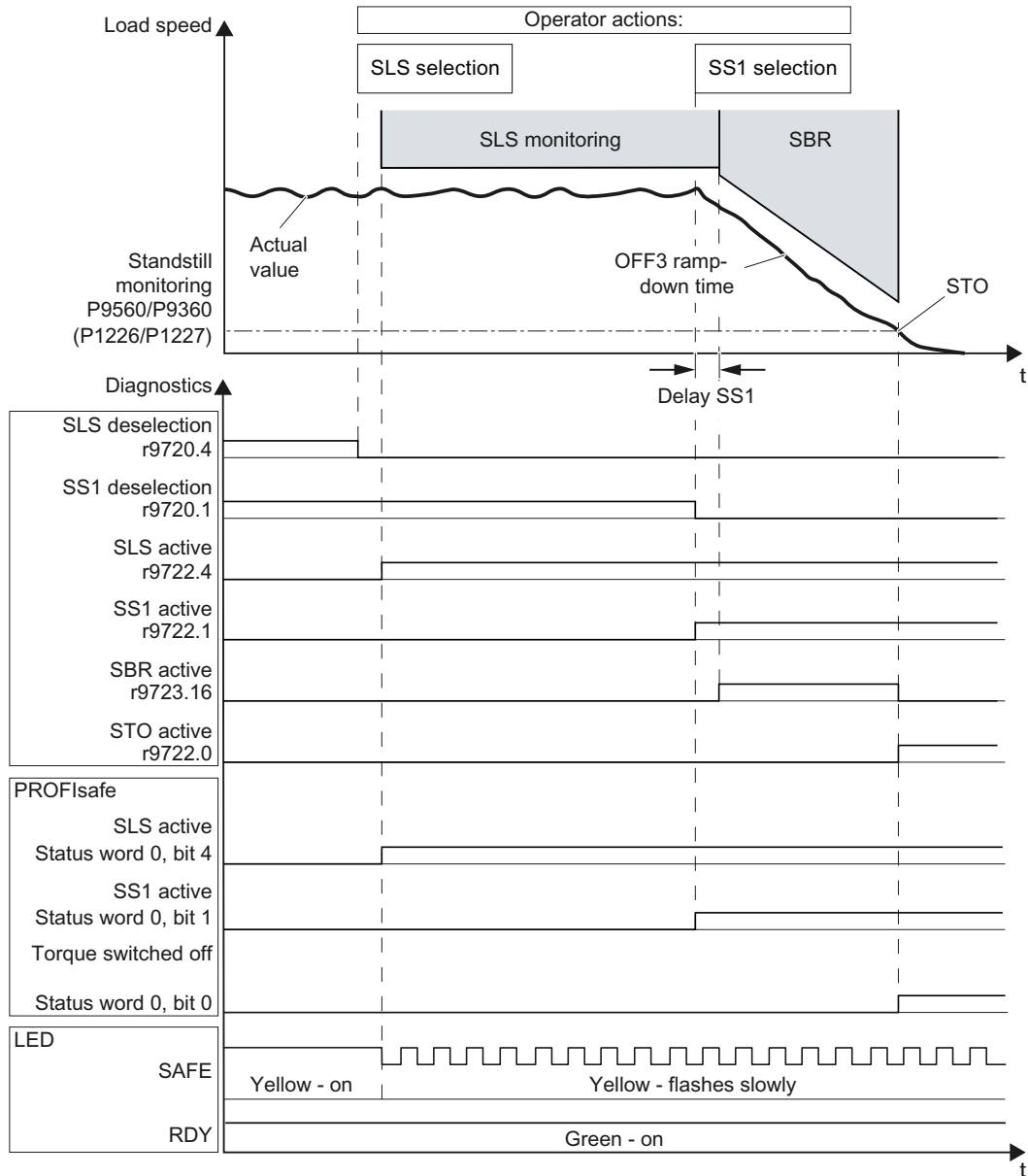


Figure 2-12 Selecting SS1 when SLS is active

You can switch the motor on again in one of two ways:

Proceed as follows if you want to deselect SLS:

- Specify the OFF1 command.
- Deselect the SS1 and SLS safety functions.
- Switch on the motor (ON command).

Proceed as follows if SLS is to remain active when the motor is switched on:

- Specify the OFF1 command.
- Deselect SS1.
- Switch on the motor within 5 seconds (ON command).
Further information can be found in the section Switching on the motor when SLS is active (Page 27).

2.7.4 Switching off the motor when SS1 is active

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

If you switch the motor off with the OFF2 command when SS1 is active, the inverter cuts off the motor torque immediately (STO). The motor then coasts to a standstill.

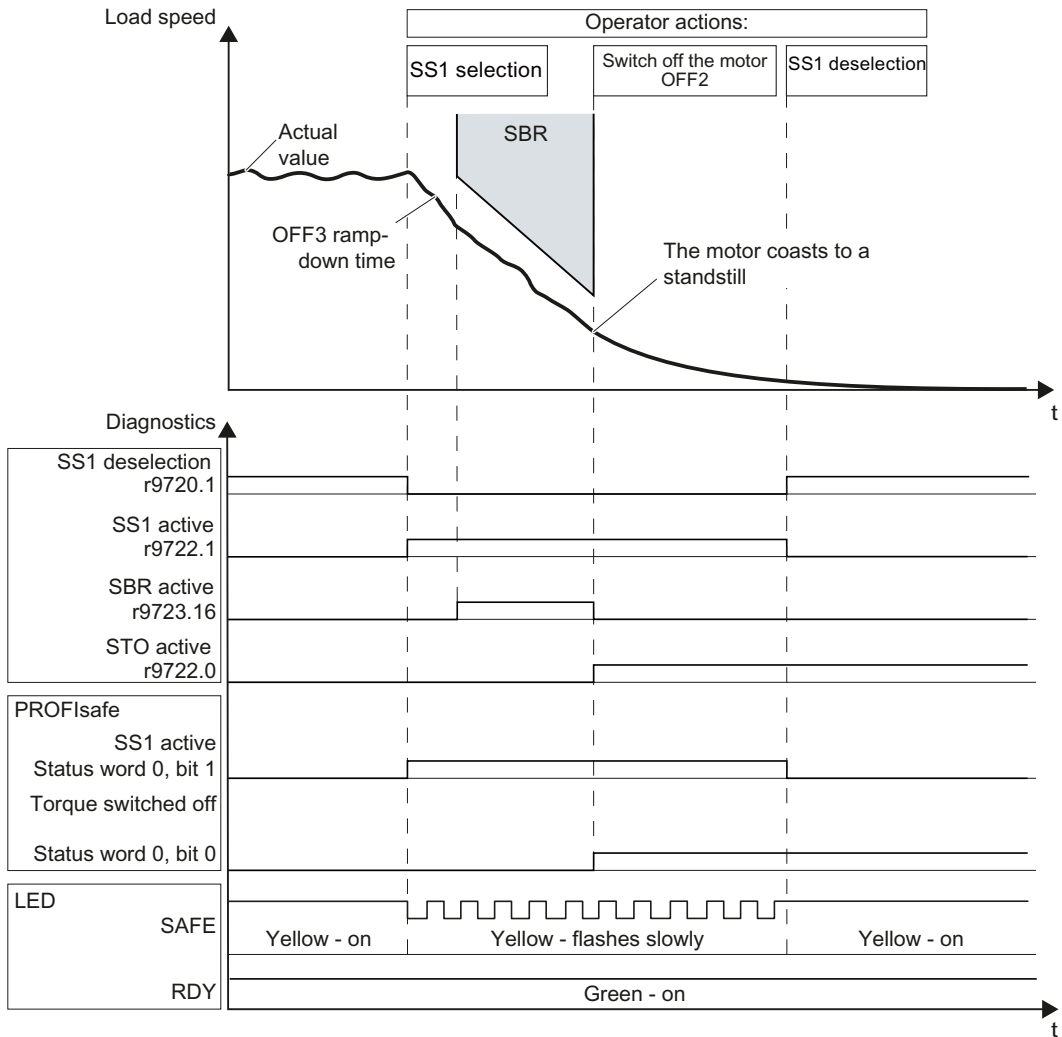


Figure 2-13 OFF2 command when the SS1 safety function is active

To switch the motor on again, proceed as follows:

- Deactivate SS1.
- Specify the OFF1 command.
- Switch on the motor (ON command).

2.7.5 Switching off the motor when SLS is active

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, the inverter brakes the motor with the OFF1 or OFF3 ramp-down time. The inverter monitors the motor speed to determine whether the permissible limit is overshoot during the braking operation as well.

When the standstill detection threshold is reached, the inverter cuts off the motor torque. The motor then coasts to a standstill.

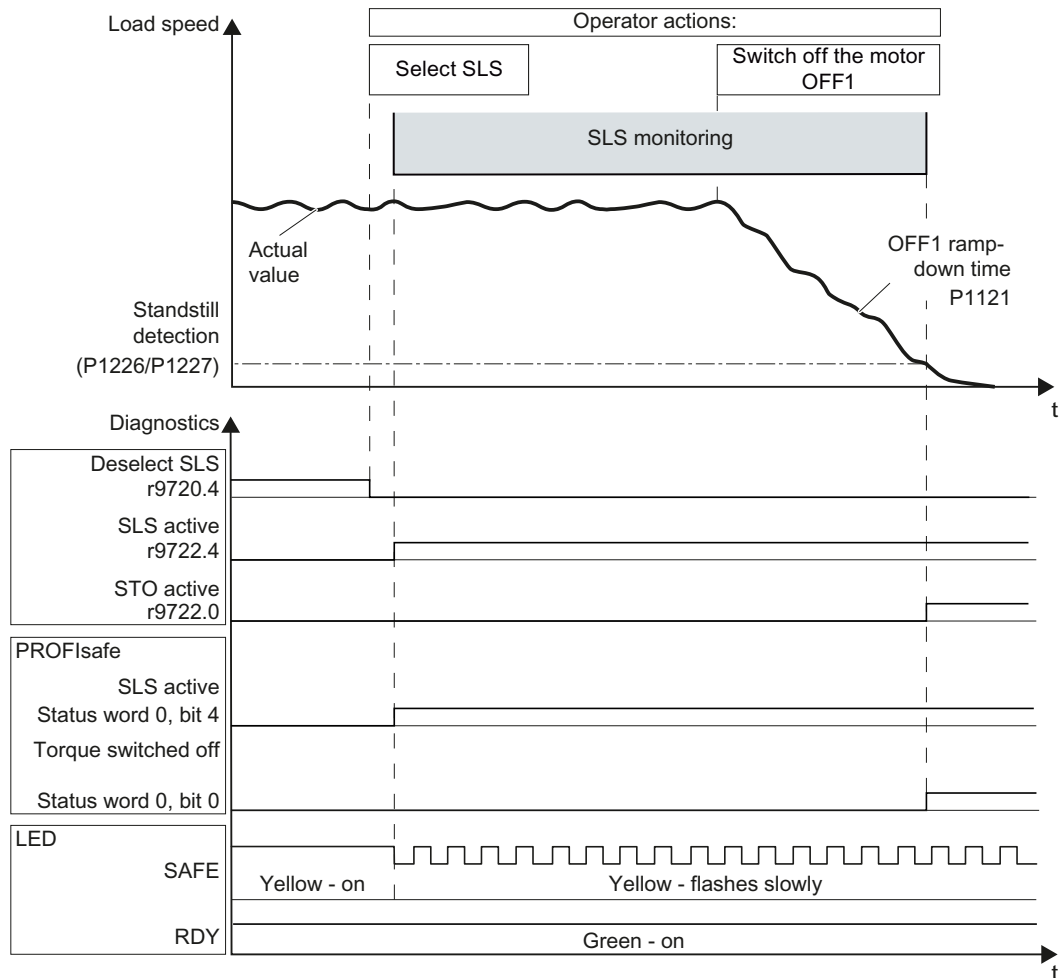


Figure 2-14 OFF1 command when the SLS safety function is active

If you also issue the OFF2 command when SLS is active, the inverter cuts off the motor torque immediately (STO). The motor then coasts to a standstill.

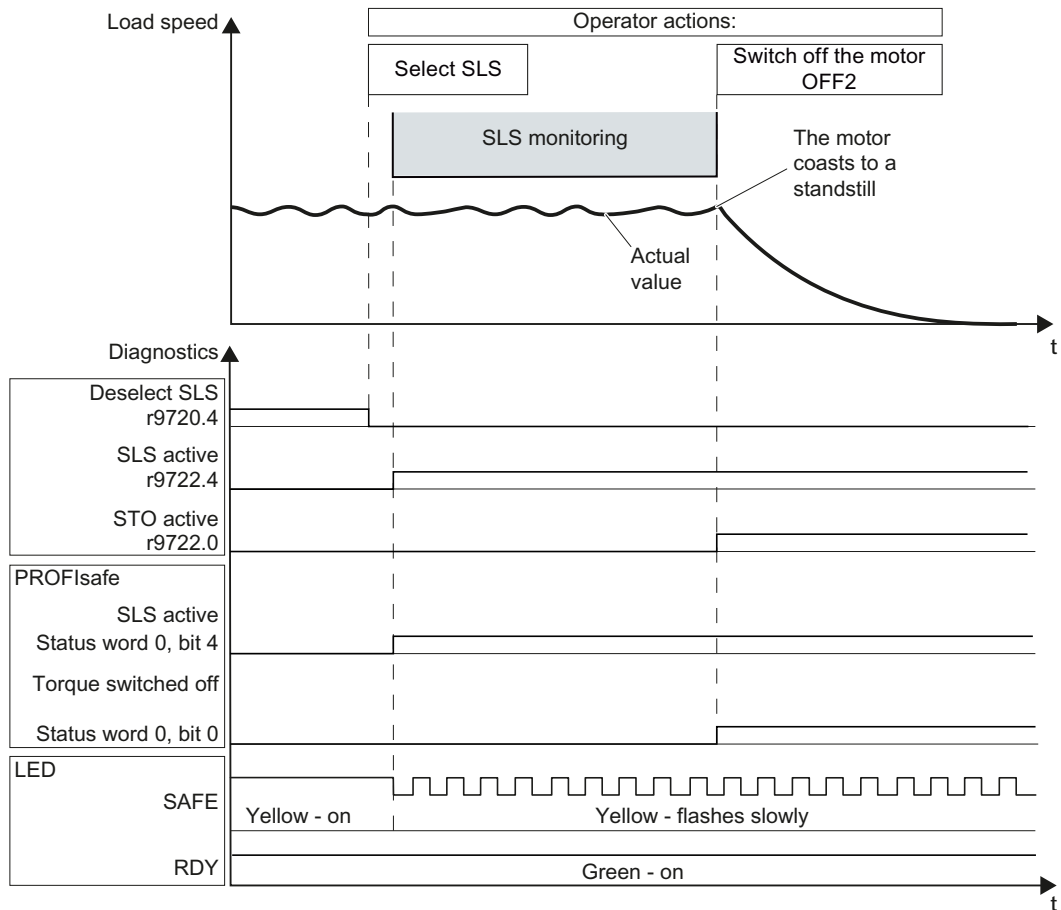


Figure 2-15 OFF2 command when the SLS safety function is active

To switch the motor on again, proceed as follows:

- Deselect SLS.
- Specify the OFF1 command.
- Switch on the motor (ON command).

The section Switching on the motor when SLS is active (Page 27) describes how to switch the motor on again when SLS is active.

2.7.6 Switching the motor on and off when SLS is active

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, activate STO.
- Deselect STO before switching the motor on again.
- Switch on the motor within 5 seconds (ON command).

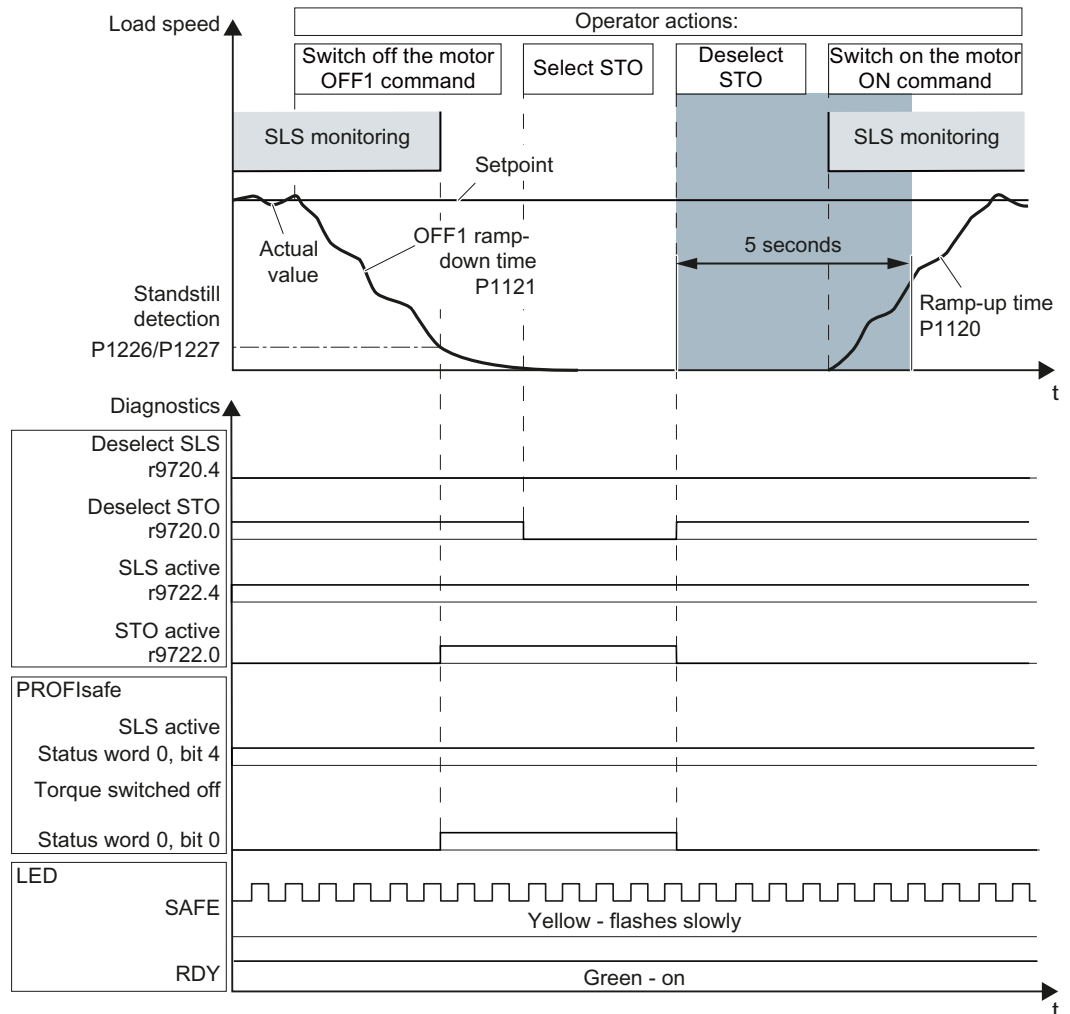


Figure 2-16 Switching the motor on and off when SLS is active

If you do not switch on the motor within 5 seconds, the inverter switches to the STO status again and does not respond to the ON command. To switch the motor on again, proceed as follows:

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

2.8 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.

The factory setting for the password is "0". During commissioning, choose your password from the permissible range 1 ... FFFF FFFF.

2.9 Checksum

Each parameter of the safety functions is available twice. Following commissioning, the inverter permanently monitors the parameters for any unwanted changes by means of checksums (Cyclic Redundancy Check, CRC).

During commissioning, you set only one of the two redundant parameters at a time. Once commissioning is complete, duplicate all parameters of the safety functions using a copy function.

2.10 Forced dormant error detection

To fulfill the requirements of standards EN 954-1, ISO 13849-1 and IEC 61508 regarding timely error detection, the inverter must regularly test its safety-relevant circuits to ensure that they function correctly - this must be performed at least once every year.

Forced dormant error detection (test stop)

The inverter monitors the regular test of its safety-relevant circuits, which monitor the speed of the motor and which switch off the motor torque.

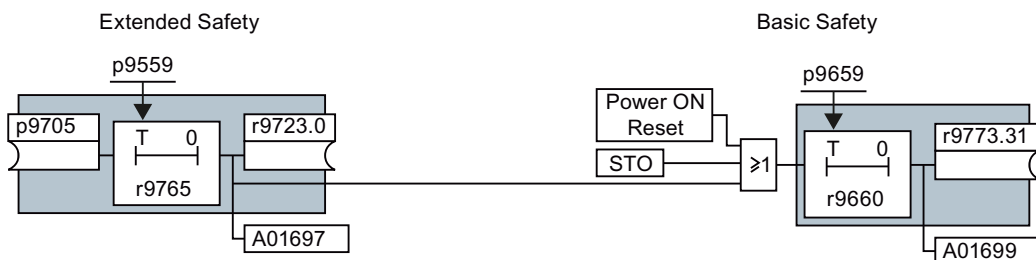


Figure 2-17 Forced dormant error detection

Table 2- 4 Triggering and monitoring the forced dormant error detection

Extended Safety	Basic Safety
<p>You define the signal with which the inverter tests its circuits for speed monitoring.</p> <p>If you select the forced dormant error detection, the inverter will check the circuits of both Extended Safety and Basic Safety.</p>	<p>The inverter checks its circuits used to switch off the torque if one of the following conditions exists:</p> <ul style="list-style-type: none"> • After the power supply has been connected (Power ON Reset). • Each time after the STO.function has been selected. • In the event of forced dormant error detection of Extended Safety.
r9765 contains the remaining monitoring time.	r9660 contains the remaining monitoring time.
The inverter signals that the monitoring time has come to an end with alarm A01697.	The inverter signals that the monitoring time has come to an end with alarm A01699.

During commissioning, you define the time interval for implementing forced dormant error detection depending on your application.

If you only use "Basic Safety", you must take the following steps during commissioning:

- Parameterize the monitoring time p9659.
- Evaluate alarm A01699 in your higher-level controller, by, for example, interconnecting r9773.31 with a digital output or a bit in the status word of the field bus.

The "Basic-Safety circuits" are an integral part of the "Extended-Safety circuits". If you use "Extended-Safety", you must take the following steps during commissioning:

- Set the two monitoring times p9559 and p9659 to the same value.
- Evaluate alarm A01697 in your higher-level controller, by, for example, interconnecting r9723.01 with a digital output or a bit in the status word of the field bus.

If alarm A01699 or A01697 signals that the monitoring time has expired, then you must initiate the forced dormant error detection at the next opportunity. These alarms do not affect the operation of your machine.

Examples for the times when forced dormant error detection 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).

Description

2.10 Forced dormant error detection

Activation

3.1 Overview

You activate the inverter safety functions via fail-safe digital inputs or PROFIsafe (safe bus communication). There are various ways of doing this depending on the version of the Control Unit.

When you activate the safety functions via...	and use the following safety functions	you will need the following Control Unit:
... one F-DI	STO	CU240E-2
... three F-DIs	STO, SS1, SLS	CU240E-2 F
... one F-DI and / or ... via PROFIsafe	STO	CU240E-2 DP
... three F-DIs and / or ... via PROFIsafe	STO, SS1, SLS	CU240E-2 DP-F

3.2 Activation via F-DI

3.2.1 Fail-safe digital inputs

In the factory setting for Control Units CU240E-2 ..., the fail-safe digital inputs are not assigned to the integrated safety functions. It is only at the parameterization stage that you define, for example, whether digital inputs DI4 and DI5 are to be used for standard functions or whether a fail-safe dual-channel input is to be created by merging.

Assignment of the fail-safe digital inputs

Table 3- 1 Fail-safe digital input on Control Units CU240E-2 and CU240E-2 DP

Terminal on the Control Unit	Digital input	Fail-safe input
Terminal 16	DI 4	F-DI 0
Terminal 17	DI 5	

Table 3-2 Fail-safe digital inputs on Control Units CU240E-2 F and CU240E-2 DP-F

Terminal on the Control Unit	Digital input	Fail-safe input	
		Basic Safety	Extended Safety
Terminal 5	DI 0	-	F-DI 0
Terminal 6	DI 1		F-DI 1
Terminal 7	DI 2		
Terminal 8	DI 3		
Terminal 16	DI 4	F-DI 0	F-DI 2
Terminal 17	DI 5		

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

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 Connecting sensors directly

3.2.2.1 Permitted sensors

The fail-safe inputs of the inverter are designed for connecting sensors with two NC contacts.

It is not possible to directly connect sensors with two NO contacts and antivalent contacts (1 NO contact and 1 NC contact).

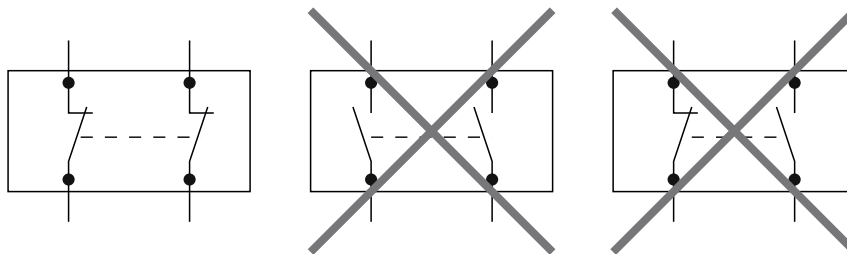


Figure 3-1 Sensors that can be connected to the fail-safe inputs

The fail-safe digital inputs are configured for both directly connecting safety sensors, e.g. emergency stop control devices or light curtains, as well as for connecting pre-processing safety relays, e.g. fail-safe controls.

3.2.2.2 Electromechanical sensor

Inverter delivers supply voltage

Connect the 24 V supply of the inverter to the sensors and connect the reference potentials of the inputs used to GND.

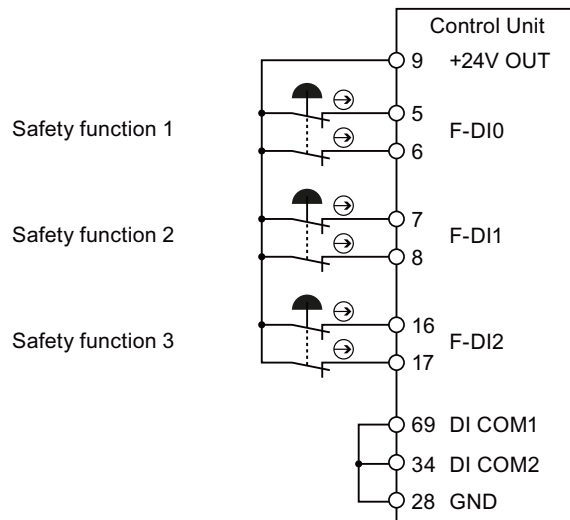


Figure 3-2 Connecting an electromechanical sensor to the inverter power supply

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.

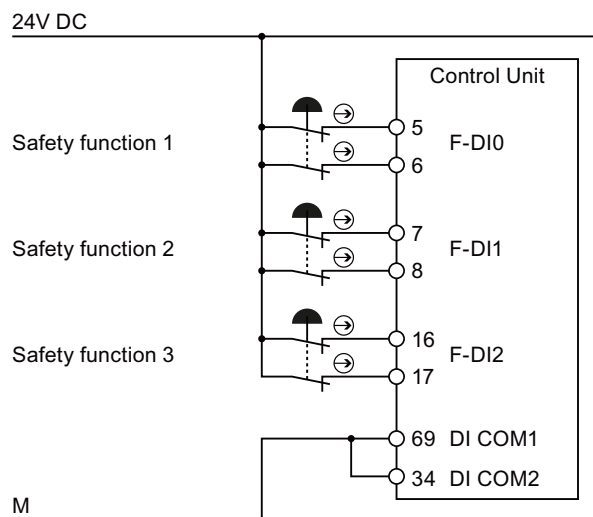


Figure 3-3 Connecting an electromechanical sensor to an external power supply

3.2.2.3 Series-connected electromechanical sensors

You may connect emergency stop control devices in series because it is not possible for these devices to fail and be actuated at the same time.

According to IEC 62061 (SIL) and ISO 13849-1 (PL), position switches of protective doors may also be 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.

Inverter delivers supply voltage

Connect the 24 V supply of the inverter to the sensors and connect the reference potentials of the inputs used to GND.

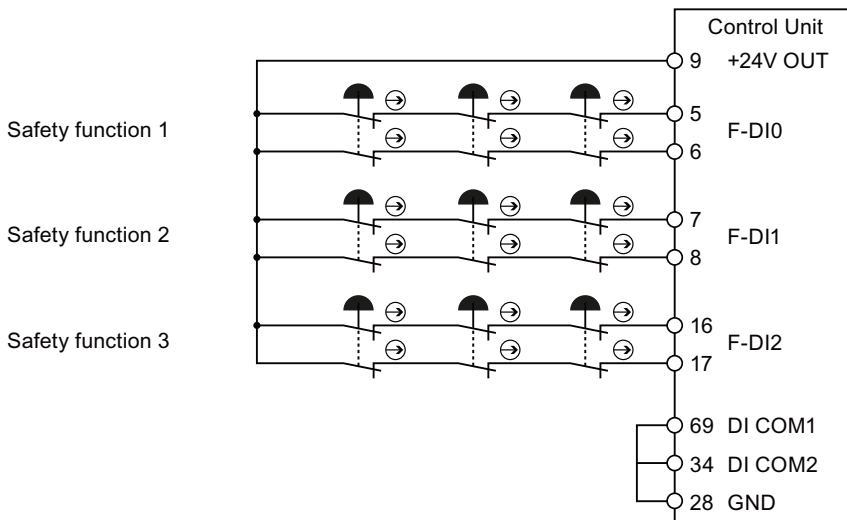


Figure 3-4 Connecting electromechanical sensors to the inverter power supply in series

External power supply

Connect the external power supply to the sensors and connect the reference potentials of the inputs used to the reference potential of the external power supply.

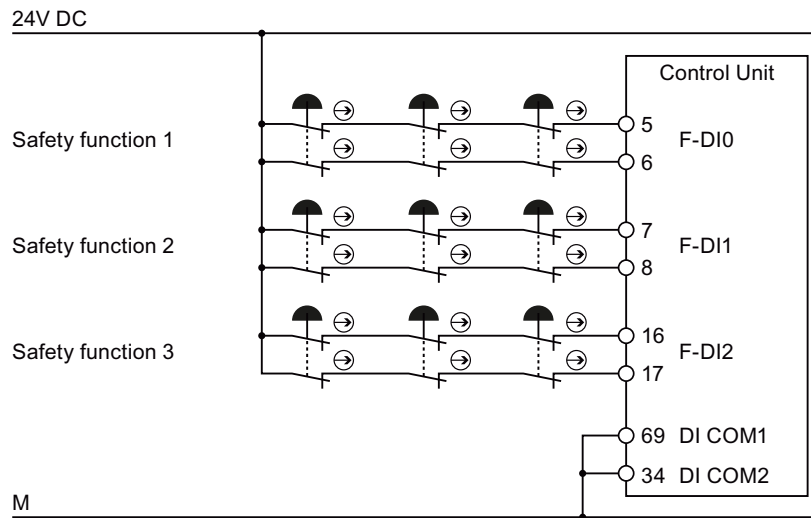


Figure 3-5 Connecting electromechanical sensors to an external power supply in series

3.2.2.4 Activating several inverters simultaneously

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

Inverter delivers supply voltage

Connect the 24 V supply of the inverter to the sensors and connect the reference potentials of the inputs used to GND.

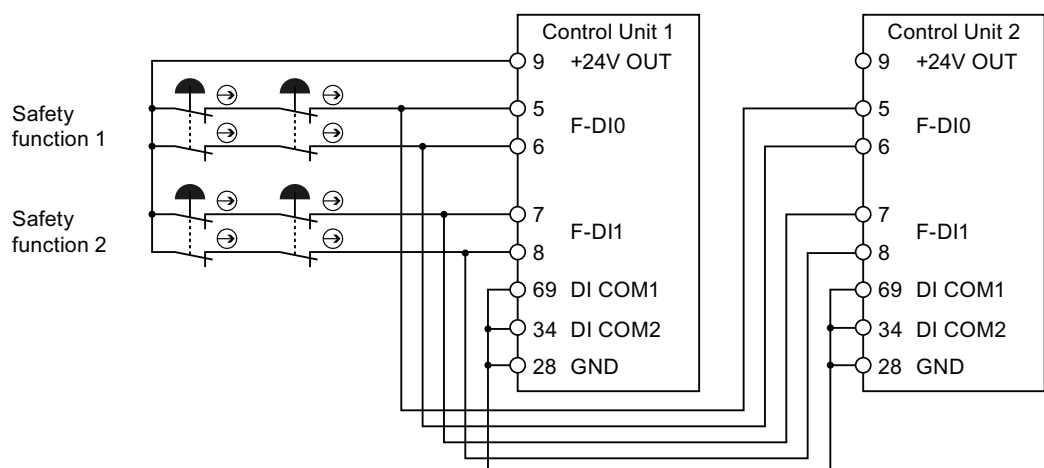


Figure 3-6 Simultaneous activation of several inverters with inverter power supply

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.

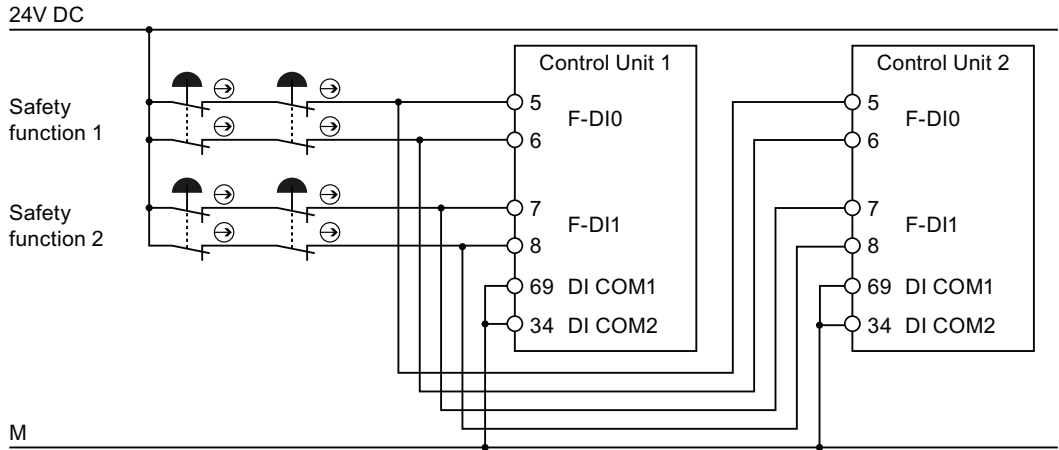


Figure 3-7 Simultaneous activation of several inverters with external power supply

3.2.2.5 Electronic sensor

In this example, you activate one of the safety functions with a safe light curtain.

The diagram only shows how the sensor and inverter are interconnected. Information providing full details of how the sensor is wired can be found in the product-specific documentation: Light curtains and arrays (<http://support.automation.siemens.com/WW/view/en/29586138/133300>).

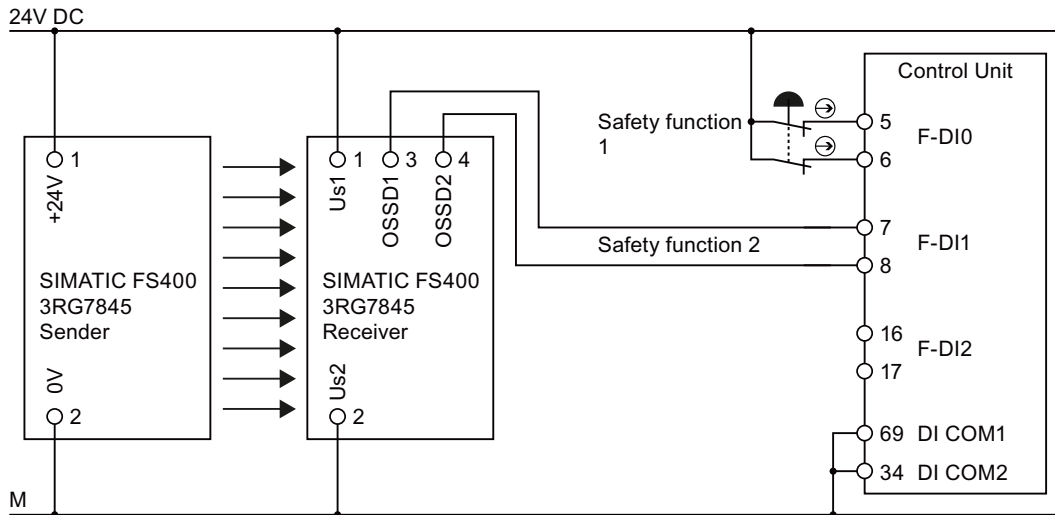


Figure 3-8 Connecting an electronic sensor

3.2.3 Connecting pre-processing devices

3.2.3.1 Permissible 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 inverter but not the ground return line.

Safety relays with relay enabling circuits are only permitted if they have an internal dual-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 inverter are housed in the same or separate control cabinets.

3.2.3.2 3TK28 safety relay

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

The diagrams only show how the safety relay and inverter are interconnected. Information providing full details of how the safety relay is wired can be found in the product-specific documentation: SIRIUS 3TK28 safety relays

(<http://support.automation.siemens.com/WW/view/en/26414637/133300>).

Components in the same control cabinet

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

For this reason, you may interconnect a safety relay and inverter 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 inverter.

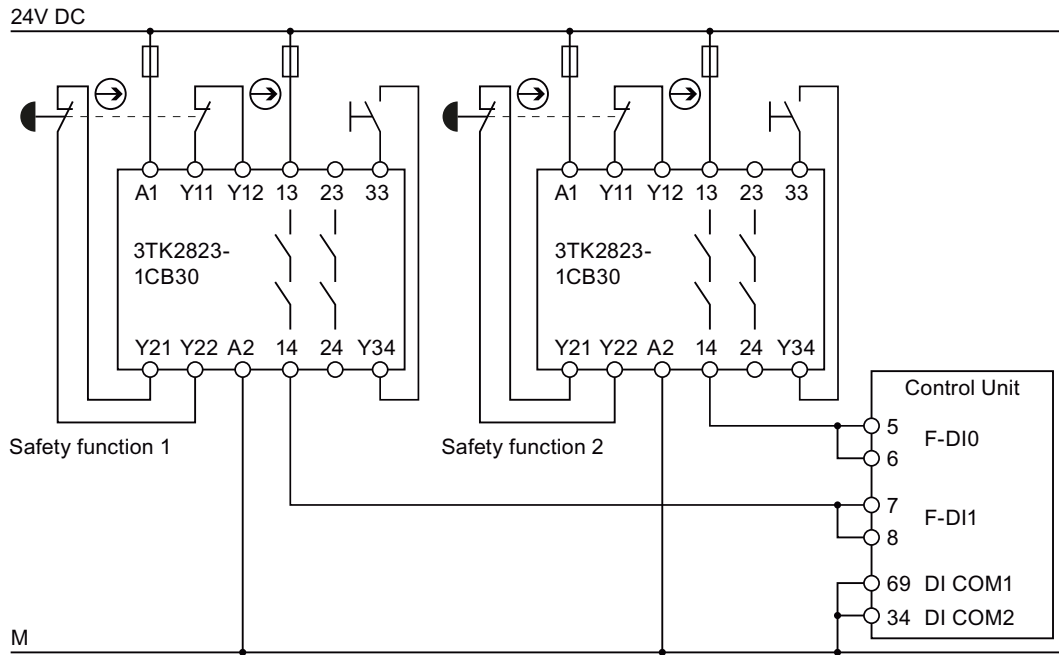


Figure 3-9 Interconnecting the inverter and safety relay within the same control cabinet

Components in separate control cabinets

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

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

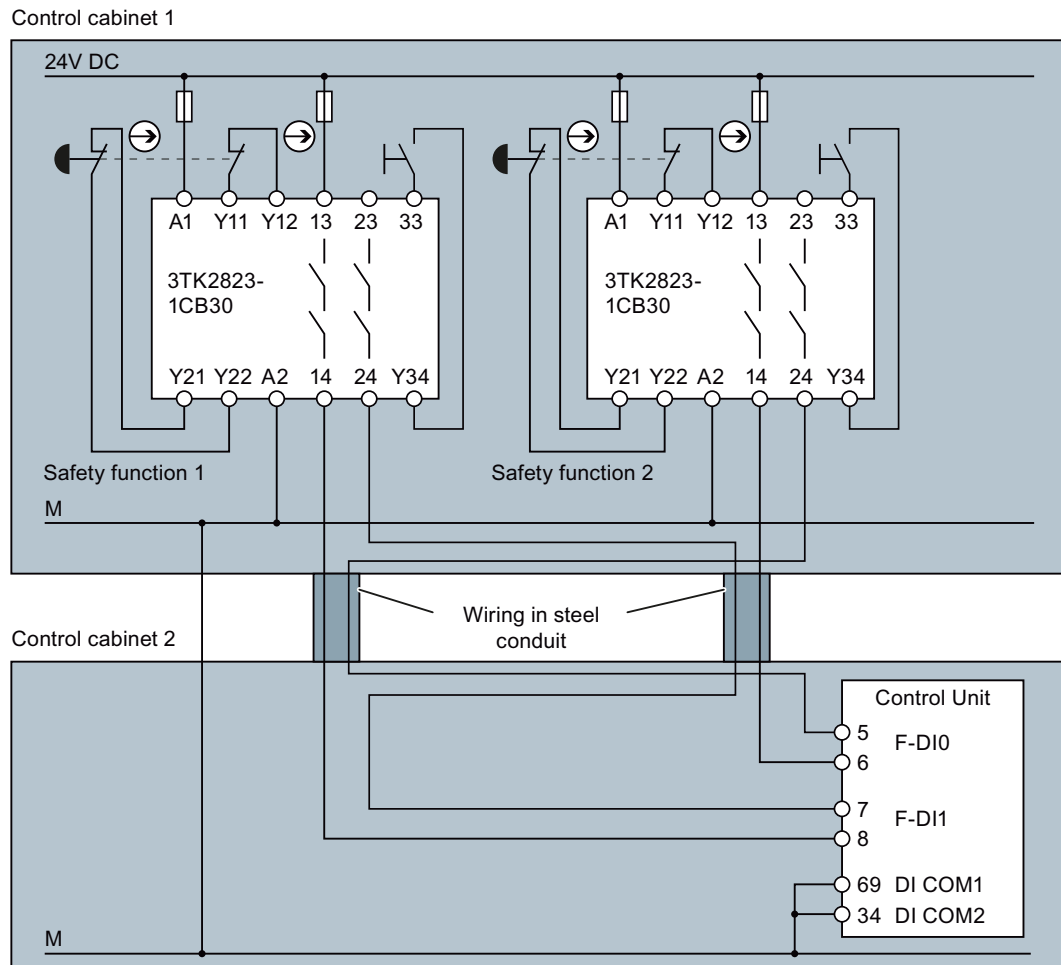


Figure 3-10 Interconnecting the inverter and safety relay in separate control cabinets

3.2.3.3 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 inverter.

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

Components in the same control cabinet

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

You may interconnect the Modular Safety System and inverter 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 inverter.

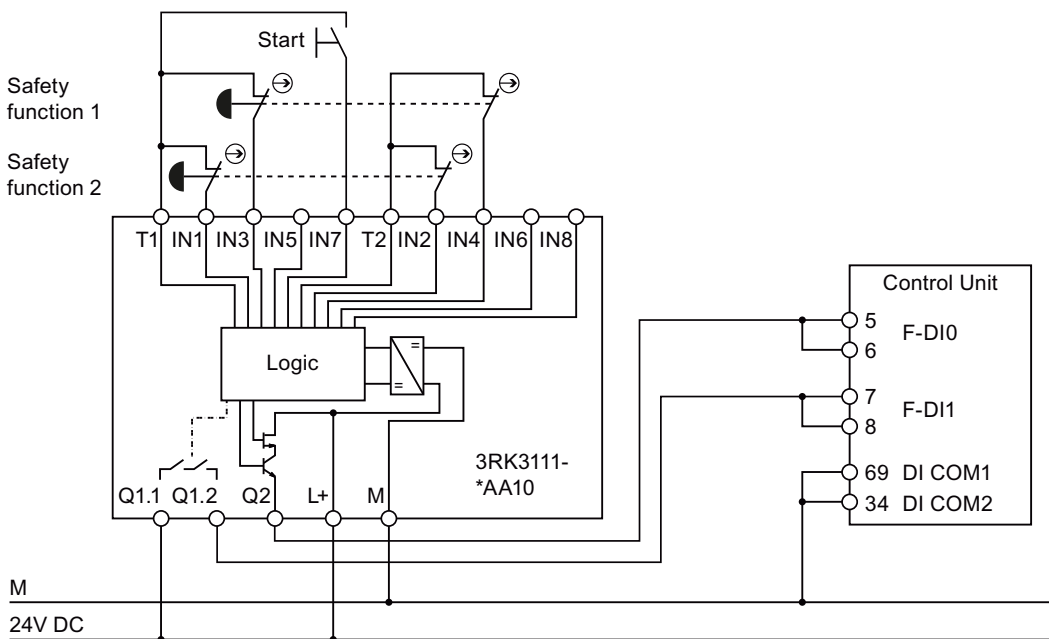


Figure 3-11 Interconnecting the inverter and Modular Safety System within the same control cabinet

Components in separate control cabinets

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

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

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

Control cabinet 1

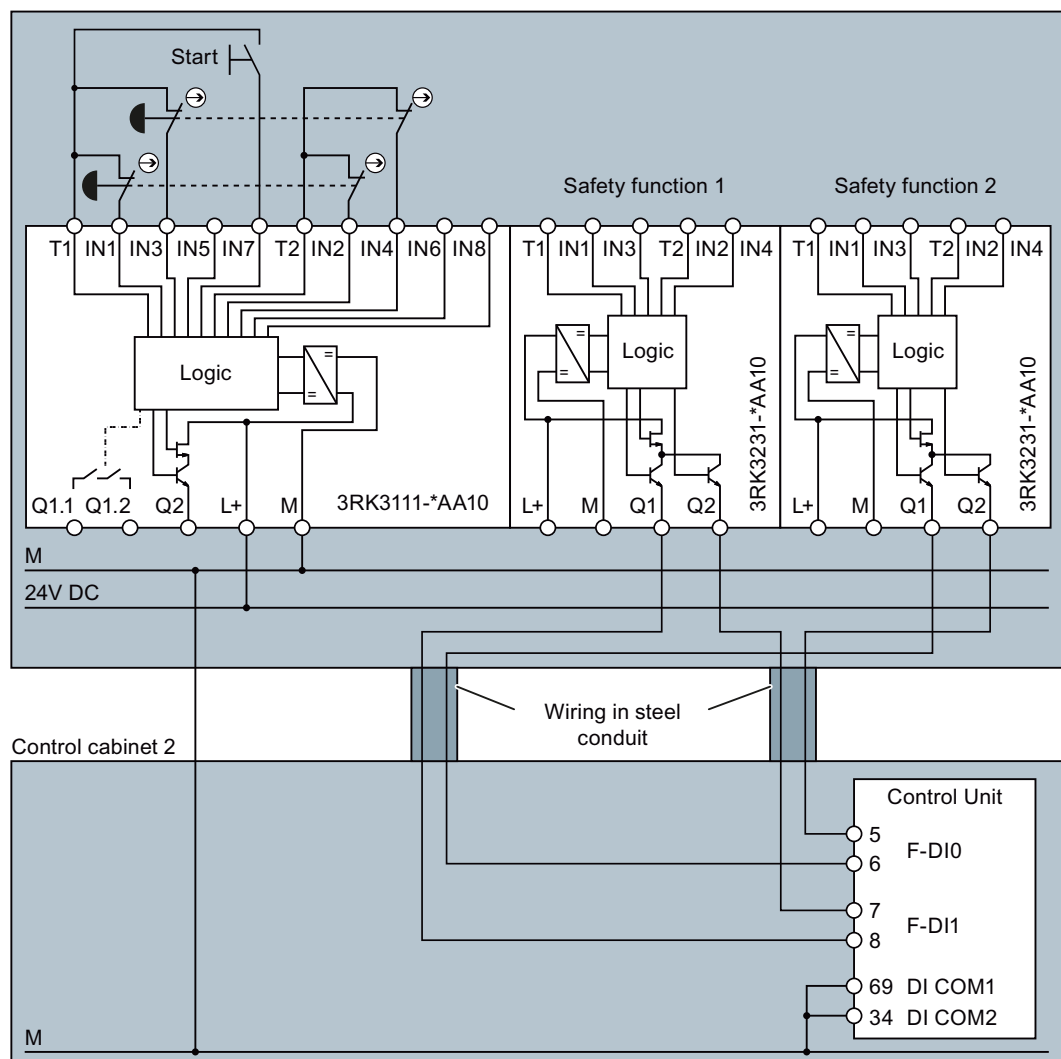


Figure 3-12 Interconnecting the inverter and Modular Safety System in separate control cabinets

3.2.3.4 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. Of the S7-300 range, only the SM326 DO 10 x 24 V / 2 A PP I/O module fulfills this requirement.

The diagrams only show how the I/O module and inverter are interconnected. Information providing full details of how the I/O module is wired can be found in the product-specific documentation: S7-300

(<http://support.automation.siemens.com/WW/view/en/10805159/133300>).

Components in the same control cabinet

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

You may interconnect the SM326 I/O module and inverter 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 inverter.

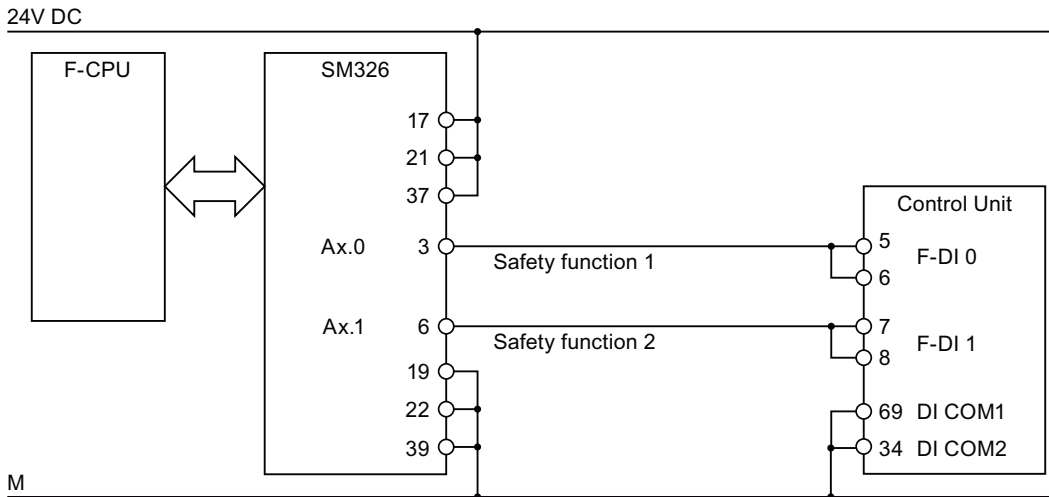


Figure 3-13 Interconnecting the inverter and SM326 I/O module within the same control cabinet

Components in separate control cabinets

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

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

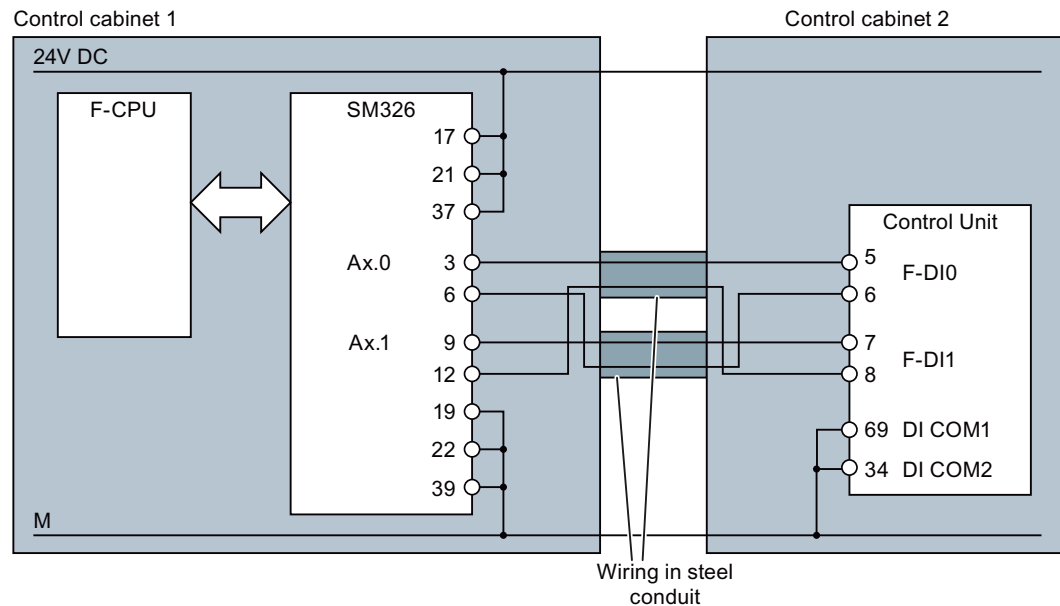


Figure 3-14 Interconnecting the inverter and SM326 I/O module in separate control cabinets

3.2.3.5 ET 200S I/O modules

Fail-safe outputs that switch to P potential are required for activating the fail-safe digital inputs of the SINAMICS G120. Out of the ET 200S system range, only the fail-safe relay module EM 1 F-RO DC 24 V / AC 24...230 V / 5 A 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 inverter are interconnected. Information providing full details of how the I/O modules is wired can be found in the product-specific documentation: ET 200S

(<http://support.automation.siemens.com/WW/view/en/10805258/133300>).

Components in the same control cabinet

A control cabinet that has been 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 inverter 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 inverter.

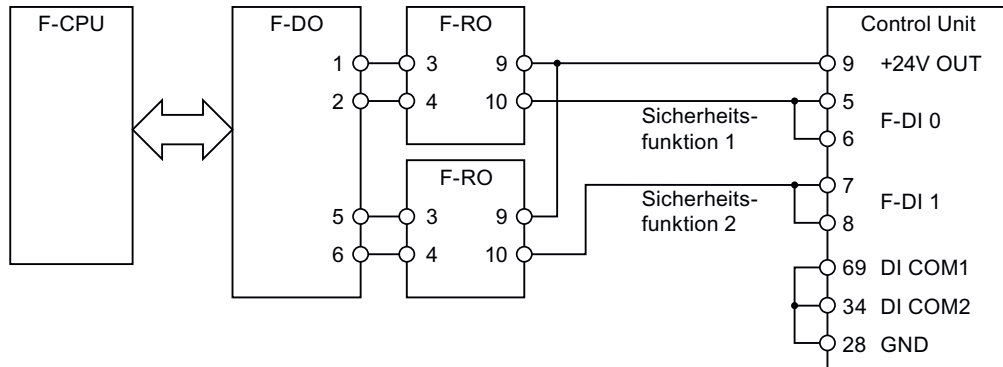


Figure 3-15 Interconnecting the inverter and I/O modules within the same control cabinet

Components in separate control cabinets

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

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

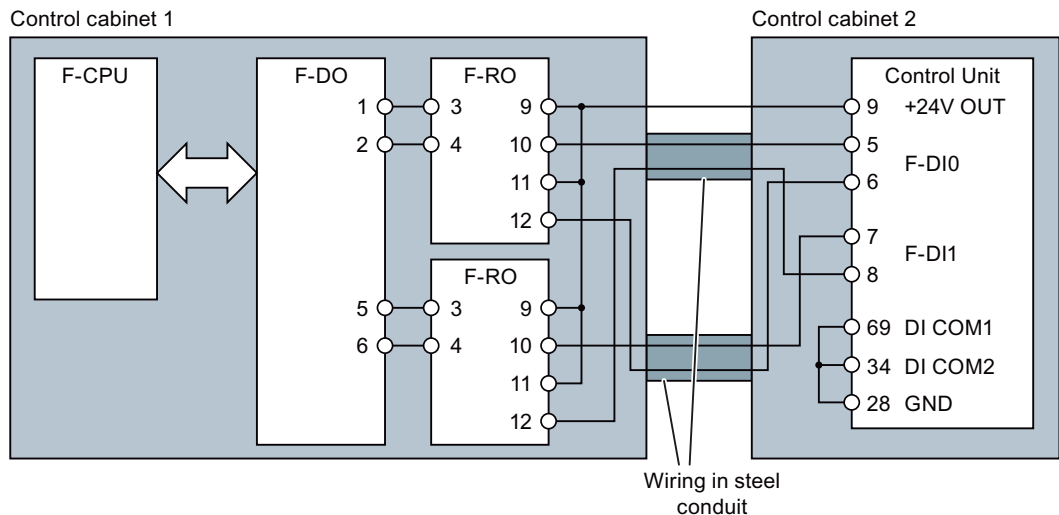


Figure 3-16 Interconnecting the inverter and I/O modules in separate control cabinets

3.2.3.6 S7-400 I/O modules

There are no fail-safe digital output modules available for the S7-400 controller.

Use S7-300 modules (see the section S7-300 I/O modules (Page 54)) or the distributed I/O system ET 200S (see the section ET 200S I/O modules (Page 55)).

3.2.4 F-DI signal filtering

The inverter checks the consistency of the fail-safe digital input signals. Consistent signals at both inputs always assume the same signal state (high or low).

Discrepancy

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 points toward a fault in the wiring of a fail-safe input, e.g. a wire break.

An adjustable filter in the inverter prevents faults caused by temporary discrepancy. Within the filter's tolerance time, the inverter suppresses the discrepancy monitoring of the fail-safe inputs.

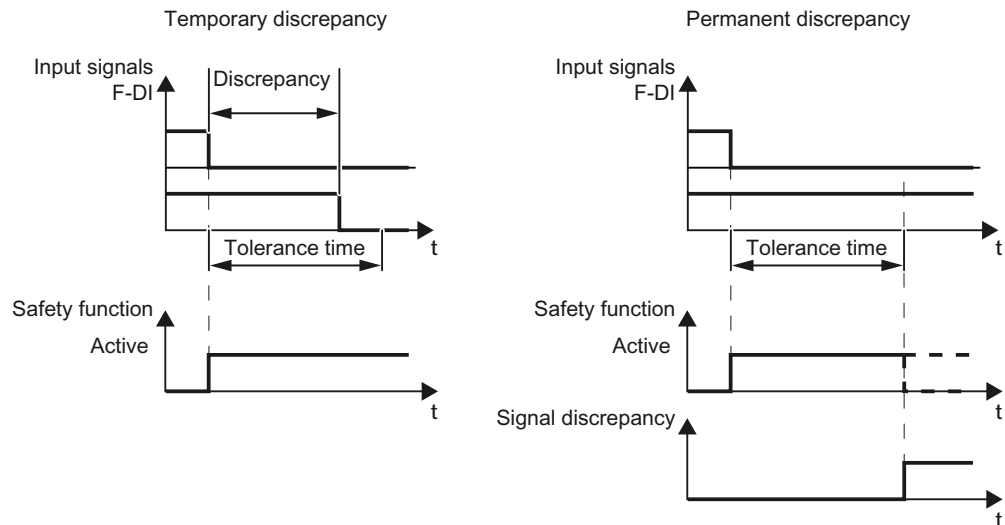


Figure 3-17 Filter for suppressing discrepancy monitoring

Table 3-3 Parameters for the discrepancy monitoring tolerance time

Basic Safety	Extended Safety	
	Activation via F-DI	Activation both via F-DI and PROFIsafe
p9650, p9850	p10002, p10102	p9650, p9850

The filter does not increase the inverter response time. The inverter activates its safety functions as soon as one of the two F-DI signals changes its state from high to low.

The way in which the inverter responds to a discrepancy depends on the active safety function. Further information can be found in the section Cause of fault (Page 135).

Bit pattern test of fail-safe outputs and contact bounces of sensors

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

1. When you interconnect a fail-safe input of the inverter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the inverter 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 or cross circuiting. When you interconnect a fail-safe input of the inverter with a fail-safe output of a control module, the inverter responds to these test signals.

A signal change during a bit pattern test usually lasts:

- Bright test: 1 ms
- Dark test: 4 ms

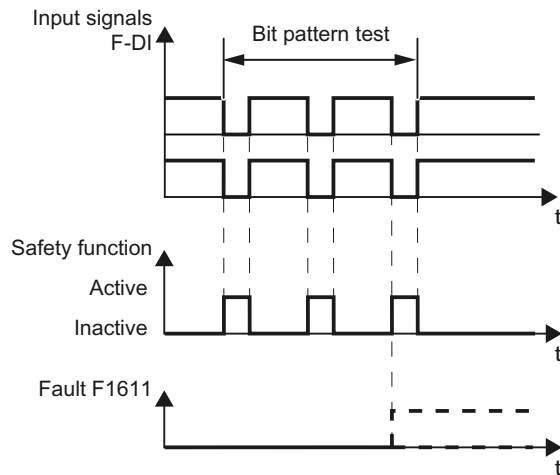


Figure 3-18 Inverter response to a bit pattern test

When the signal for STO control in "Basic Safety" is not "stable", the inverter responds to this by means of a fault.

(Definition of a stable signal: Following a change to the F-DI input signals, the inverter triggers an internal monitoring time. Up until the end of the time interval 5 x p9650, both input signals must have a constant signal level. A constant signal level is a high or a low state, for a period of at least p9650).

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

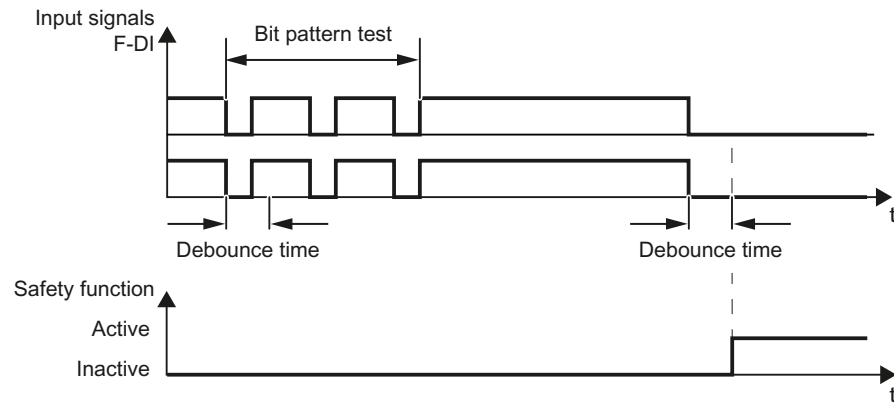


Figure 3-19 Filter for suppressing temporary signal changes

Table 3- 4 Parameters for debounce time

Basic Safety	Extended Safety	
	Activation via F-DI	Activation both via F-DI and PROFIsafe
p9651, p9851	p10017, p10117	p9651, p9851

Note

The filter increases the inverter response time. The inverter initially activates its safety function following completion of the debounce time.

Note

Debounce times for standard and safety functions

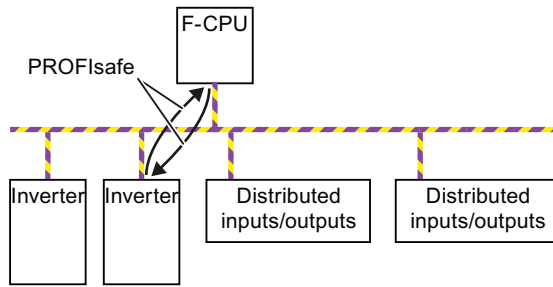
The debounce time p0724 for "standard" digital inputs has no influence over the fail-safe input signals. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

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

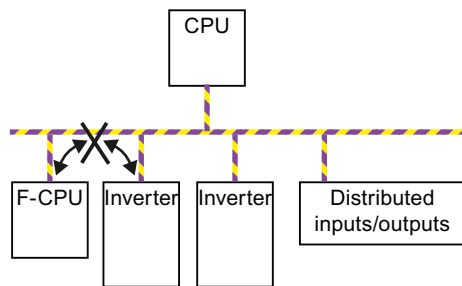
If you use an input as a fail-safe input, set the debounce time as described above.

3.3 Activation via PROFIsafe

3.3.1 Communication via PROFIsafe



If you want to use the PROFIsafe telegram, you must connect the inverter to a fieldbus with a central F-CPU.



PROFIsafe communication is not possible between the inverter and an I-slave (F-CPU configured as a slave on the fieldbus).

3.3.2 Telegram types

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

Table 3- 5 Telegram types

Telegram type	Process data (PZD) - control and status words		Optional with:	Available with the Control Units:
	PZD01	PZD02		
Telegram 30 PZD 1/1	STW0	-	Basic Safety and Extended Safety	CU240E-2 CU240E-2 DP CU240E-2 F CU240E-2 DP-F
	ZSW0	-		
Telegram 900 PZD 2/2	STW0	STW2	Extended Safety	CU240E-2 F CU240E-2 DP-F
	ZSW0	ZSW2		

STW: Control word; ZSW: Status word

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

The section Selecting the commissioning method (Page 70) contains information to help you decide whether you must operate your inverter with "Basic Safety" or "Extended Safety".

3.3.3 Control word 0 and status word 0 (Basic Safety)

Table 3- 6 Control word 0 (bit 0 ... 15)

Bit	Meaning	Comment	
0	STO	1	STO deselection
		0	STO selection
1 ... 6	<i>Reserved</i>		Assign the value 0 to the reserved bits.
7	Internal event ack	1	Acknowledge signal change 1 → 0
		0	No acknowledgement
8 ... 15	<i>Reserved</i>		Assign the value 0 to the reserved bits.

Table 3- 7 Status word 0 (bit 0 ... 15)

Bit	Meaning	Comment	
0	Power removed	1	The motor torque has been switched off safely.
		0	The motor torque has not yet been switched off safely.
1 ... 6	<i>Reserved</i>		
7	Internal Event	1	Operation OK
		0	The inverter has detected a major fault and responded accordingly, e.g. with a STOP A
8 ... 15	<i>Reserved</i>		

3.3.4 Control word 0 and status word 0 (Extended Safety)

Table 3-8 Control word 0 (bit 0 ... 15)

Bit	Meaning	Comment	
0	STO	1	STO deselection
		0	STO selection
1	SS1	1	SS1 deselection
		0	SS1 selection
2	Reserved	Assign the value 0 to the reserved bits.	
3	Reserved		
4	SLS	1	SLS deselection
		0	SLS selection
5	Reserved	Assign the value 0 to the reserved bits.	
6	Reserved		
7	Internal event ack	1	Acknowledge signal change 1 → 0
		0	No acknowledgement
8	Reserved	Assign the value 0 to the reserved bits.	
9	Select SLS level bit 0	Select the monitoring threshold for SLS	00: Level 1 01: Level 2 10: Level 3 11: Level 4
10	Select SLS level bit 1		
11	Reserved	Assign the value 0 to the reserved bits.	
12	Reserved		
13	Reserved		
14	Reserved		
15	Reserved		

Assign the value 0 to the reserved bits.

Table 3-9 Status word 0 (bit 0 ... 15)

Bit	Meaning	Comment	
0	Power removed	1	The motor torque has been switched off safely.
		0	The motor torque has not yet been switched off safely.
1	SS1 active	1	SS1 is currently active
		0	SS1 is not active
2	Reserved		
3	Reserved		
4	SLS active	1	SLS is currently active
		0	SLS is not active
5	Reserved		
6	Reserved		

Bit	Meaning	Comment	
7	Internal Event	1	Operation OK
		0	The inverter has detected a major fault and responded accordingly, e.g. with a STOP A
8	Reserved		
9	Active SLS level bit 0	Load speed is less than SLS level currently selected (monitoring threshold)	00: Level 1
10	Active SLS level bit 1		01: Level 2 10: Level 3 11: Level 4
11	Reserved		
12	Reserved		
13	Reserved		
14	Reserved		
15	Reserved		

3.3.5 Control word 2 and status word 2

Telegram 900 of the PROFIsafe profile also contains control and status word 2. The inverter uses status word 2 to transfer the status of the fail-safe digital inputs to the controller.

Table 3- 10 Control word 2 (bit 0 ... 15)

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

Table 3- 11 Status word 2 (bit 0 ... 15)

Bit	Meaning	Comment	
0	Reserved	-	
...			
7			
8	Status of fail-safe inputs	0	LOW signal (0 V present) at terminals 5 and 6
		1	HIGH signal (24 V present) at terminals 5 and 6
9	Status of fail-safe inputs	0	LOW signal (0 V present) at terminals 7 and 8
		1	HIGH signal (24 V present) at terminals 7 and 8
10	Status of fail-safe inputs	0	LOW signal (0 V present) at terminals 16 and 17
		1	HIGH signal (24 V present) at terminals 16 and 17
11	Reserved	-	
...			
15			

An overview of the fail-safe inputs can be found in the section Fail-safe digital inputs (Page 43).

The status bit of a fail-safe input in status word 2 is always 0 if one of the following two conditions is fulfilled:

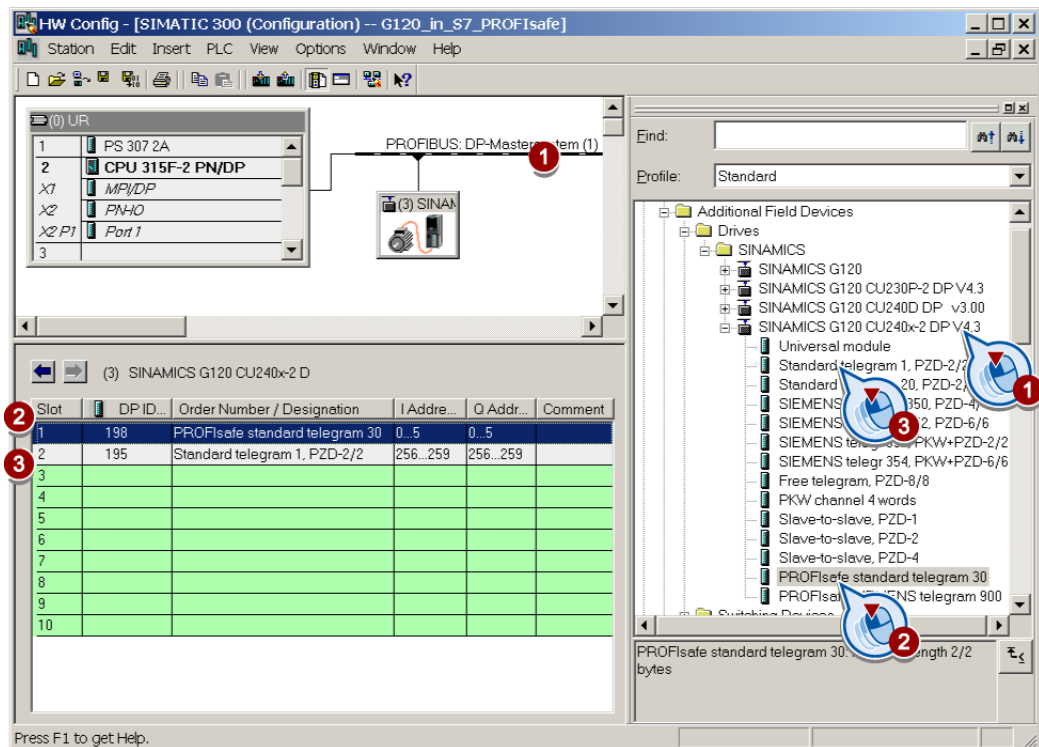
- The relevant fail-safe input is not used.
- The inverter has deactivated the relevant fail-safe input due to a discrepancy.

3.3.6 Configuring communication in STEP 7 (telegram 30)

Hardware configuration

In STEP 7, the inverter is integrated in PROFIsafe communication via HW Config.

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



- Double-click the PROFIsafe telegram to open the properties dialog and set the input and output range to address 14, for example:

Properties - DP slave

Address / ID | Address configuration | Parameter Assignment | PROFIsafe

I/O Type: Out-input [Direct Entry...]

Output

Start: 14 | Length: 6 | Unit: Byte | Consistent over: Total length

End: 19

Process image: OB1 PI

Input

Start: 14 | Length: 6 | Unit: Byte | Consistent over: Total length

End: 19

Process image: OB1 PI

Manufacturer-specific data: 05.05.0A.05.05.0A
(Maximum 14 bytes hexadecimal, separated by comma or blank space)

OK Cancel Help

- Then choose the "PROFIsafe" tab page:
 - ① F_Dest_Add:
Set a unique PROFIsafe address for the inverter.
 - 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.

Properties - DP slave

Address / ID | Address configuration | Parameter Assignment | PROFIsafe

Parameter name	Value	Hex
F_Check_SeqNr	No Check	
F_SIL	SIL 2	
F_CRC_Length	3 Byte CRC	
F_Per_Version	ParVersion 1	
F_Source_Add	2002	
F_Dest_Add	100	64
F_WD_Time	200	

Change value...

Current F parameter CRC (CRC1) hexadecimal:
BC3

OK Cancel Help

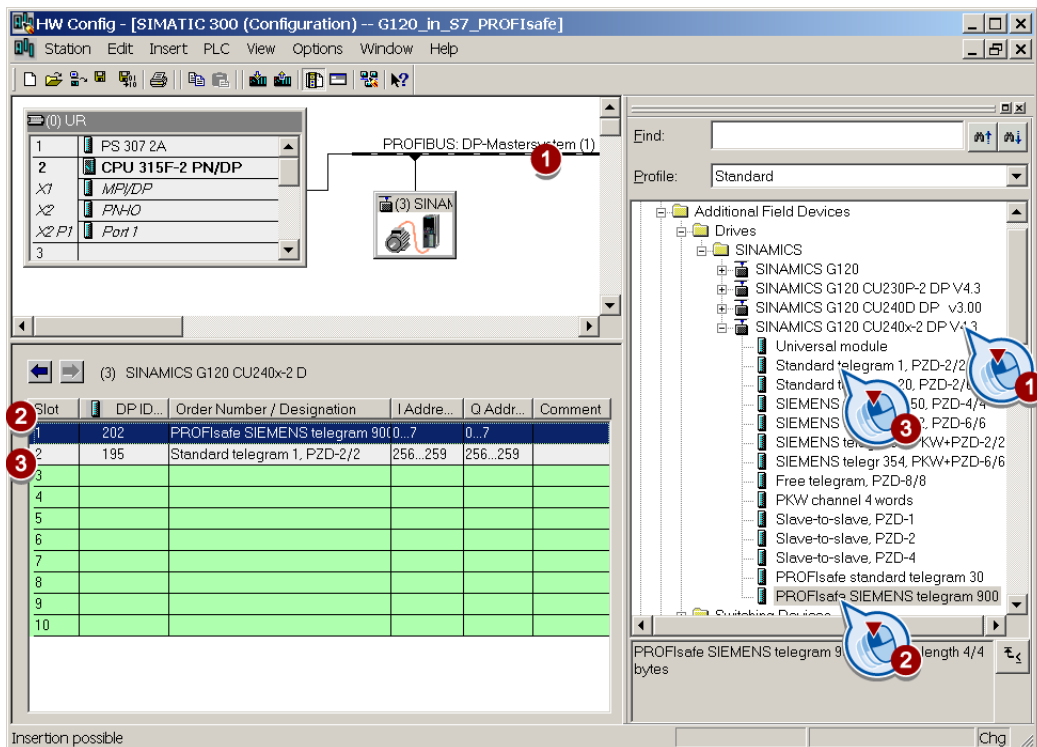
- Save and compile your project and download the data to your SIMATIC CPU.
- Close HW Config.

3.3.7 Configuring communication in STEP 7 (telegram 900)

If you want to evaluate the status of the fail-safe inputs in the higher-level controller directly, choose PROFIsafe telegram 900. The inverter writes the signals of its F-DIs to status word 2.

Hardware configuration

The basic procedure is described in the section Configuring communication in STEP 7 (telegram 30) (Page 64). Simply choose telegram 900 instead of telegram 30 here:



3.3.8 Further steps

Once you have completed the controller side, configure PROFIsafe communication in the inverter. This is described in the chapter Commissioning (Page 69).

3.3.9 Example: Interface to the S7 safety program

When you configure the hardware in STEP 7, you assign the control word and status word in the PROFIsafe profile of the inverter to specific output and input addresses of the SIMATIC controller. In the section Configuring communication in STEP 7 (telegram 30) (Page 64), start address 14, for example, was assigned. This results in the following assignments between the I/O addresses and inverter signals for this example:

Table 3- 12 Control word 0

I/O address	Meaning	Comment	
A14.0	STO	1	Deselect STO
		0	Select STO
A14.1	SS1	1	Deselect SS1
		0	Select SS1
A14.4	SLS	1	Deselect SLS
		0	Select SLS
A14.7	Internal event ACK	1	Acknowledge signal change 1 → 0
		0	No acknowledgement
A15.1	Select SLS level bit 0	Select the monitoring threshold for SLS.	
A15.2	Select SLS level bit 1		

Table 3- 13 Status word 0

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	The motor is currently being braked with the SS1 ramp-down time.
		0	SS1 ramp-down time is not active.
E14.4	SLS active	1	The motor speed is currently below the selected SLS limit value.
		0	SLS not active
E14.7	Internal event	1	The inverter has detected an internal fault and responded accordingly, e.g. with a STOP A.
		0	Operation OK
E15.1	Active SLS level bit 0	Monitoring threshold currently active for SLS.	
E15.2	Active SLS level bit 1		

A detailed description of the PROFIsafe interface can be found in the section Control word 0 and status word 0 (Extended Safety) (Page 62).

Commissioning

Before you can start commissioning the safety functions, you must carry out the following steps (providing these are necessary for your application):

- Create the higher-level control program, e.g. SIMATIC.
- Wire and configure the inverter inputs and outputs.
 - The "standard" inputs and outputs are described in the operating instructions (Overview of documentation (Page 10)).
 - The fail-safe inputs are described in this manual in the section Activation via F-DI (Page 43).
- Establish a connection to the fieldbus.
 - The procedure for establishing a connection to "standard" communication is described in the operating instructions.
 - The PROFIsafe connection is described in this manual in the section Activation via PROFIsafe (Page 60).

An overview of all the commissioning steps can be found in the section Commissioning guidelines (Page 12)

4.1 Commissioning: Offline or online

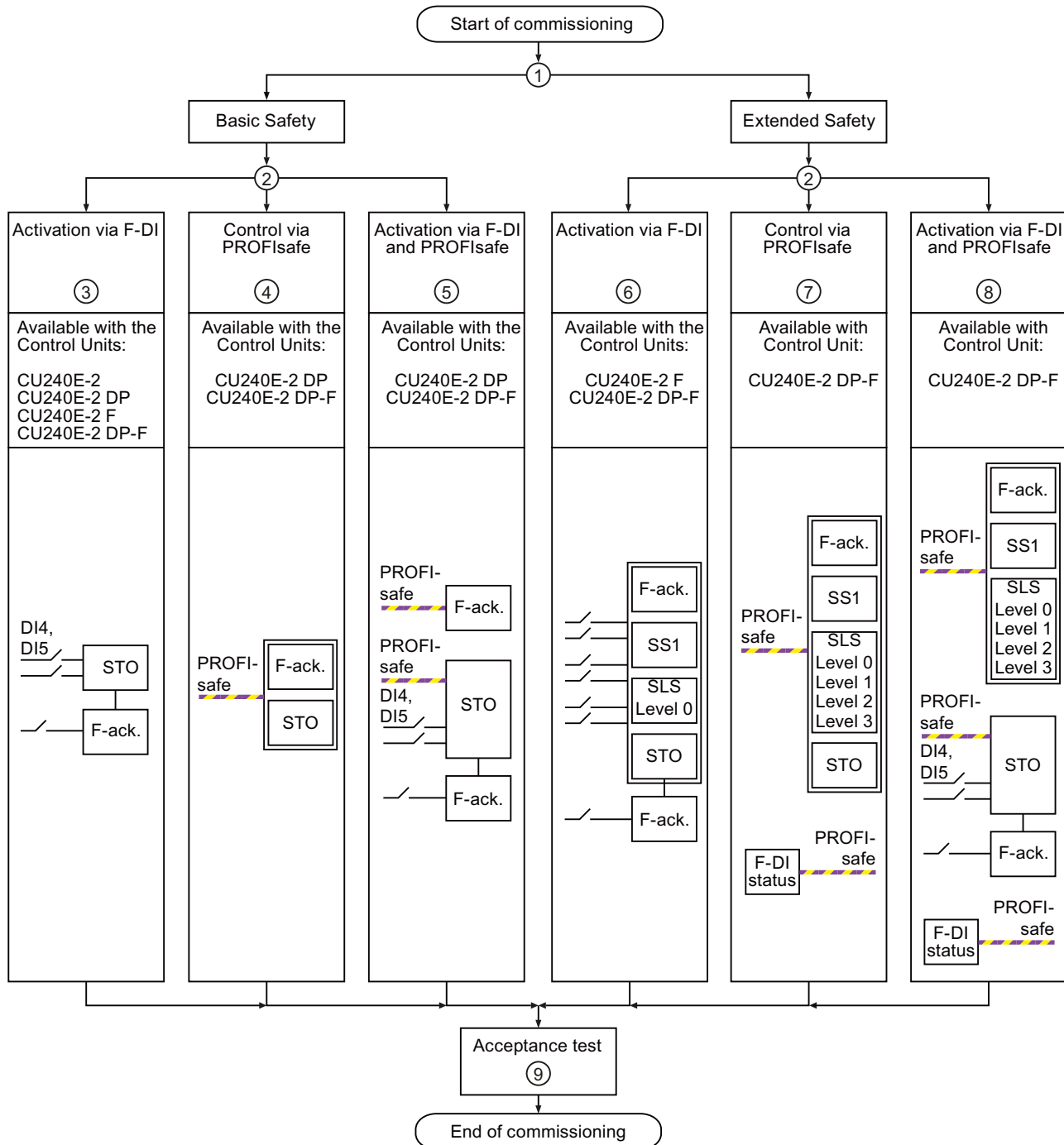
You can parameterize the safety functions both offline and online. We strongly recommend that you commission the safety functions with the STARTER PC tool.

This manual provides a detailed description of the online commissioning procedure. The section Offline commissioning (Page 113) describes the important points to remember when commissioning the safety functions offline.

The operating instructions describe how to go online with STARTER.

4.2 Selecting the commissioning method

When you start commissioning, you must choose the commissioning method that best suits your application. The following overview lists the alternatives and the outcome of using a particular method.



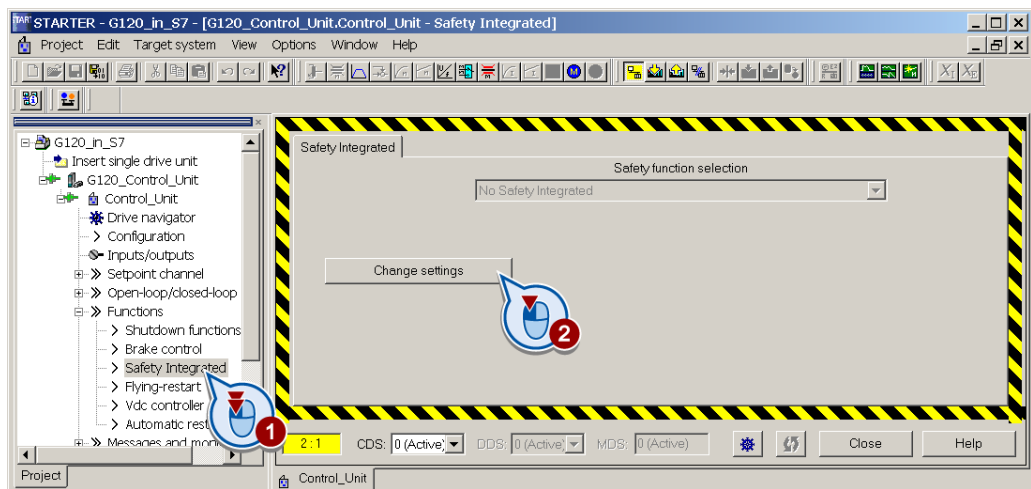
- ① Decide whether you want to use "Basic Safety" or "Extended Safety".
- If the only inverter safety function you want to use is STO, choose "Basic Safety".
 - If you use SS1, SLS or several safety functions, choose "Extended Safety".
- ② Choose one of the following three alternatives after you have activated the safety functions in your application: F-DI, PROFIsafe or both interfaces.
- | Outcome of commissioning | See section ... | |
|---------------------------------|---|--|
| ③ | <ul style="list-style-type: none"> • Activating STO via F-DI • Acknowledge safety faults after activating and deactivating STO via standard DI. | Activate STO via F-DI. (Page 72). |
| ④ | <ul style="list-style-type: none"> • Activate STO via PROFIsafe. • Acknowledge safety faults via PROFIsafe. | Activating STO via PROFIsafe (Page 76). |
| ⑤ | <ul style="list-style-type: none"> • Activate STO both via F-DI and PROFIsafe. • Acknowledge safety faults: <ul style="list-style-type: none"> – via PROFIsafe – after activating and deactivating STO via standard DI | Activating STO via PROFIsafe and F-DI (Page 79). |
| ⑥ | <ul style="list-style-type: none"> • Activate STO, SS1 and SLS via F-DI. • Only one SLS level 0. • Acknowledge safety faults: <ul style="list-style-type: none"> – via F-DI – after activating and deactivating STO via standard DI | Extended Safety with activation via F-DI (Page 84). |
| ⑦ | <ul style="list-style-type: none"> • Activate STO, SS1 and SLS via PROFIsafe. • Up to four SLS levels 0 ... 3 • Acknowledge safety faults via PROFIsafe. • Transfer the status of the fail-safe inputs via PROFIsafe. | Extended Safety with activation via PROFIsafe (Page 95). |
| ⑧ | <ul style="list-style-type: none"> • Activate SS1 and SLS via PROFIsafe. • Up to four SLS levels 0 ... 3 • Activate STO both via F-DI and PROFIsafe. • Acknowledge safety faults: <ul style="list-style-type: none"> – via PROFIsafe – after activating and deactivating STO via standard DI • Transfer the status of the fail-safe inputs via PROFIsafe. | Extended Safety with activation via PROFIsafe and F-DI (Page 103). |
- ⑨ The instructions for checking the safety functions and for completing the acceptance report can be found in the section Acceptance test - Completion of commissioning (Page 116).

4.3 Basic Safety

4.3.1 Activate STO via F-DI.

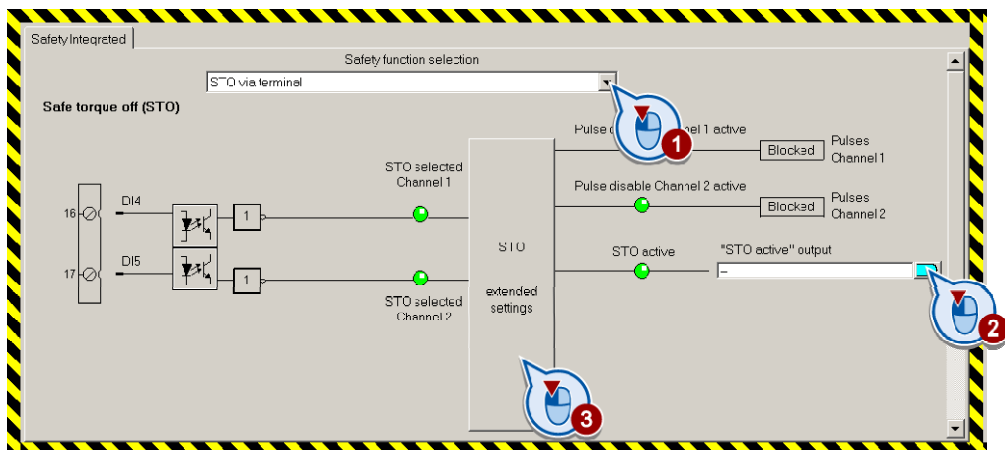
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":



4.3.1.1 Defining the commissioning method

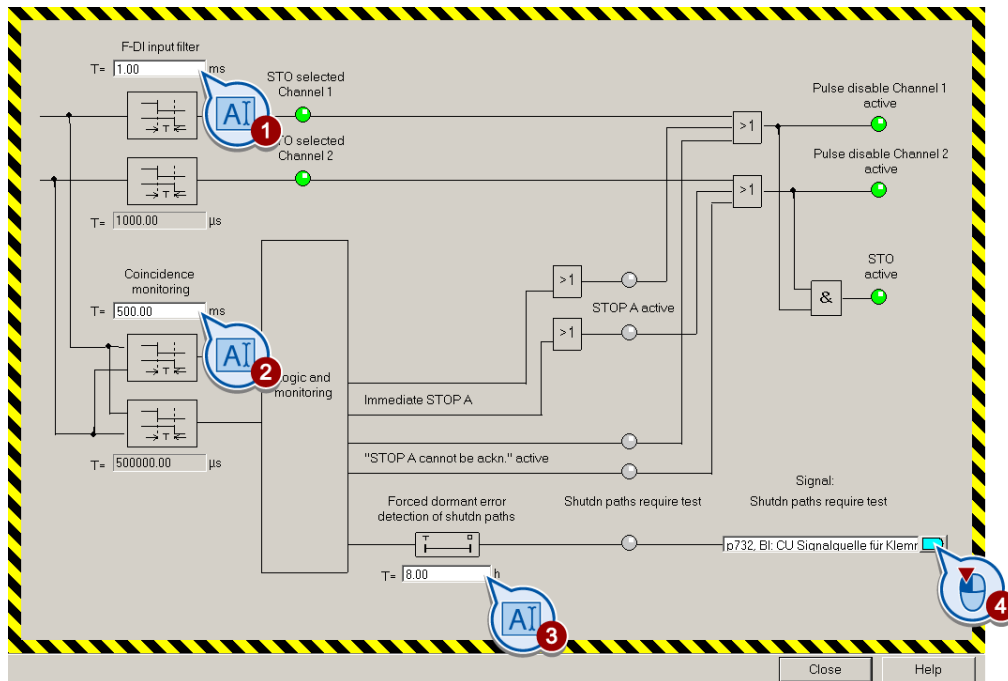
- Select "STO via terminal".



- If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.
- Click the button to call up the advanced settings for STO.

4.3.1.2 Assigning parameters to the STO

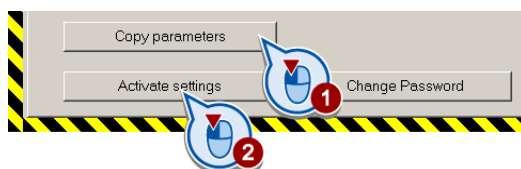
- You can adapt the STO function according to your requirements in the following screen.



- Set the following in the above screen:
 - ① ② **F-DI input filter (debounce time) and monitoring for simultaneous operation (discrepancy):**
The method of functioning of the two filters is described in the section entitled F-DI signal filtering (Page 57).
 - ③ ④ **Time interval for forced dormant error detection:**
Information regarding forced dormant error detection can be found in the Forced dormant error detection (Page 40) section.
- Close the screen.

4.3.1.3 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

4.3.1.4 Multiple assignment of the DI

- 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:

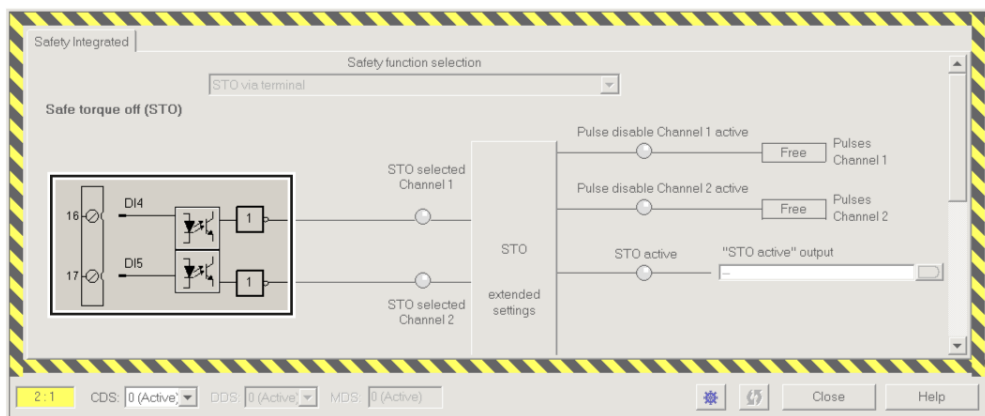


Figure 4-1 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

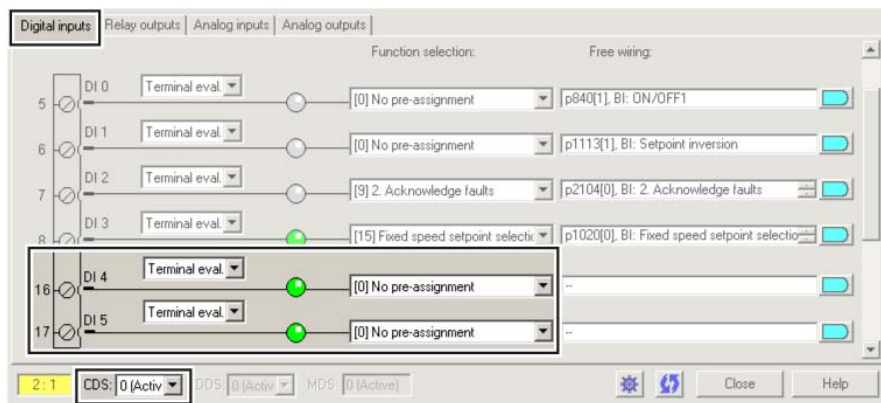


Figure 4-2 Remove pre-assignment of digital inputs DI 4 and DI 5

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

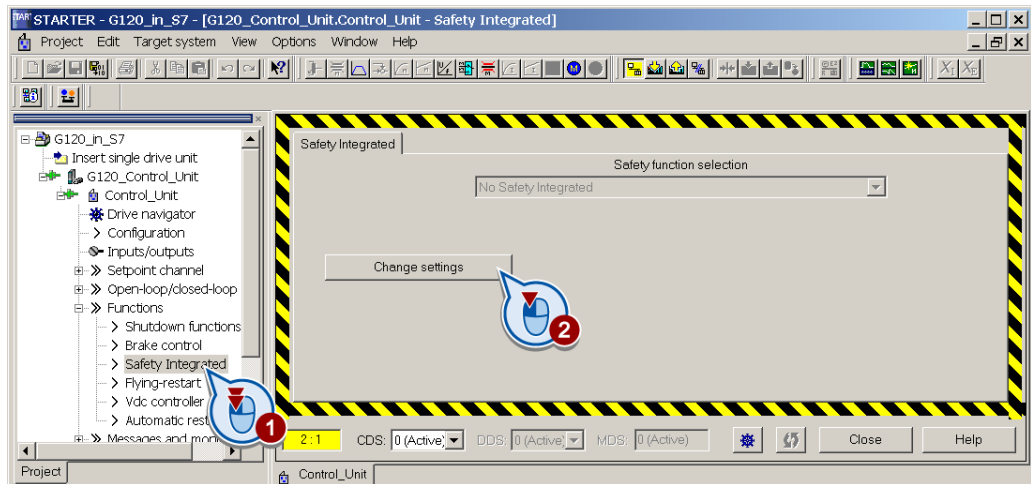
4.3.1.5 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

4.3.2 Activating STO via PROFIsafe

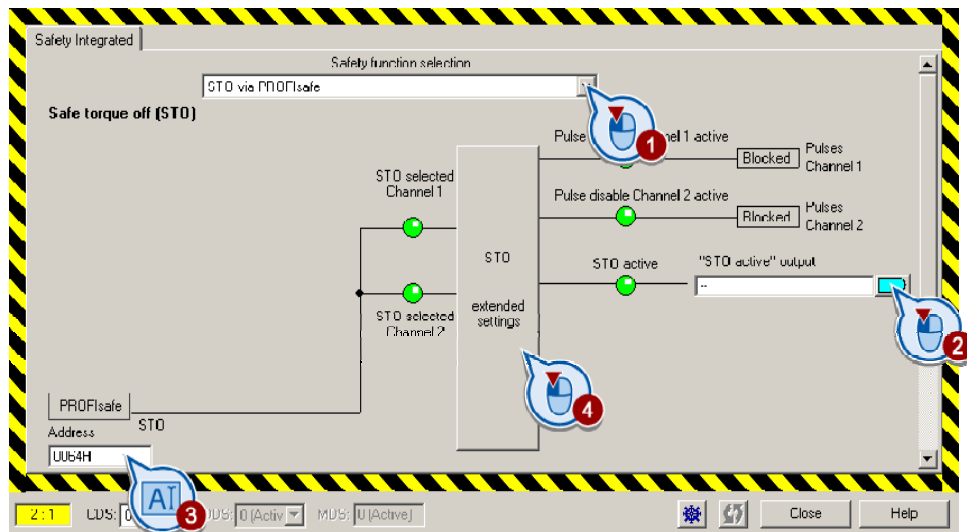
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":



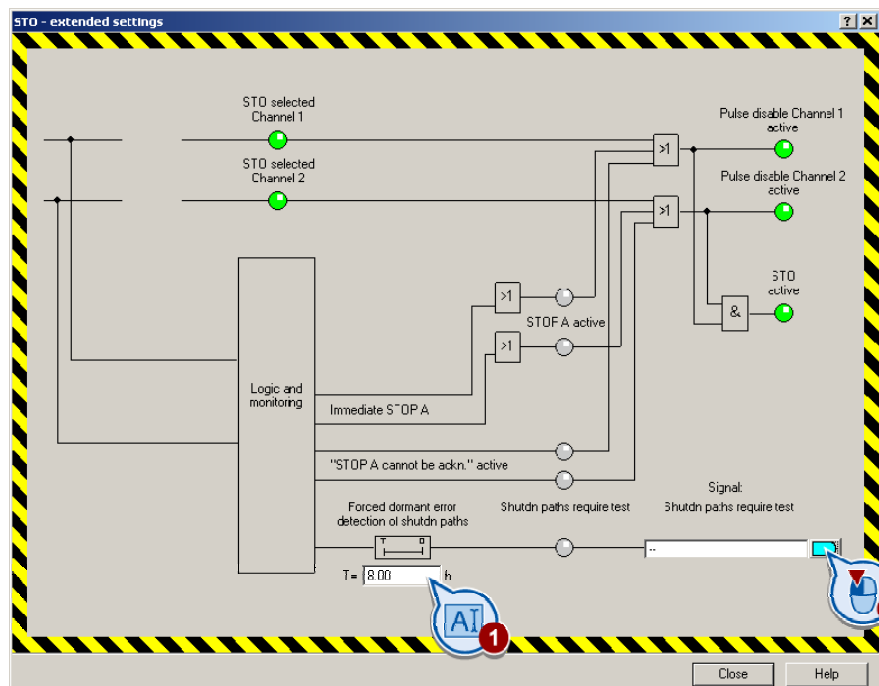
4.3.2.1 Defining the commissioning method

- ① Set "STO via PROFIsafe".
- ② If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.
- ③ Enter the same PROFIsafe address as a hexadecimal value that you defined in the hardware configuration, see Section Configuring communication in STEP 7 (telegram 30) (Page 64).
- ④ Click the button to set the STO.



4.3.2.2 Parameterizing STO

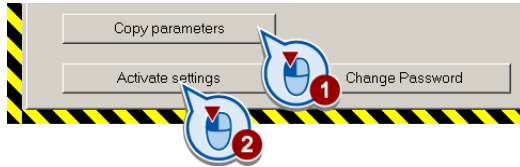
- Define the time interval for forced dormant error detection and connect the appropriate message to any signal:



Information on forced dormant error detection can be found in the section Forced dormant error detection (Page 40).

4.3.2.3 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

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

Note

Monitoring PROFIsafe communication

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

4.3.2.4 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

4.3.3 Activating STO via PROFIsafe and F-DI

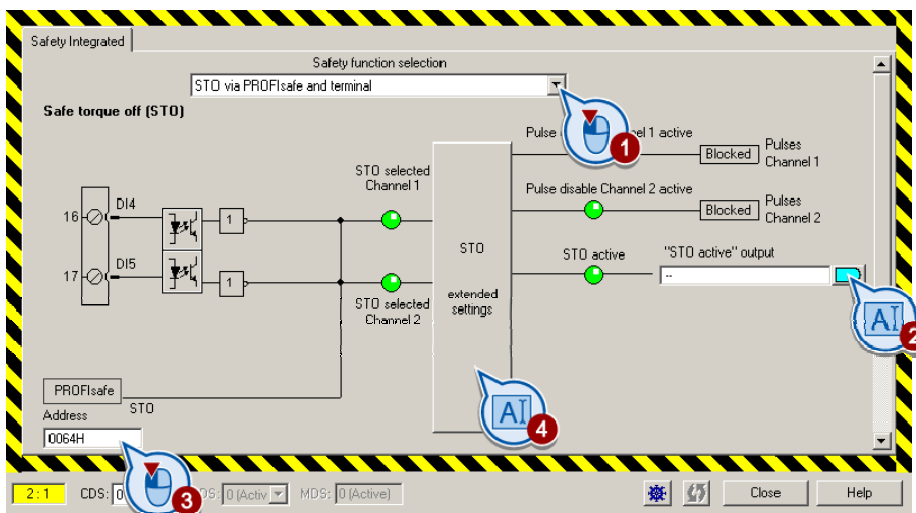
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":



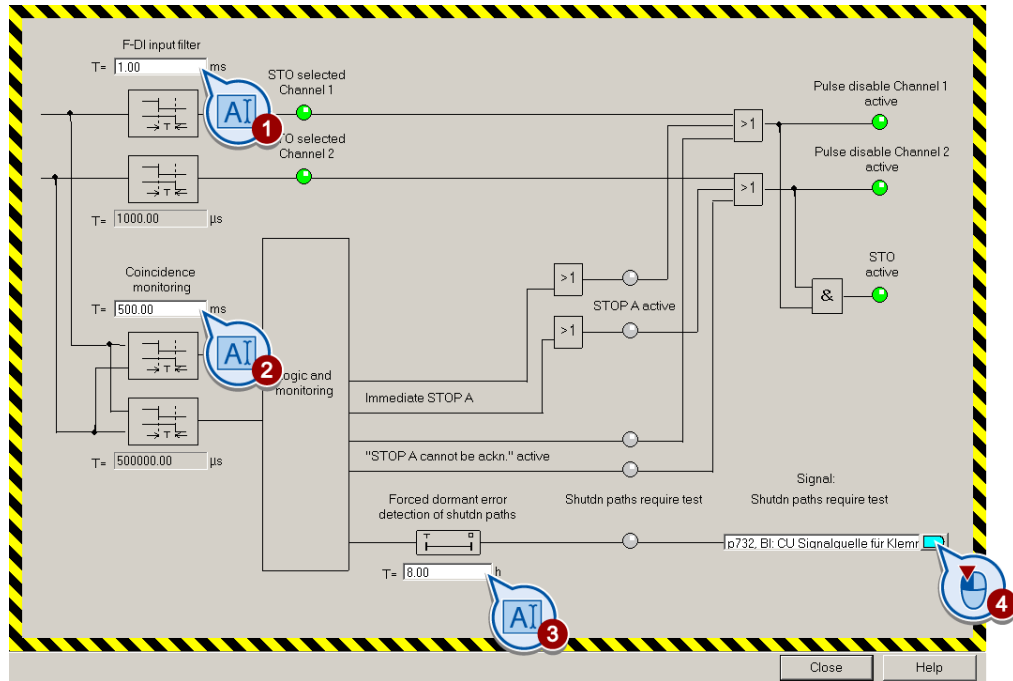
4.3.3.1 Defining the commissioning method

- ① Set "STO via PROFIsafe and Terminal".
- ② If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.
- ③ Enter the same PROFIsafe address as a hexadecimal value that you defined in the hardware configuration, see Section Configuring communication in STEP 7 (telegram 30) (Page 64).
- ④ Click the button to set the STO.



4.3.3.2 Assigning parameters to the STO

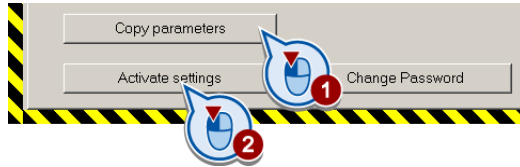
- You can adapt the STO function according to your requirements in the following screen.



- Set the following in the above screen:
 - ① ② **F-DI input filter (debounce time) and monitoring for simultaneous operation (discrepancy):**
The method of functioning of the two filters is described in the section entitled F-DI signal filtering (Page 57).
 - ③ ④ **Time interval for forced dormant error detection:**
Information regarding forced dormant error detection can be found in the Forced dormant error detection (Page 40) section.
- Close the screen.

4.3.3.3 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

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

Note

Monitoring PROFIsafe communication

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

4.3.3.4 Multiple assignment of the DI

- 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:

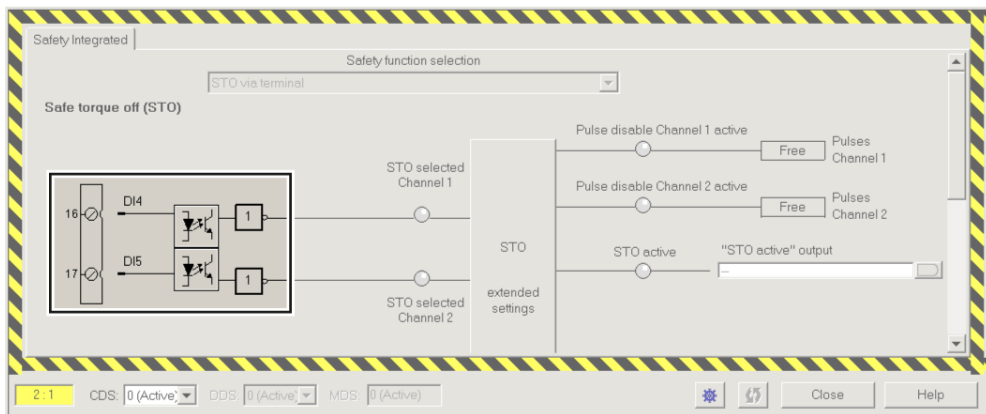


Figure 4-3 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

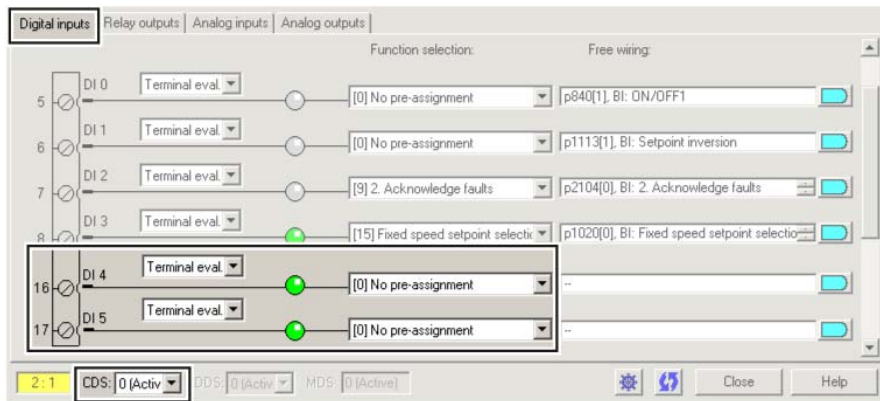


Figure 4-4 Remove pre-assignment of digital inputs DI 4 and DI 5

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

4.3.3.5 Further steps

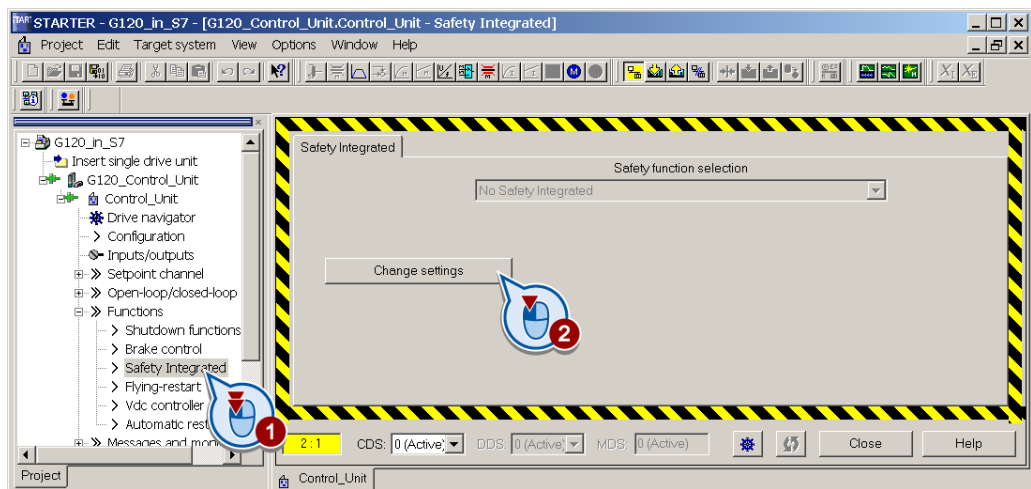
- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- Perform an acceptance test for the safety functions:
 - Document your settings in an acceptance report.
 - Check whether the safety functions are functioning correctly in your application.
 - The instructions for the acceptance test can be found in the section Acceptance test - Completion of commissioning (Page 116).

4.4 Extended Safety

4.4.1 Extended Safety with activation via F-DI

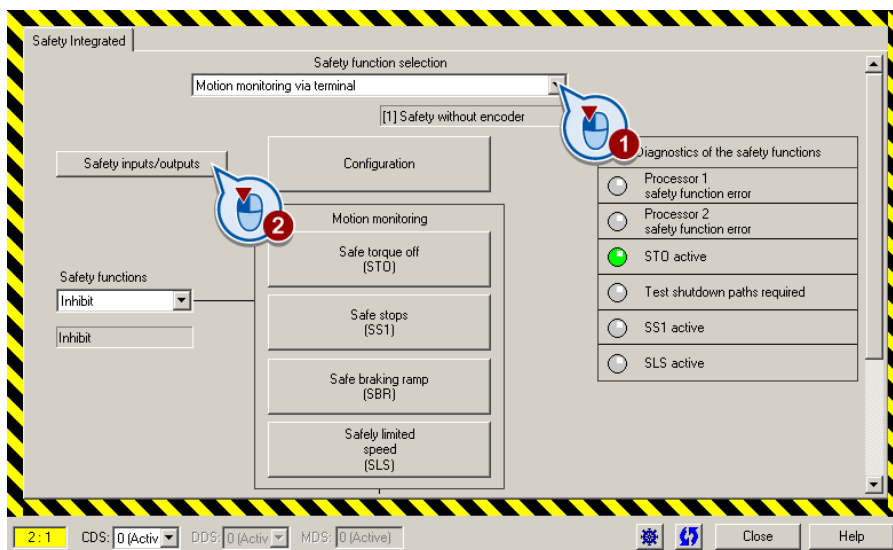
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":



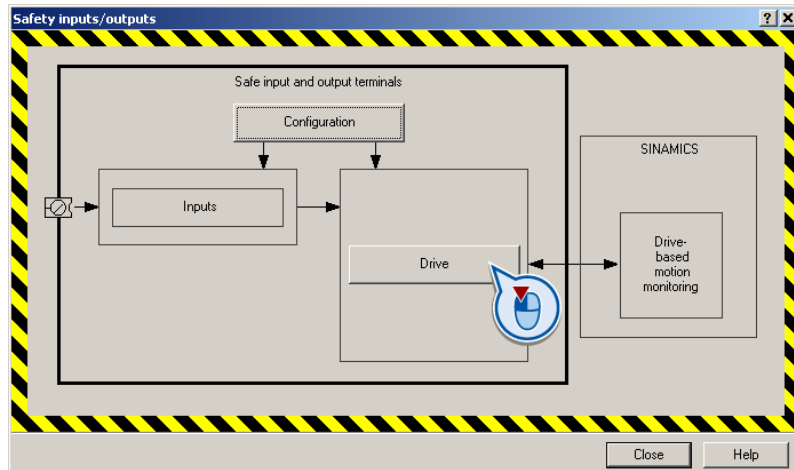
4.4.1.1 Defining the commissioning method

- Select "Motion Monitoring via Terminal" and click the button for configuring the fail-safe inputs and outputs:

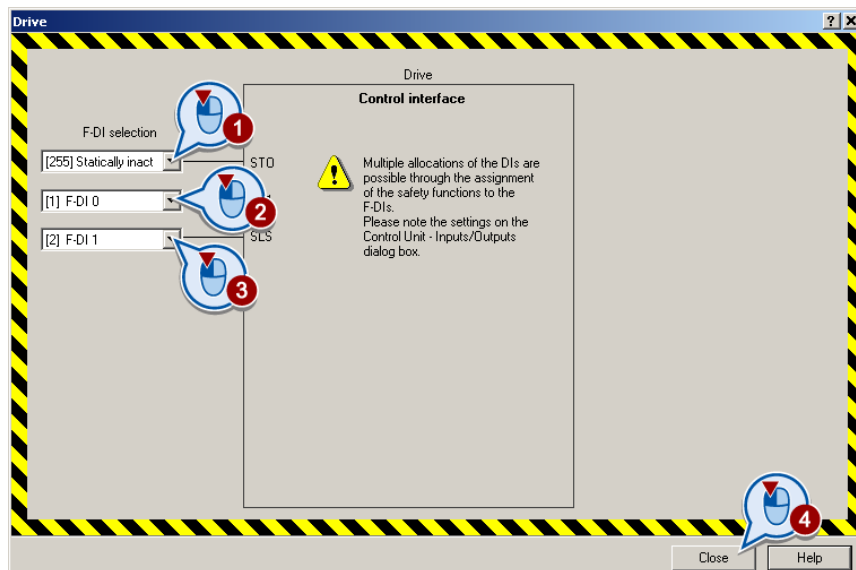


4.4.1.2 Configuring activation via FDI

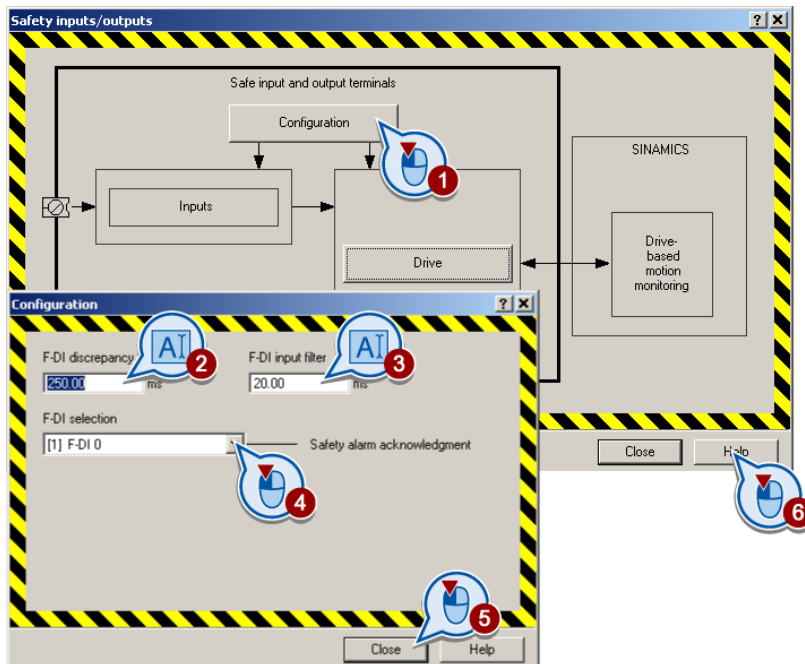
- Click the "Drive" button.



- In the following screen, you assign the fail-safe inputs to the safety functions. If you do not want to use a particular safety function, set the relevant input to "(255) Statically inactive".



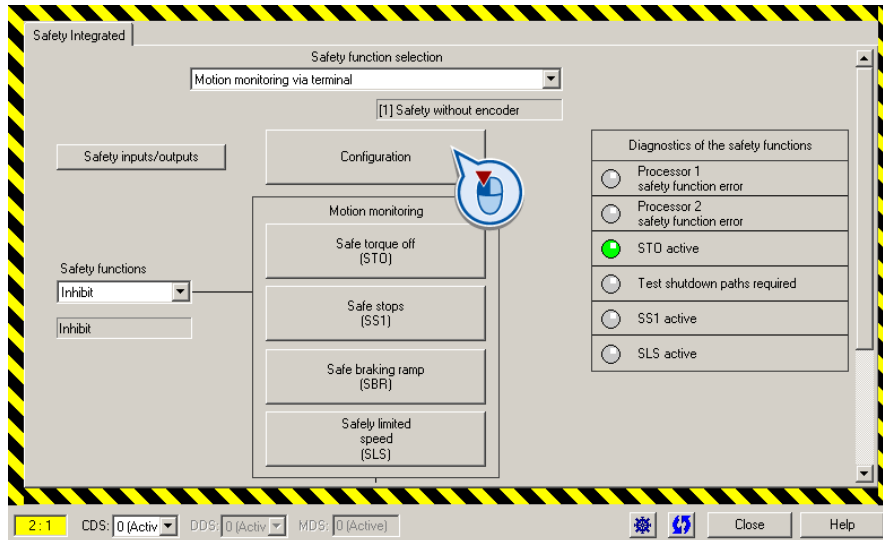
- Click the "Configuration" button:



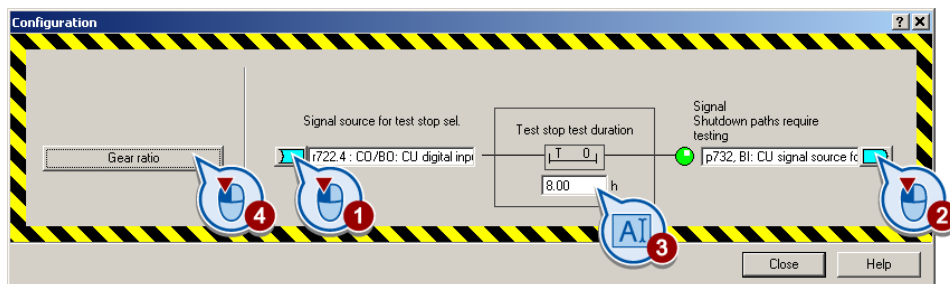
- Set the following in the above screen:
 - ② ③ **F-DI input filter (debounce time) and monitoring for simultaneous operation (discrepancy):**
A functional description of the two filters is provided in the section F-DI signal filtering (Page 57).
 - ④ **Acknowledging safety faults:**
Choose a free F-DI to acknowledge the safety faults. If there are no free F-DIs available, you have to acknowledge the safety function faults using a different method (see Acknowledging faults using a fail-safe signal (Page 136)).

4.4.1.3 Configuring safety functions

- Click the "Configuration" button.

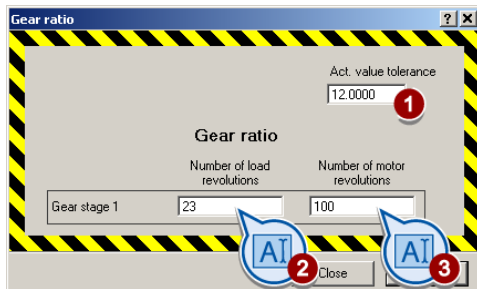


4.4.1.4 Setting forced dormant error detection



- Select the values compatible with your application.
 - ① This signal triggers a forced dormant error detection and resets the timer. Interconnect this signal with a binector of your choice, for example a digital input or a control bit in the field bus.
 - ② You must conduct a forced dormant error detection for this signal. Interconnect this binector with a signal of your choice, for example a digital input or a status bit in the field bus.
 - ③ Time interval for forced dormant error detection.
 - Further information can be found in the section Forced dormant error detection (Page 40).
- If you only want to use STO, close this screen and go to the section Enabling safety functions (Page 88).
- ④ If you want to use SS1 or SLS, click this button and go to the next section.

4.4.1.5 Setting the gear ratio



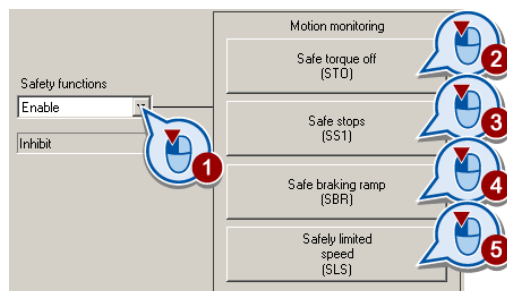
- If you want to use SS1 or SLS, set the following:
 - ① **Actual value tolerance:**
Leave this set to the factory setting (12.0 °).
 - ② ③ **Gear ratio:**
Enter your machine's data in accordance with the following table.

	② Number of load revolutions	③ Number of motor revolutions
Without gear	1	Number of pole pairs (r0313)
Gear with speed ratio Load/motor = L/M	L	M x number of pole pairs (r0313)
Example: Gear with speed ratio Load/motor = 1/3	1	3 x number of pole pairs (r0313)

- Close the screen for the gear ratio.
- Close the screen for forced dormant error detection.

4.4.1.6 Enabling safety functions

- ① Enable the safety functions via the drop-down menu:

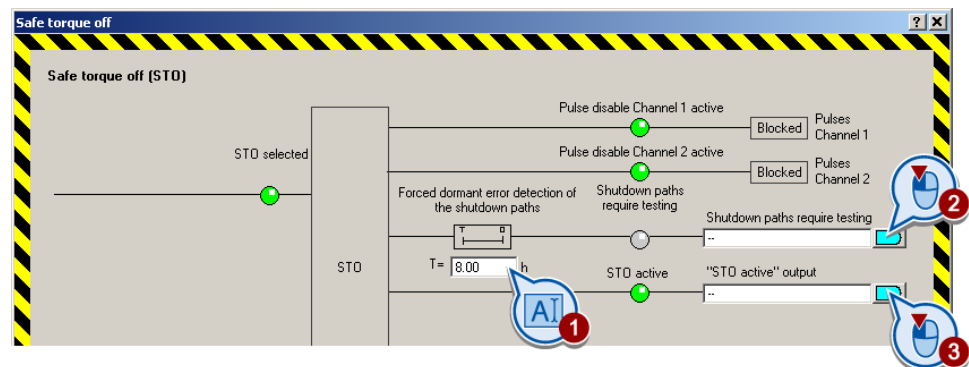


The rest of the procedure depends on which safety functions you use:

- ② The safety function "Safe Torque Off" (STO) must always be selected. The settings are described in the section Parameterizing STO (Page 89).
- ③ ④ If you use the safety function "Safe Stop 1" (SS1), follow the instructions in the following sections:
 - Parameterizing SS1 (Page 90)
 - Parameterizing SBR (Page 90).
- ⑤ If you want to use the safety function "Safely Limited Speed" (SLS), follow the instructions in the section Parameterizing SLS (Page 91).

4.4.1.7 Parameterizing STO

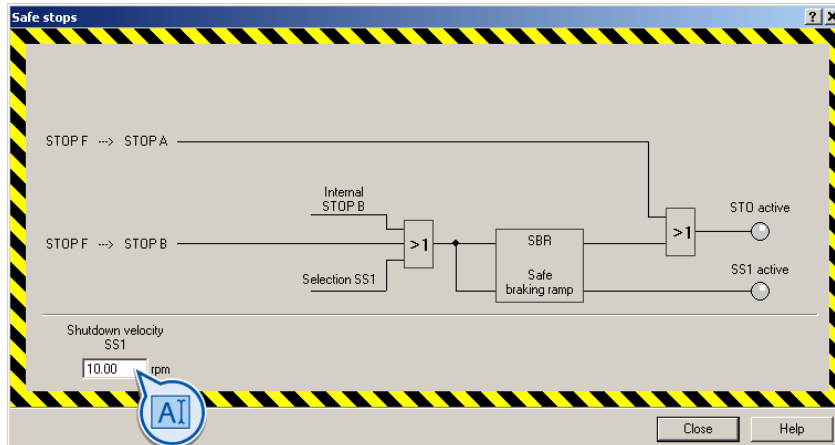
- Configure the following settings in this screen:
 - ① Forced dormant error detection of the switch-off signal paths
Enter the same time that you selected to configure the safety functions (check time test stop). See the section Defining the commissioning method (Page 84).
 - ② Connect the signal to any digital output or to a status word on the fieldbus. Further information can be found in the section Forced dormant error detection (Page 40).
 - ③ If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.



- Close the screen.
- If you do not use any other safety function, go directly to Section Activate settings (Page 92).

4.4.1.8 Parameterizing SS1

- Set the shutdown speed (standstill detection).
A functional description of standstill detection can be found in the section Dynamic response of SS1 (Page 21).

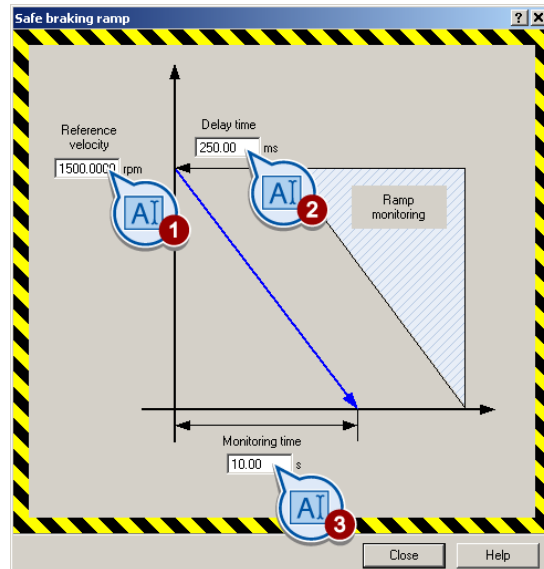


- Close the screen.

4.4.1.9 Parameterizing SBR

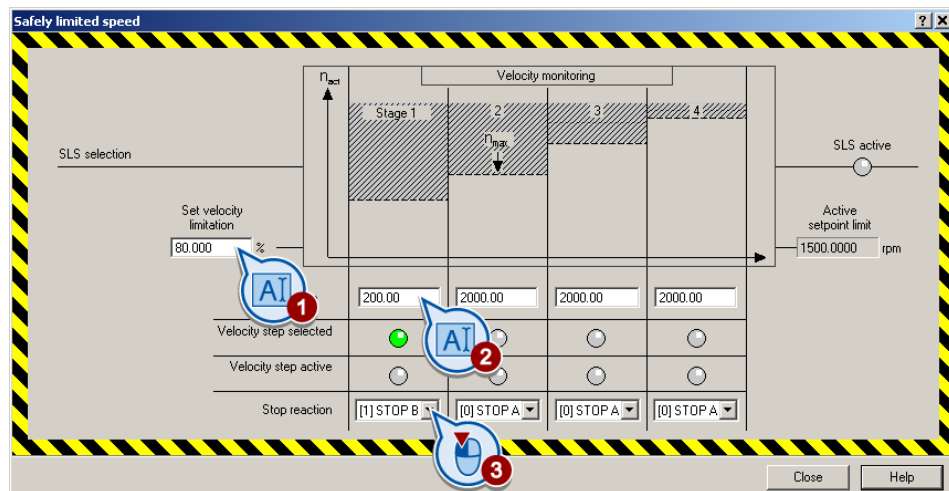
- Set the following in this screen:
 - ① Reference speed:
Reference speed = rated speed of the motor (p1082) × gear ratio
Gear ratio = load / motor revolutions
Example: p1082 = 1500 rpm, gear ratio = 1 / 3
⇒ reference speed = 500 rpm
 - ② Delay time:
If the OFF3 ramp-down time (p1135) is less than 10 seconds, leave the delay time set to the factory setting. If SS1 switches to the fault status during the function test, increase this value until the motor brakes normally.
If the OFF3 ramp-down time is set to several minutes, you must extend the delay time to a number of seconds in order to avoid any unwanted interruptions caused by SS1.
 - ③ Monitoring time
Monitoring time ≥ OFF3 ramp-down time (p1135).
If the monitoring time and OFF3 ramp-down time are identical, the deceleration ramp and monitoring curve run parallel to each other. Longer monitoring times result in flatter monitoring curves.

- A functional description of monitoring can be found in the section Dynamic response of SS1 (Page 21).



- Close the screen.
- If you do want to use any further safety functions, go directly to the section Activate settings (Page 92).

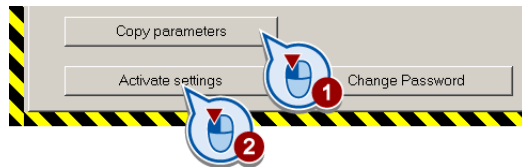
4.4.1.10 Parameterizing SLS



- Set the following in this screen:
 - ① Setpoint speed limit as a % of the monitoring threshold.
This parameter defines the upper speed limit when SLS is active.
 - ② Monitoring threshold
Enter the load-side speed to be monitored. The inverter calculates the maximum motor speed on the basis of this parameter and the gear ratio.
 - ③ Response when monitoring is activated. Further information on the stop responses can be found in the section STOP reactions (Page 137).
 - A functional description of monitoring can be found in the section Selecting SLS when the motor is switched on (Page 24).
- Close the screen.

4.4.1.11 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

4.4.1.12 Multiple assignment of the DI

- 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:

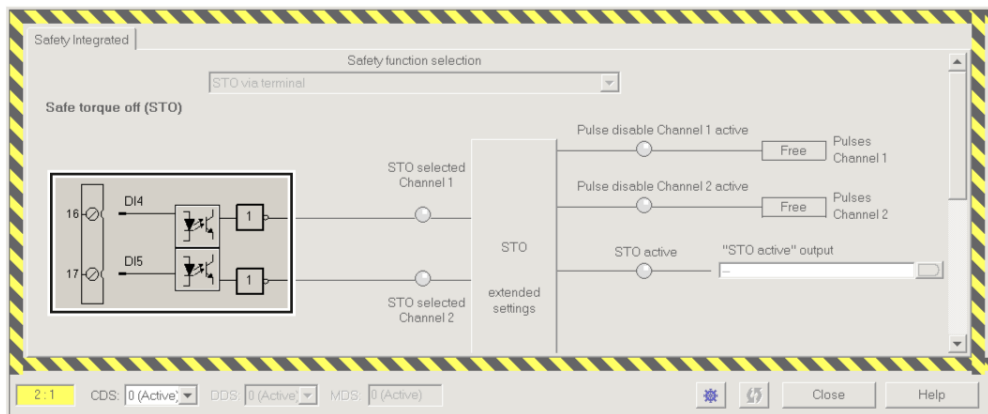


Figure 4-5 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

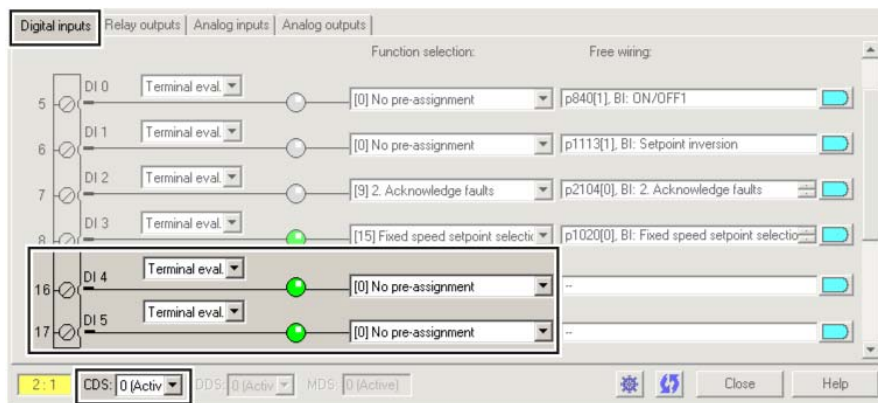


Figure 4-6 Remove pre-assignment of digital inputs DI 4 and DI 5

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

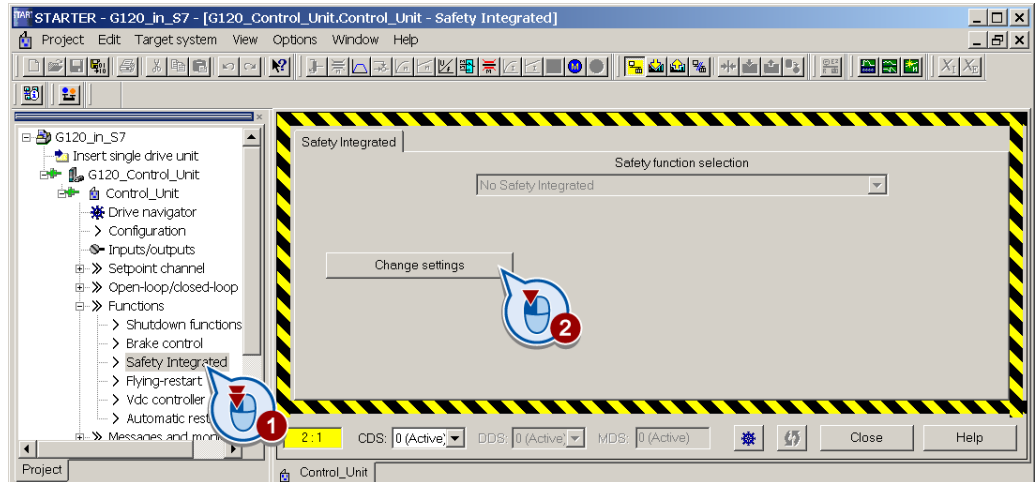
4.4.1.13 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

4.4.2 Extended Safety with activation via PROFIsafe

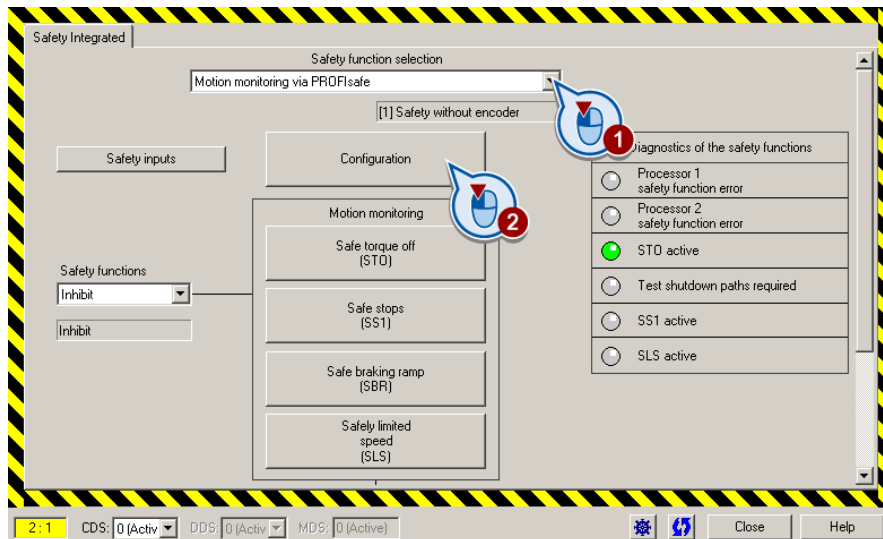
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":

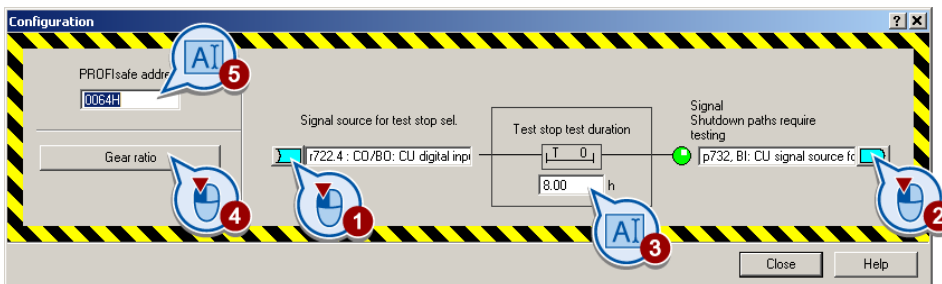


4.4.2.1 Defining the commissioning method

- Select "Motion Monitoring via Profligate" and click the "Configuration" button:

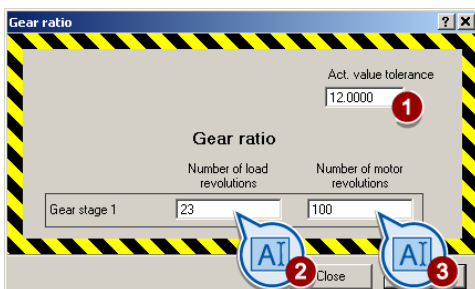


4.4.2.2 Setting forced dormant error detection and the PROFIsafe address



- Select the values compatible with your application.
 - ① This signal triggers a forced dormant error detection and resets the timer. Interconnect this signal with a binector of your choice, for example a digital input or a control bit in the field bus.
 - ② You must conduct a forced dormant error detection for this signal. Interconnect this binector with a signal of your choice, for example a digital input or a status bit in the field bus.
 - ③ Time interval for forced dormant error detection.
 - Further information can be found in the section Forced dormant error detection (Page 40).
- ⑤ **PROFIsafe address**
Enter the same PROFIsafe address as a hexadecimal value, that you defined in the hardware configuration, see the section Configuring communication in STEP 7 (telegram 30) (Page 64).
- If you only want to use STO, close this screen and go to the section Enabling safety functions (Page 97).
- ④ If you want to use SS1 or SLS, click this button and go to the next section.

4.4.2.3 Setting the gear ratio



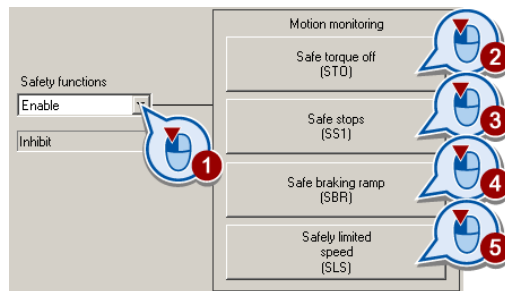
- If you want to use SS1 or SLS, set the following:
 - ① **Actual value tolerance:**
Leave this set to the factory setting (12.0 °).
 - ② ③ **Gear ratio:**
Enter your machine's data in accordance with the following table.

	② Number of load revolutions	③ Number of motor revolutions
Without gear	1	Number of pole pairs (r0313)
Gear with speed ratio Load/motor = L/M	L	M x number of pole pairs (r0313)
Example: Gear with speed ratio Load/motor = 1/3	1	3 x number of pole pairs (r0313)

- Close the screen for the gear ratio.
- Close the screen for forced dormant error detection.

4.4.2.4 Enabling safety functions

- ① Enable the safety functions via the drop-down menu:

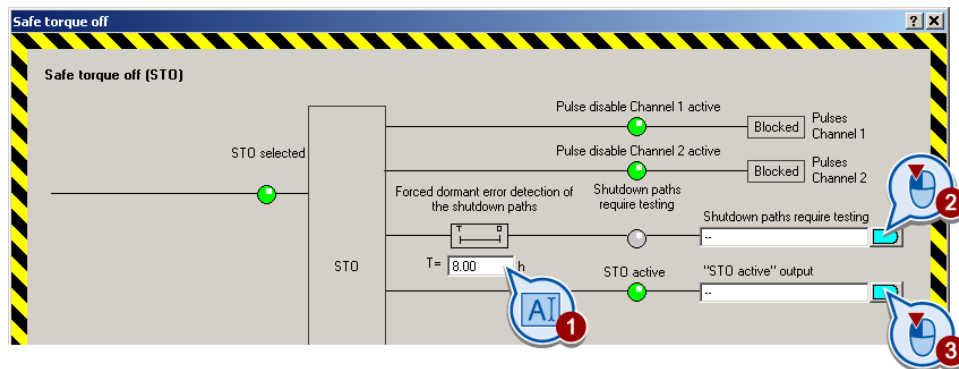


The rest of the procedure depends on which safety functions you use:

- ② The safety function "Safe Torque Off" (STO) must always be selected. The settings are described in the section Parameterizing STO (Page 98).
- ③ ④ If you use the safety function "Safe Stop 1" (SS1), follow the instructions in the following sections:
 - Parameterizing SS1 (Page 98)
 - Parameterizing SBR (Page 99).
- ⑤ If you want to use the safety function "Safely Limited Speed" (SLS), follow the instructions in the section Parameterizing SLS (Page 100).

4.4.2.5 Parameterizing STO

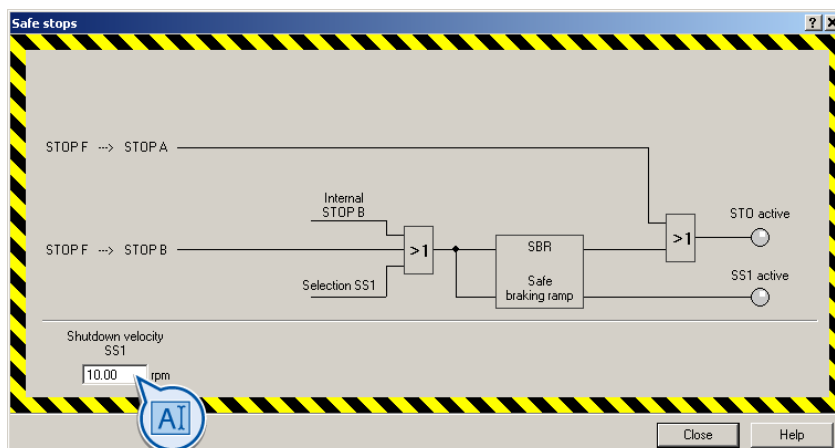
- Configure the following settings in this screen:
 - ① Forced dormant error detection of the switch-off signal paths
Enter the same time that you selected to configure the safety functions (check time test stop). See the section Defining the commissioning method (Page 95).
 - ② Connect the signal to any digital output or to a status word on the fieldbus. Further information can be found in the section Forced dormant error detection (Page 40).
 - ③ If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.



- Close the screen.
- If you do not use any other safety function, go directly to Section Activate settings (Page 101).

4.4.2.6 Parameterizing SS1

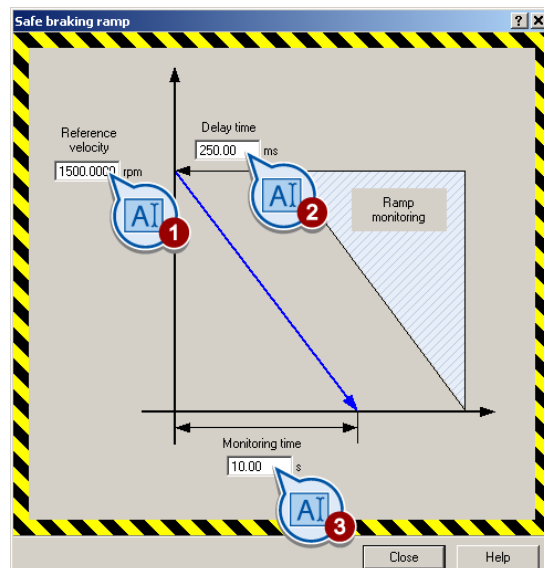
- Set the shutdown speed (standstill detection).
A functional description of standstill detection can be found in the section Dynamic response of SS1 (Page 21).



- Close the screen.

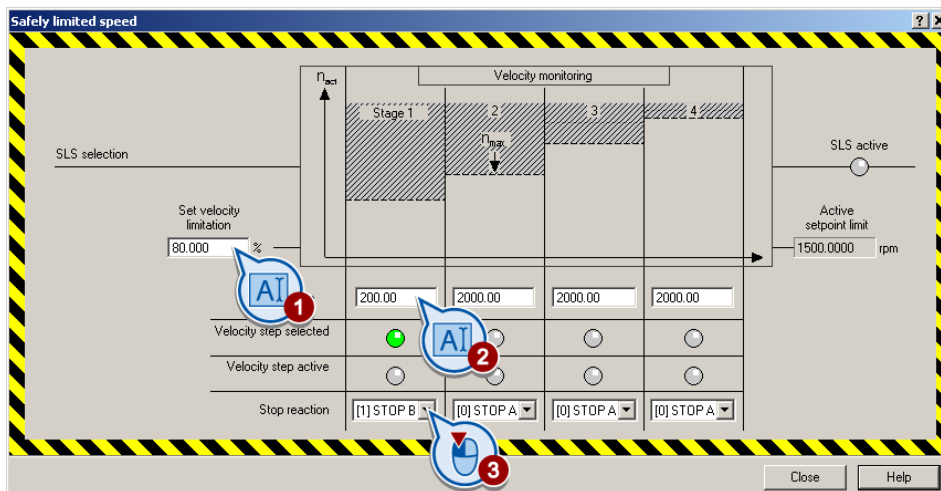
4.4.2.7 Parameterizing SBR

- Set the following in this screen:
 - ① Reference speed:
Reference speed = rated speed of the motor (p1082) × gear ratio
Gear ratio = load / motor revolutions
Example: p1082 = 1500 rpm, gear ratio = 1 / 3
⇒ reference speed = 500 rpm
 - ② Delay time:
If the OFF3 ramp-down time (p1135) is less than 10 seconds, leave the delay time set to the factory setting. If SS1 switches to the fault status during the function test, increase this value until the motor brakes normally.
If the OFF3 ramp-down time is set to several minutes, you must extend the delay time to a number of seconds in order to avoid any unwanted interruptions caused by SS1.
 - ③ Monitoring time
Monitoring time ≥ OFF3 ramp-down time (p1135).
If the monitoring time and OFF3 ramp-down time are identical, the deceleration ramp and monitoring curve run parallel to each other. Longer monitoring times result in flatter monitoring curves.
 - A functional description of monitoring can be found in the section Dynamic response of SS1 (Page 21).



- Close the screen.
- If you do want to use any further safety functions, go directly to the section Activate settings (Page 101).

4.4.2.8 Parameterizing SLS



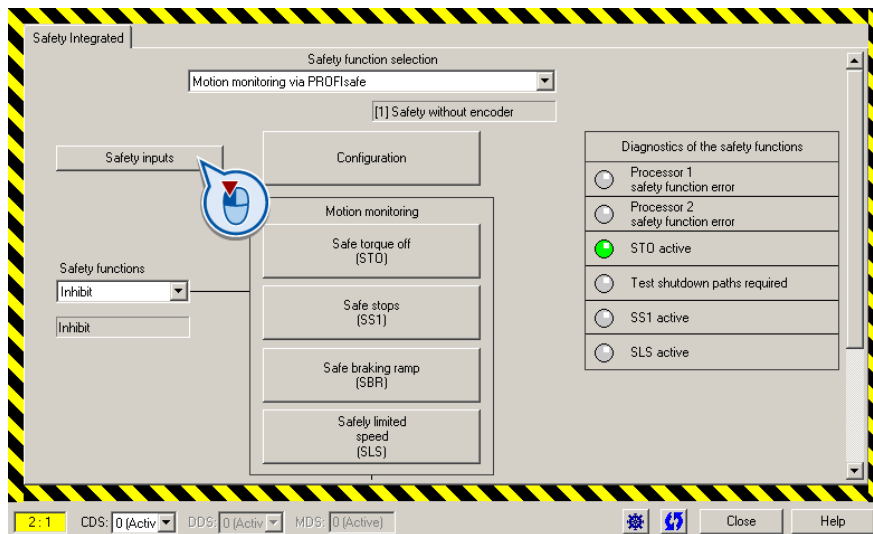
- Set the following in this screen:
 - ① Setpoint speed limit as a % of the monitoring threshold.
This parameter defines the upper speed limit when SLS is active.
 - ② Monitoring threshold
Enter the load-side speed to be monitored. The inverter calculates the maximum motor speed on the basis of this parameter and the gear ratio.
 - ③ Response when monitoring is activated. Further information on the stop responses can be found in the section STOP reactions (Page 137).
 - A functional description of monitoring can be found in the section Selecting SLS when the motor is switched on (Page 24).
- Close the screen.

4.4.2.9 Defining the F-DI status

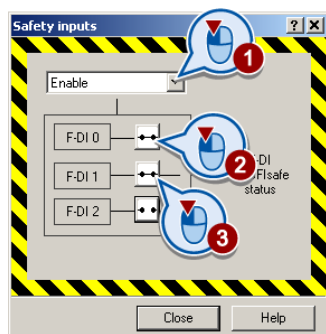
If you do not want to transfer the status of the fail-safe inputs via PROFIsafe, go straight to the section Activate settings (Page 101).

If you want to transfer the status of the fail-safe digital inputs via PROFIsafe, you first have to configure the relevant PROFIsafe telegram; see the section Configuring communication in STEP 7 (telegram 900) (Page 66). In STARTER, you then have to specify which F-DI-Status you want to transfer via PROFIsafe.

- Click the "Safety Inputs" button.



- Specify which F-DI-Status you want to transfer via PROFIsafe:

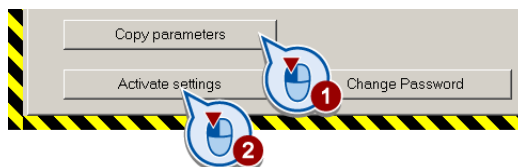


Note

The F-DI status is transferred irrespective of whether you use the F-DI to activate a fail-safe function.

4.4.2.10 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).

- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

4.4.2.11 Starting communication via PROFIsafe

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

Note

Monitoring PROFIsafe communication

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

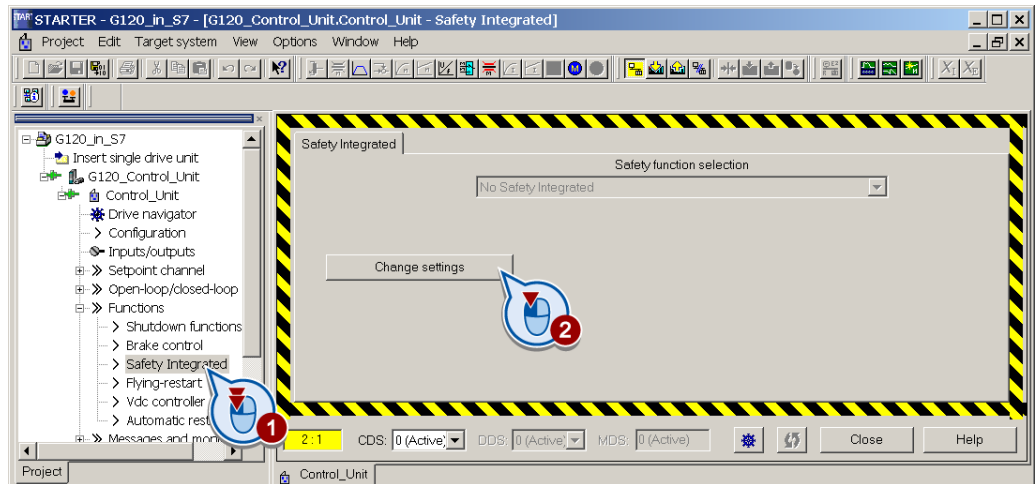
4.4.2.12 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

4.4.3 Extended Safety with activation via PROFIsafe and F-DI

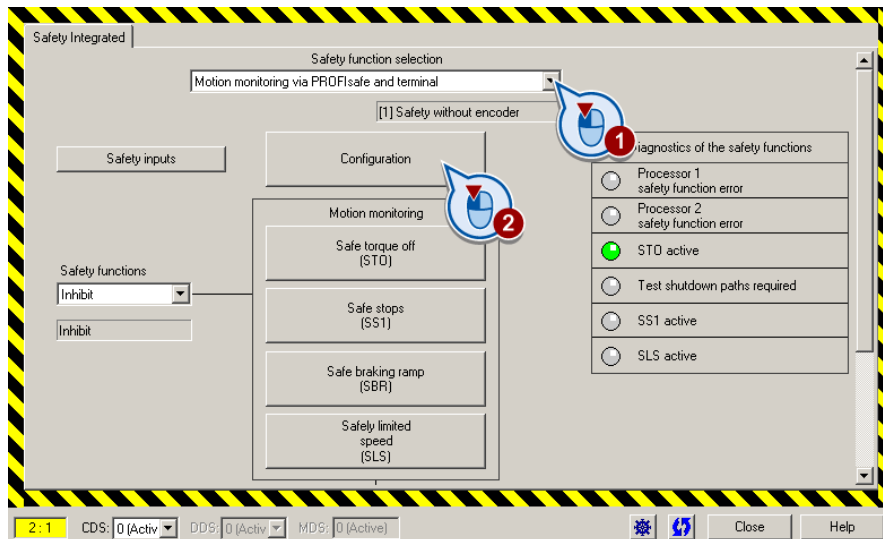
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":

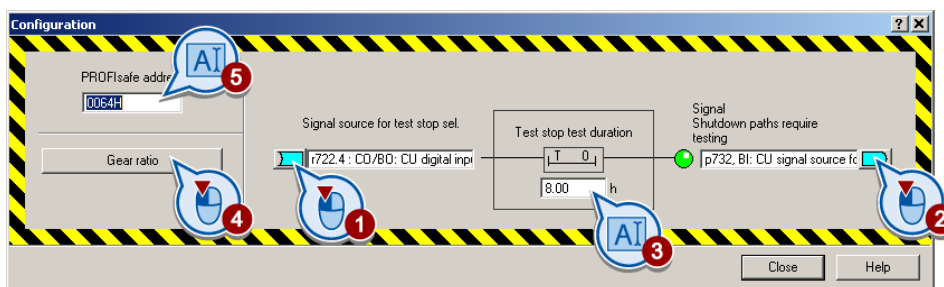


4.4.3.1 Defining the commissioning method

- Select "Motion Monitoring via PROFIsafe and F-DI" and click the "Configuration" button:

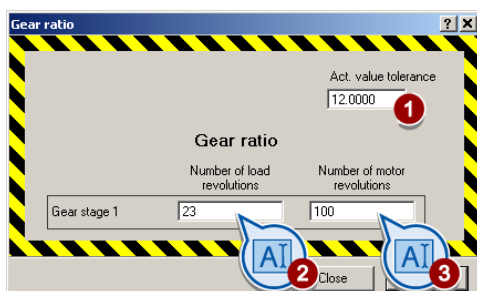


4.4.3.2 Setting forced dormant error detection and the PROFIsafe address



- Select the values compatible with your application.
 - ① This signal triggers a forced dormant error detection and resets the timer. Interconnect this signal with a binector of your choice, for example a digital input or a control bit in the field bus.
 - ② You must conduct a forced dormant error detection for this signal. Interconnect this binector with a signal of your choice, for example a digital input or a status bit in the field bus.
 - ③ Time interval for forced dormant error detection.
 - Further information can be found in the section Forced dormant error detection (Page 40).
- ⑤ **PROFIsafe address**
Enter the same PROFIsafe address as a hexadecimal value, that you defined in the hardware configuration, see the section Configuring communication in STEP 7 (telegram 30) (Page 64).
- If you only want to use STO, close this screen and go to the section Enabling safety functions (Page 105).
- ④ If you want to use SS1 or SLS, click this button and go to the next section.

4.4.3.3 Setting the gear ratio



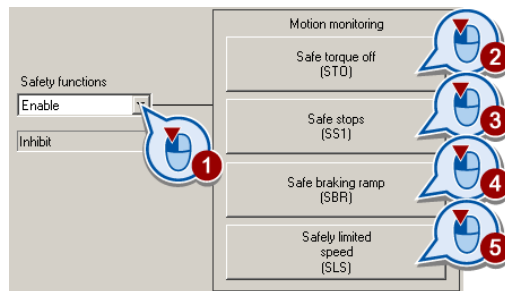
- If you want to use SS1 or SLS, set the following:
 - ① **Actual value tolerance:**
Leave this set to the factory setting (12.0 °).
 - ② ③ **Gear ratio:**
Enter your machine's data in accordance with the following table.

	② Number of load revolutions	③ Number of motor revolutions
Without gear	1	Number of pole pairs (r0313)
Gear with speed ratio Load/motor = L/M	L	M x number of pole pairs (r0313)
Example: Gear with speed ratio Load/motor = 1/3	1	3 x number of pole pairs (r0313)

- Close the screen for the gear ratio.
- Close the screen for forced dormant error detection.

4.4.3.4 Enabling safety functions

- ① Enable the safety functions via the drop-down menu:

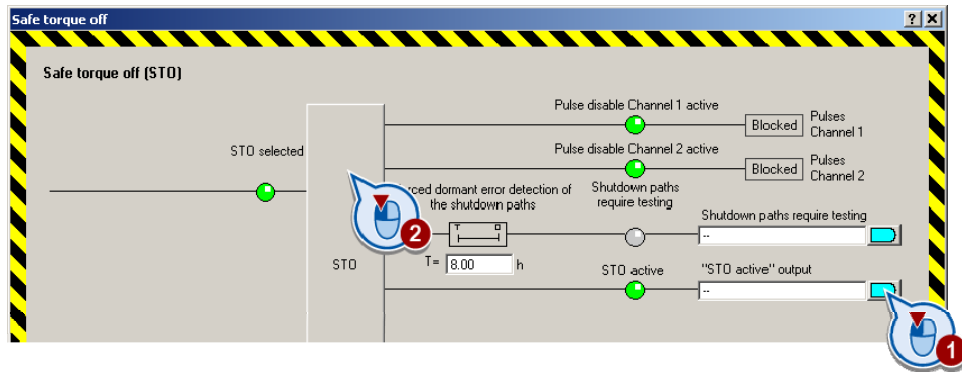


The rest of the procedure depends on which safety functions you use:

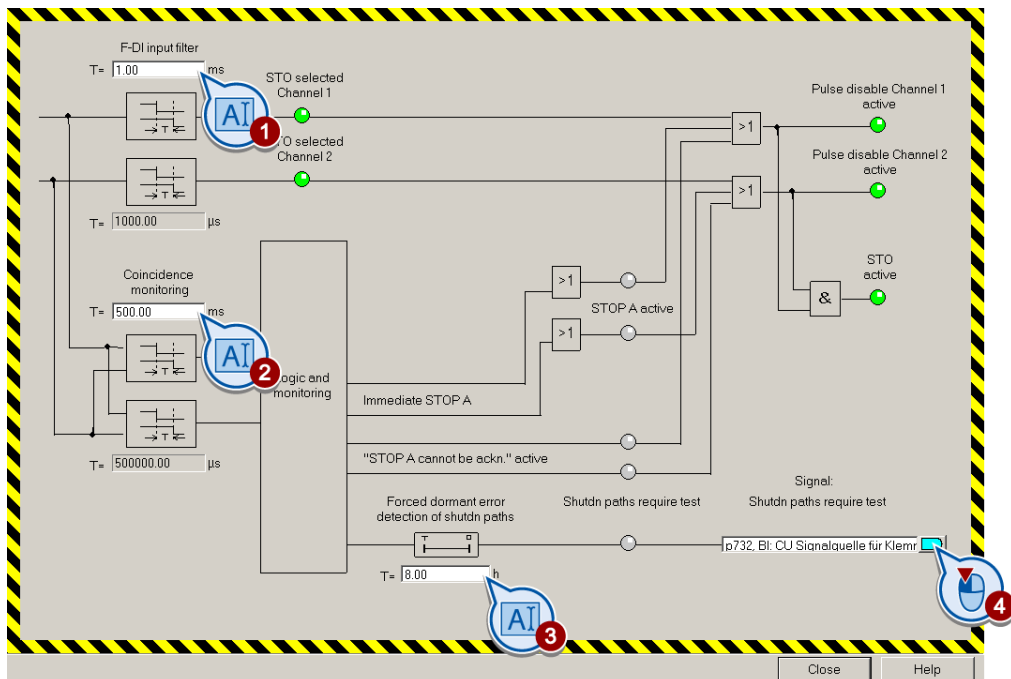
- ② The safety function "Safe Torque Off" (STO) must always be selected. The settings are described in the section Parameterizing STO (Page 106).
- ③ ④ If you use the safety function "Safe Stop 1" (SS1), follow the instructions in the following sections:
 - Parameterizing SS1 (Page 107)
 - Parameterizing SBR (Page 107).
- ⑤ If you want to use the safety function "Safely Limited Speed" (SLS), follow the instructions in the section Parameterizing SLS (Page 108).

4.4.3.5 Parameterizing STO

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



- Do not enter any other settings in this screen, instead click on the "STO" button.
- In the next screen, do not enter any settings here either, instead click on the "STO" button again.
- You can adapt the STO function according to your requirements in the following screen.

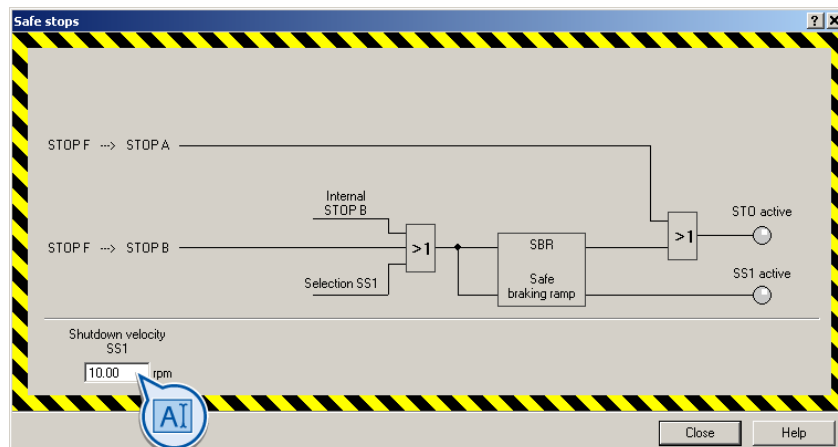


- Set the following in the above screen:
 - ① ② F-DI input filter (debounce time) and monitoring for simultaneous operation (discrepancy):
The method of functioning of the two filters is described in the section entitled F-DI signal filtering (Page 57).
 - ③ ④ Time interval for forced dormant error detection:
Information regarding forced dormant error detection can be found in the Forced dormant error detection (Page 40) section.

- Close the screen.
- Also, close any other STO screens.
- If you do not use any other safety function, go directly to Section Activate settings (Page 110).

4.4.3.6 Parameterizing SS1

- Set the shutdown speed (standstill detection).
A functional description of standstill detection can be found in the section Dynamic response of SS1 (Page 21).

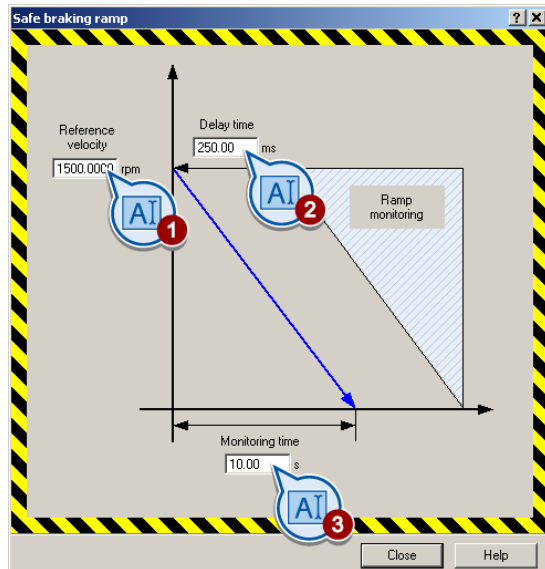


- Close the screen.

4.4.3.7 Parameterizing SBR

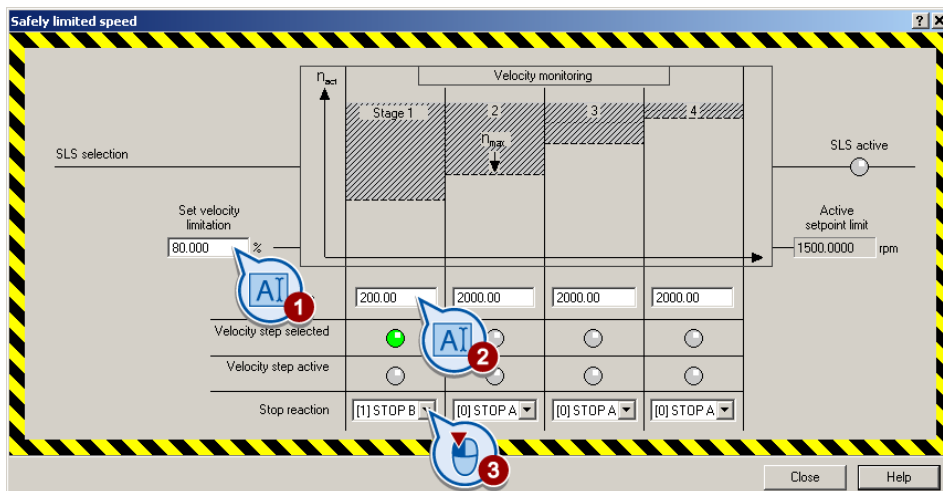
- Set the following in this screen:
 - ① Reference speed:
Reference speed = rated speed of the motor (p1082) × gear ratio
Gear ratio = load / motor revolutions
Example: p1082 = 1500 rpm, gear ratio = 1 / 3
⇒ reference speed = 500 rpm
 - ② Delay time:
If the OFF3 ramp-down time (p1135) is less than 10 seconds, leave the delay time set to the factory setting. If SS1 switches to the fault status during the function test, increase this value until the motor brakes normally.
If the OFF3 ramp-down time is set to several minutes, you must extend the delay time to a number of seconds in order to avoid any unwanted interruptions caused by SS1.
 - ③ Monitoring time
Monitoring time ≥ OFF3 ramp-down time (p1135).
If the monitoring time and OFF3 ramp-down time are identical, the deceleration ramp and monitoring curve run parallel to each other. Longer monitoring times result in flatter monitoring curves.

- A functional description of monitoring can be found in the section Dynamic response of SS1 (Page 21).



- Close the screen.
- If you do want to use any further safety functions, go directly to the section Activate settings (Page 110).

4.4.3.8 Parameterizing SLS



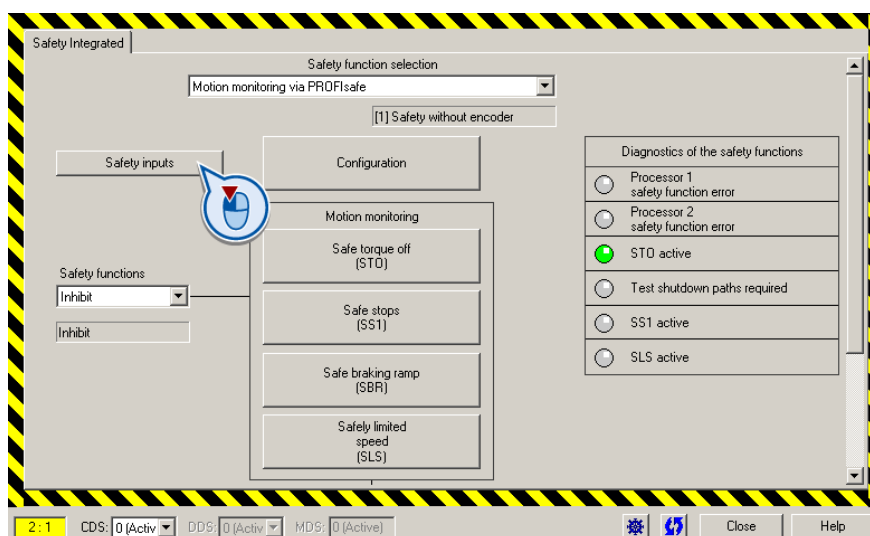
- Set the following in this screen:
 - ① Setpoint speed limit as a % of the monitoring threshold.
This parameter defines the upper speed limit when SLS is active.
 - ② Monitoring threshold
Enter the load-side speed to be monitored. The inverter calculates the maximum motor speed on the basis of this parameter and the gear ratio.
 - ③ Response when monitoring is activated. Further information on the stop responses can be found in the section STOP reactions (Page 137).
 - A functional description of monitoring can be found in the section Selecting SLS when the motor is switched on (Page 24).
- Close the screen.

4.4.3.9 Defining the F-DI status

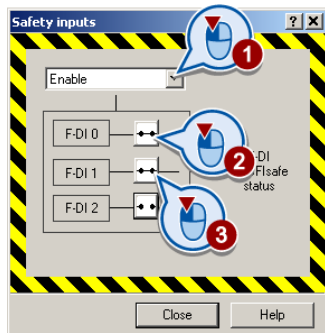
If you do not want to transfer the status of the fail-safe inputs via PROFIsafe, go straight to the section Activate settings (Page 110).

If you want to transfer the status of the fail-safe digital inputs via PROFIsafe, you first have to configure the relevant PROFIsafe telegram; see the section Configuring communication in STEP 7 (telegram 900) (Page 66). In STARTER, you then have to specify which F-DI-Status you want to transfer via PROFIsafe.

- Click the "Safety Inputs" button.



- Specify which F-DI-Status you want to transfer via PROFIsafe:

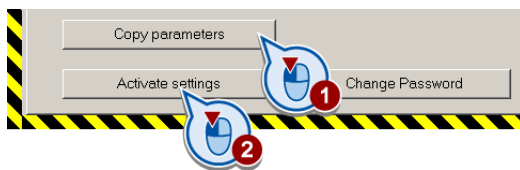


Note

The F-DI status is transferred irrespective of whether you use the F-DI to activate a fail-safe function.

4.4.3.10 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- If the password = 0 (factory setting), follow the prompts in order to set a 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 40).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

4.4.3.11 Starting communication via PROFIsafe

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

Note

Monitoring PROFIsafe communication

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

4.4.3.12 Multiple assignment of the DI

- 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:

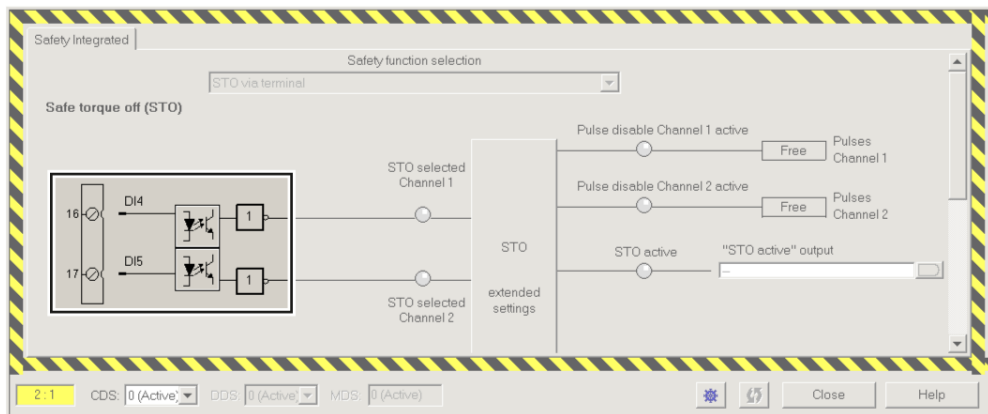


Figure 4-7 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

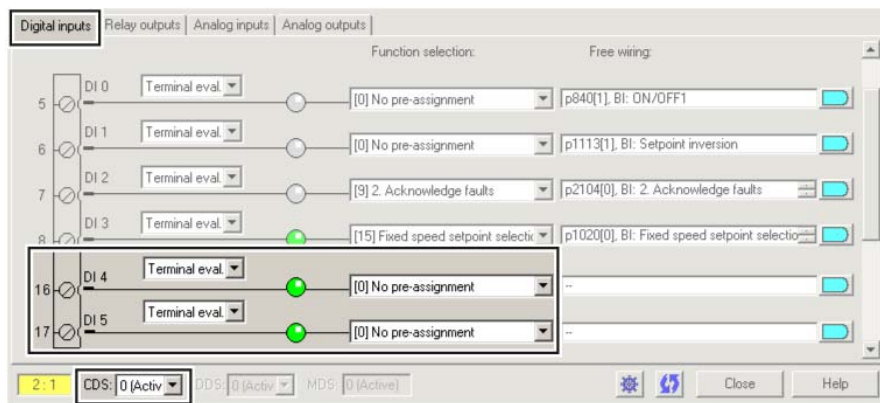


Figure 4-8 Remove pre-assignment of digital inputs DI 4 and DI 5

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

4.4.3.13 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

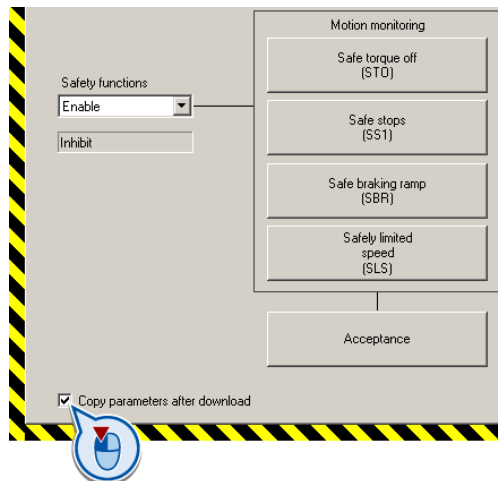
4.5 Offline commissioning


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).


4.5.1 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 Selecting the commissioning method (Page 70).
- Once you have finished setting the parameters, save your project by clicking the  button.

4.5.2 Downloading parameters

- Go online with STARTER and start downloading the parameters to the inverter. To do so, click the  button. You download both the standard parameters and the parameters for the safety functions in your STARTER project to the inverter.
- Open the safety functions screen and click the "Change Settings" and "Activate Settings" buttons.
- If the password is 0 (factory setting), you will be prompted to define a new 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 40).

- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset). Only then will your changes become effective.

4.5.3 Further steps

- Commission the standard inverter functions by following the operating instructions. The link to the operating instructions can be found in the section Overview of documentation (Page 10).
- 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 test - Completion of commissioning (Page 116).

4.6 Series commissioning

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

To copy all the parameters of one inverter to a second inverter, follow the instructions in the section Downloading parameters (Page 113).

Steps to be carried out after downloading the parameters:

- If you activate your inverter via PROFIsafe, you have to modify the PROFIsafe address.
- Perform a reduced acceptance test for the safety functions. The necessary steps are described in the section Reduced acceptance test (Page 117).

4.7 Restoring the factory setting

Resetting parameters when the safety functions are active

In order to reset the safety function parameters together with all other parameters of the inverter, proceed as follows:

- Go online with STARTER.
- Open the safety functions screen and deactivate the safety functions.
- Go offline with STARTER.
- Switch off the Control Unit power supply for approximately 10 seconds (Power ON Reset).
- Go online with STARTER.
- Reset the Control Unit to the factory setting.

4.8 Acceptance test - Completion of commissioning

4.8.1 Prerequisites and authorized persons

Requirements for acceptance tests are derived from the EC Machinery Directive and ISO 13849-1.

- Check the safety-related functions and machine parts following commissioning.
- Issue an "Acceptance certificate" which describes 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 must be complete. These include, for example:
 - Configuration of the setpoint channel.
 - Position control in the higher-level controller.
 - Drive 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.

4.8.2 Complete acceptance test

A complete acceptance test includes the following:

1. Documentation
 - Description of the machines and overview/block diagram
 - Safety functions of the drive
 - Description of safety equipment
2. Function test
 - Test of the shutdown paths
 - Test of safety functions used
3. Conclusion of the report
 - Inspection of safety function parameters
 - Recording of the checksums
 - Verify the data backup
 - Countersignatures

4.8.3 Reduced acceptance test

A complete acceptance test is only necessary following first commissioning. An acceptance test with a reduced scope is sufficient for expansions of safety functions.

The reduced acceptance tests must be carried out separately for each individual drive, as far as the machine allows.

Table 4- 1 Reduced acceptance test for function extensions

Measure	Acceptance test		
	Documentation	Function test	Conclusion of the report
Replacing the Control Unit or the Power Modules.	Supplement: <ul style="list-style-type: none"> • Hardware data • Configuration • Firmware Versions 	Yes.	Supplement: <ul style="list-style-type: none"> • New checksums and countersignature
Hardware replacement of safety-related distributed I/O devices (e.g. emergency off switch).	Supplement: <ul style="list-style-type: none"> • Hardware data • Configuration • Firmware Versions 	Partially. <ul style="list-style-type: none"> • Limitation to replaced components. 	No.
Update the firmware of the Control Unit.	Supplement: <ul style="list-style-type: none"> • Version data • New safety functions 	Yes.	Supplement: <ul style="list-style-type: none"> • New checksums and countersignature.
Change to a single limit (e.g. SLS limit).	Supplement to the safety functions for each drive.	Partially. <ul style="list-style-type: none"> • Testing the changed limit value. 	Supplement: <ul style="list-style-type: none"> • New checksums and countersignature.
Functional expansion of the machine (additional drive).	Supplementary safety functions for each drive and function table.	Yes. <ul style="list-style-type: none"> • Testing the additional functions. 	Supplement: <ul style="list-style-type: none"> • New checksums and countersignature.
Functional expansion of a drive (e.g. additional SLS limit).	Supplement to the safety functions for each drive and function table.	Yes. <ul style="list-style-type: none"> • Test the additional functions. 	Supplement. <ul style="list-style-type: none"> • New checksums and countersignature.
Transfer of inverter parameters to other identical machines by means of standard commissioning.	Supplement to the machine description (checking of the firmware versions).	No.	No, if data are identical (checking of checksums).

4.8.4 Documentation

If you want to use the acceptance report as a template and edit it for your machine, configure a download of this manual using the "My Documentation Manager" service on the Internet.

On the Internet, click the link to this manual (Overview of documentation (Page 10)) followed by "Display and Configure". Once you have registered, you can choose individual chapters of the manual and download them as a file in rtf format.

Machine overview

Enter your machine's data into the following table.

Designation	...
Type	...
Serial number	...
Manufacturer	...
End customer	...
Overview image of the machine:	
<p>...</p> <p>...</p> <p>...</p> <p>...</p> <p>...</p> <p>...</p> <p>...</p>	

Inverter hardware and firmware versions

Document the firmware version for each safety-related inverter of your machine.

Labeling the drive	MLFB of the Control Unit and Power Module	Firmware version of the Control Unit	Version of the safety functions			
			r9770[0]	r9770[1]	r9770[2]	r9770[3]
(Drive 1)	...	r0018 = ...	r9870[0]	r9870[1]	r9870[2]	r9870[3]
			r9390[0]	r9390[1]	r9390[2]	r9390[3]
			r9590[0]	r9590[1]	r9590[2]	r9590[3]

(Drive 2)	...	r0018 = ...	r9770[0]	r9770[1]	r9770[2]	r9770[3]
	...					
			r9870[0]	r9870[1]	r9870[2]	r9870[3]
			r9390[0]	r9390[1]	r9390[2]	r9390[3]
			r9590[0]	r9590[1]	r9590[2]	r9590[3]

Function table

Fill in the following table for your machine.

Mode of operation	Safety device	Drive	Activating the safety function	Status of the safety function
...
...

Table 4-2 Example:

Mode of operation	Safety device	Drive	Activating the safety function	Status of the safety function
Production	Protective door closed and locked	1 2	- PROFIsafe	not active SLS level 2 active
	Protective door unlocked	1 2	F-DI 0 PROFIsafe	STO SS1
Setup	Protective door closed and locked	1 2	- PROFIsafe	not active SLS level 2 active
	Protective door unlocked	1 2	F-DI 1 PROFIsafe	SS1 SLS level 0 active

Setting the safety functions

Enter the limit values for the safety functions in the following table.

Drive	Safety function	Limit
...
...
...
...

Table 4- 3 Example:

Drive	Safety function	Limit
1	STO	-
	SS1	Reference speed = 1500 rpm Delay time = 250 ms Monitoring time = 5 s
2	SS1	Reference speed = 1500 rpm Delay time = 250 ms Monitoring time = 8 s
	SLS 0	150 rpm
	SLS 2	1500 rpm

4.8.5 Function test

4.8.5.1 Safe Torque Off, STO (Basic Safety)

The following is checked during the function test:

- The hardware is functioning properly.
- The digital inputs of the inverter are assigned correctly for the safety function.
- The PROFIsafe address of the inverter is set correctly.
- The safety function is parameterized correctly.
- Routine for forced dormant error detection of the switch-off signal paths on the Control Unit.

Note

Perform the acceptance test with the maximum possible speed and acceleration.

Procedure

Table 4- 4 "Safe Torque Off" (STO) function

No.	Description	Status
1.	Initial state:	
	• The inverter is in "Ready" state (p0010 = 0).	
	• The inverter indicates neither faults nor alarms for safety functions (r0945, r2122, r2132).	
	• STO is not active.	
2.	Switch on the motor (ON command).	
3.	Ensure that the correct motor is running.	
4.	Select STO while the motor is running Note: Test each configured activation, e.g. via digital inputs and PROFIsafe.	

No.	Description	Status
5.	Check the following:	
	<ul style="list-style-type: none"> 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. 	
	<ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions. 	
	<ul style="list-style-type: none"> The inverter indicates: "STO is selected" (r9773.0 = 1). "STO is active" (r9773.1 = 1). 	
6.	Deselect STO.	
7.	Check the following:	
	<ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions. 	
	<ul style="list-style-type: none"> The inverter indicates: "STO is not selected" (r9773.0 = 0). "STO is not active" (r9773.1 = 0). 	
	<ul style="list-style-type: none"> The inverter is in "Closing lockout" state (p0046.0 = 1). 	
8.	Switch the motor off (OFF1 command) and then on again (ON command).	
9.	Ensure that the correct motor is running.	

4.8.5.2 Safe Torque Off, STO (Extended Safety)

The following is checked during the function test:

- The hardware is functioning properly.
- The digital inputs of the inverter are assigned correctly for the safety function.
- The PROFIsafe address of the inverter is set correctly.
- The safety function is parameterized correctly.
- Routine for forced dormant error detection of the switch-off signal paths on the Control Unit.

Note

Perform the acceptance test with the maximum possible speed and acceleration.

Procedure

Table 4- 5 "Safe Torque Off" (STO) function

No.	Description	Status
1.	Initial state	
	The inverter is in "Ready" state (p0010 = 0).	
	The inverter indicates neither faults nor alarms for safety functions (r0945, r2122, r2132).	
	STO is not active.	
2.	Switch on the motor (ON command).	
3.	Ensure that the correct motor is running.	

4.8 Acceptance test - Completion of commissioning

No.	Description	Status
4.	Select STO while the motor is running. Note: Test each configured activation, e.g. via digital inputs and PROFIsafe.	
5.	Check the following:	
	<ul style="list-style-type: none"> 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. 	
	<ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions. 	
	<ul style="list-style-type: none"> The inverter indicates: "STO is selected" (r9720.0 = 0) "STO is active" (r9722.0 = 1) 	
6.	Deselect STO.	
7.	Check the following:	
	<ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions. 	
	<ul style="list-style-type: none"> The inverter indicates: "STO is not selected" (r9720.0 = 1) "STO is not active" (r9722.0 = 0) 	
	<ul style="list-style-type: none"> The inverter is in "Closing lockout" state (p0046.0 = 1). 	
8.	Switch the motor off (OFF1 command) and then on again (ON command).	
9.	Ensure that the correct motor is running.	

4.8.5.3 Safe Stop 1, SS1

The following is checked during the function test:

- The hardware is functioning properly.
- The digital inputs of the inverter are assigned correctly for the safety function.
- The PROFIsafe address of the inverter is set correctly.
- The safety function is parameterized correctly.
- Routine for forced dormant error detection of the switch-off signal paths on the Control Unit.

Procedure

Note

Perform the acceptance test with the maximum possible speed and acceleration.

Table 4- 6 "Safe Stop 1" function (SS1)

No.	Description	Status
1.	Initial state:	
	<ul style="list-style-type: none"> The inverter is in "Ready" state (p0010 = 0). 	
	<ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions (r0945, r2122, r2132). 	

No.	Description	Status
	<ul style="list-style-type: none"> SS1 is not active. 	
2.	Switch on the motor (ON command).	
3.	Ensure that the correct motor is running.	
4.	Select SS1 while the motor is running. Note: Test each configured activation, e.g. via digital inputs and PROFIsafe.	
5.	Check the following: <ul style="list-style-type: none"> The motor speed decreases in line with the selected ramp time (if necessary, use a stopwatch). The inverter indicates: "SS1 is selected" (r9720.1 = 0). "SS1 is active" (r9722.1 = 1). The motor coasts to a standstill after the standstill detection threshold has been reached. The inverter indicates: "STO is active" (r9772.0 = 1). A mechanical brake brakes the motor and holds it to ensure that it remains at a standstill. The inverter indicates neither faults nor alarms for safety functions. 	
6.	Deselect SS1.	
7.	Check the following: <ul style="list-style-type: none"> The inverter indicates neither faults nor alarms for safety functions. The inverter indicates: "STO is not active" (r9722.0 = 0). "SS1 is deselected" (r9720.1 = 1). 	
8.	Switch the motor off (OFF1 command) and then on again (ON command).	
9.	Ensure that the correct motor is running.	

4.8.5.4 Safely Limited Speed, SLS

The following is checked during the function test:

- The hardware is functioning properly.
- The digital inputs of the inverter are assigned correctly for the safety function.
- The PROFIsafe address of the inverter is set correctly.
- The safety function is parameterized correctly.
- Routine for forced dormant error detection of the switch-off signal paths on the Control Unit.

Procedure

Table 4- 7 "Safely Limited Speed" (SLS) function

No.	Description	Status
1.	Initial state <ul style="list-style-type: none"> The inverter is in "Ready" state (p0010 = 0). 	

4.8 Acceptance test - Completion of commissioning

No.	Description	Status
	<ul style="list-style-type: none"> • The inverter indicates neither faults nor alarms for safety functions (r0945, r2122, r2132). • SLS is not active. 	
2.	Switch on the motor (ON command). Note: Select a higher motor speed than the SLS limit currently set (providing the machine allows this).	
3.	Ensure that the correct motor is running.	
4.	Select the SLS monitoring speed to be checked. Notes: If you are using several SLS monitoring speeds, repeat the test for each of the monitoring speeds. Test each configured activation, e.g. via digital inputs and PROFIsafe.	
5.	Select SLS while the motor is running.	
6.	Check the following: <ul style="list-style-type: none"> • The motor speed decreases in line with the selected ramp time. The motor then rotates below the parameterized safely limited speed. 	
	<ul style="list-style-type: none"> • The inverter indicates: "SLS is selected" (r9720.4 = 0). "SLS is active" (r9722.4 = 1). 	
7.	Deselect SLS.	
8.	Check the following:	
	<ul style="list-style-type: none"> • The motor speed increases until the setpoint is reached. 	
	<ul style="list-style-type: none"> • The inverter indicates neither faults nor alarms for safety functions. • The inverter indicates: "SLS is deselected" (r9720.4 = 1). "SLS is not active" (r9722.4 = 0). 	

4.8.6 Completion of certificate

Document your machine's data for each drive based on the following specifications.

Parameters of the safety functions

The function test does not detect all faults in the parameter assignment of safety functions, e.g. forced dormant error detection time or filtering time of fail-safe inputs. Therefore, check all parameters once more.

Labeling the drive	All parameter values checked
...	
...	

Checksums of the safety functions

The inverter calculates checksums across all parameters and safety functions. The parameters of Basic Safety and Extended Safety have their own checksums.

When you change the safety function settings, the inverter calculates new checksums. This means that subsequent changes in your machine can be tracked.

In addition to the individual checksums of the parameters, the inverter calculates and saves the following values:

1. The "total" checksum across all checksums.
2. Time of the last parameter changed.

Labeling the drive	Checksums					Total	Time stamp
	Basic Safety		Extended Safety		Processor 2 [0] = Parameter [1] = Actual values		
	Processor 1	Processor 2	Processor 1	Processor 2			
...	p9798	p9898	p9398[0]	p9728[0]		r9781[0]	r9782[0]
	p9799	p9899	p9399[0]	p9728[1]			
				p9729[0]			
				p9729[1]			

Commissioning

4.8 Acceptance test - Completion of commissioning

...	p9798	p9898	p9398[0]	p9728[0]	r9781[0]	r9782[0]
	p9799	p9899	p9399[0]	p9728[1]		
				p9729[0]		
				p9729[1]		

Data backup

	Storage medium			Holding area
	Type	Designation	Date	
Parameter				
PLC program				
Circuit diagrams				

Countersignatures

Confirmation that the tests and checks have been carried out properly.

Table 4- 8 Commissioning engineer

Date	Name	Company/dept.	Signature

Confirmation that the parameters documented above are correct.

Table 4- 9 Machine manufacturer

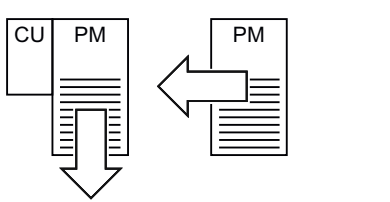
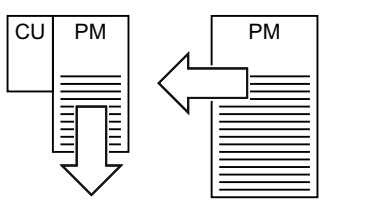
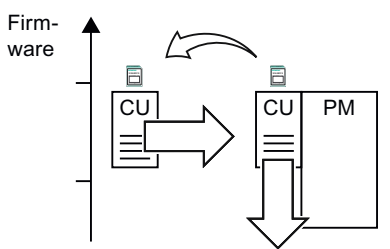
Date	Name	Company/dept.	Signature

5.1 Replacing the inverter components

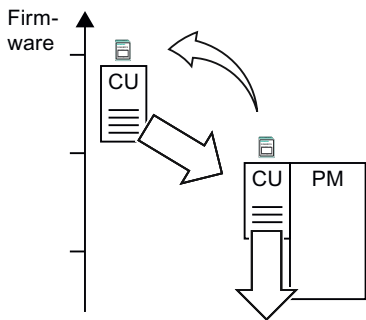
In the event of a long-term function fault, you can replace the inverter's Power Module or Control Unit separately. In many cases, you can switch the motor back on again straight after the replacement.

Replacing components without recommissioning the drive

In the scenarios listed below, the inverter can be used straight after components have been replaced:

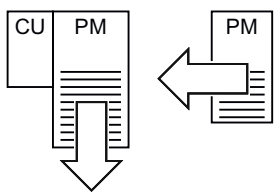
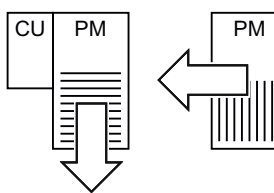
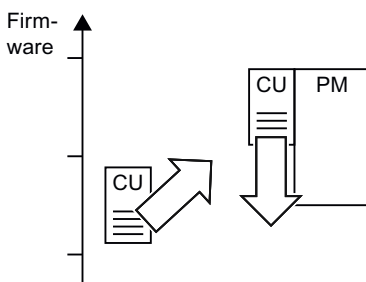
Component replacement		Remark
	Replacing Power Module with a Power Module <ul style="list-style-type: none"> • of the same type and • same power rating 	-
	Replacing Power Module with a Power Module <ul style="list-style-type: none"> • of the same type and • <i>greater</i> power rating 	Power Module and motor must be adapted to one another (ratio of motor and Power Module rated power > 1/8)
	Replacing Control Unit with memory card with a Control Unit <ul style="list-style-type: none"> • of the same type and • same firmware version 	The settings, which are saved on the memory card of the CU that has been replaced, are transferred into the new CU

5.1 Replacing the inverter components

Component replacement	Remark
	<p>Replacing Control Unit with memory card with a Control Unit</p> <ul style="list-style-type: none"> • of the same type and • <i>higher</i> firmware version: (e.g. replacing a CU with FW V4.2 by a CU with FW V4.3)

Replacing components where recommissioning is needed

In the cases below, you will need to reparameterize the inverter when the components have been replaced:

	<p>Replacing Power Module with a Power Module</p> <ul style="list-style-type: none"> • of the same type and • <i>lower</i> power rating
	<p>Replacing Power Module with a Power Module of a <i>different</i> type (e.g. replacing a PM240 with a PM250)</p>
	<p>Replacing Control Unit with a Control Unit</p> <ul style="list-style-type: none"> • of the same type and • <i>lower</i> firmware version (e.g. replacing a CU with FW V4.3 with a CU with FW V4.2)

Component replacement	
	Replacing Control Unit <i>without</i> a memory card
	Replacing Control Unit with a Control Unit of a <i>different</i> type (e.g. replacing a CU230P-2 with a CU240E-2 DP)

5.2 Replacing the Control Unit

We recommend that you back up the Control Unit parameters externally once commissioning has been completed. The options are as follows:

1. Back up using the commissioning tool STARTER on your PG/PC.
2. Back up your parameters on a memory card in the inverter.
3. Back up in the Operator Panel.

If you do not back up your parameters, 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 of the Power Module and (if installed) the external 24 V supply or the voltage for the relay outputs DO 0 and DO 2 of the Control Unit.
- Remove the signal cables of the Control Unit.
- Remove the defective CU from the Power Module.
- Plug the new CU on to 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 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.
- 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 of the Power Module and (if installed) the external 24 V supply or the voltage for the relay outputs DO 0 and DO 2 of the Control Unit.
- Remove the signal cables of the Control Unit.
- Remove the defective CU from the Power Module.
- Plug the new CU on to the Power Module.
- Reconnect the signal cables of the Control Unit.
- Connect up the line voltage again.
- The inverter goes into the "ready-to-switch-on" state.
- Check whether the new CU has the same order number and the same or a higher firmware version as the CU that was replaced.
- If yes, and if you have backed-up the parameters of the Control Unit that was replaced, then proceed as follows:
 - Load the parameters into the new CU using STARTER or an Operator Panel.
 - Switch on the motor and check the function of the drive.
- In all other cases, you must recommission the inverter.

Acceptance test

After replacing the Control Unit, you must conduct an acceptance test of the safety functions.

- If you have newly commissioned the inverter, the following steps are required: :
 - Power ON Reset
 - Perform a complete acceptance test, see Complete acceptance test (Page 116).
- In all other cases, after downloading the parameters into the inverter, the following steps are required:
 - Power ON Reset
 - Perform a reduced acceptance test. The reduced acceptance tests are described in Section Reduced acceptance test (Page 117).

5.3 Replacing the Power Module

Procedure for replacing a Power Module

- Disconnect the Power Module from the line.
- If present, switch off the 24 V supply of the Control Unit.
- After switching off the line voltage, wait 5 minutes until the device has discharged itself.
- Remove the line supply cables of the Power Module.
- Remove the Control Unit from the Power Module.
- Replace the old Power Module with the new Power Module.
- Snap the Control Unit onto the new Power Module.
- Correctly connect the line supply cables to the new Power Module.
- Connect the line supply and, if present, the 24 V supply for the Control Unit.
- If necessary, recommission. (See Replacing the inverter components (Page 127)).

Acceptance test

- Acknowledge the fault code issued by the inverter.
- Perform a reduced acceptance test. The necessary measures are described in Chapter Reduced acceptance test (Page 117).

Alarms, faults and system messages

The inverter has the following diagnostic types:

- LED
You can obtain an overview of the inverter state locally at the Control Unit LED.
- Alarms and faults
Alarms and faults have a unique number. The inverter displays the numbers on the Operator Panel and via STARTER - or signals them to a higher-level control.

If the inverter no longer responds

Due to faulty parameter settings, e.g. by loading a defective file from the memory card, the inverter can adopt the following condition:

- The motor is switched off.
- You cannot communicate with the inverter, either via the Operator Panel or other interfaces.

In this event proceed as follows:

- Switch-off and switch-on the Control Unit power supply three times.
- If the inverter signals the fault F01018, carry out the corrective actions for this fault shown in section .

F01018 can only be acknowledged by switching the CU on and off again.

6.1 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 on the Control Unit indicate the inverter state.

LED RDY and LED BF displays

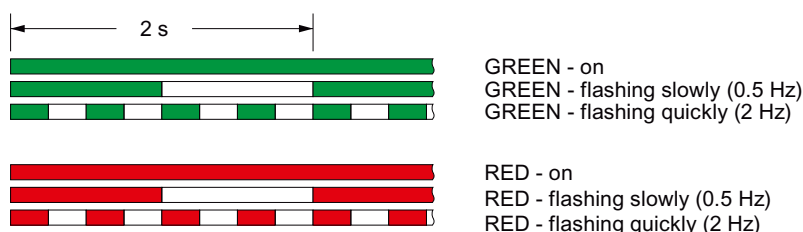


Table 6- 1 Inverter diagnostics

LED		Explanation
RDY	BF	
GREEN - on	---	Ready for operation (no active fault)
GREEN - slow	---	Commissioning or reset to factory settings
RED - on	OFF	Firmware update in progress
RED - slow	RED - slow	Firmware Update is complete, Power ON Reset required
RED - fast	---	General fault
RED - fast	RED - on	Fault during firmware update
RED - fast	RED - fast	Incompatible firmware / incorrect memory card

Table 6- 2 Communication diagnostics via RS485

LED BF	Explanation
OFF	Receive process data
RED - slow	Bus active - no process data
RED - fast	No bus activity

Table 6- 3 Communication diagnostics via PROFIBUS DP

LED BF	Explanation
off	Cyclic data exchange (or PROFIBUS not used, p2030 = 0)
RED - slow	Bus fault - configuration fault
RED - fast	Bus fault - no data exchange - baud rate search - no connection

SAFE LED displays

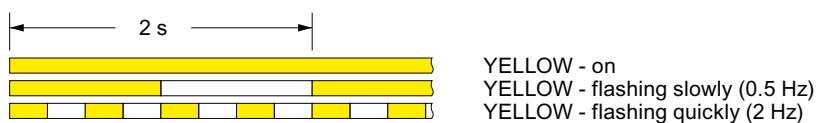


Table 6- 4 Diagnostics of the safety functions

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 inverter has detected a safety function fault and initiated a stop response.

6.2 Disturbance characteristics of the safety functions

The safety function faults are subject to special rules with regard to fault reaction and acknowledgment.

The following sections provide an overview of the causes, reaction and acknowledgement of safety function faults. After this general overview, the fault reaction to the safety functions will be described in detail.

6.2.1 Cause of fault

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

General faults

These are faults that are assigned to the inverter's safety functions, which however do not compromise the fail-safe operation of the inverter. 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 kind of acknowledgement via a fail-safe signal.

Discrepancy

A discrepancy is a fault in the external wiring of the fail-safe inputs (see Section F-DI signal filtering (Page 57)). In the event of a discrepancy, the inverter reacts in the following manner:

- The inverter switches the F-DI to the safe state (=zero).
- The F-DI remains in the safe state until you acknowledge the inverter via a fail-safe signal.

Internal event

An "internal event" is a major fault that causes the inverter to bring the motor to a standstill as quickly as possible by triggering a STOP reaction. For example, an "internal event" can be caused by one of the following:

- The inverter detects an internal fault in its hardware or its firmware on the basis of a data cross-check (F01611).
- The inverter detects an impermissible motor speed (C01714).

An "internal event" can only be acknowledged via a fail-safe signal.

6.2.2 Acknowledging faults using a fail-safe signal

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

Acknowledging via a fail-safe input

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

- Acknowledge the fault with a falling edge at the F-DI.
- Then, acknowledge the inverter with the "standard" acknowledgement signal.

Acknowledging via PROFIsafe

If you make use of the PROFIsafe telegram, proceed as follows:

- Acknowledge the fault with bit 7 of the control word 0.
- Then, acknowledge the inverter with the "standard" acknowledgement signal.

Acknowledging via Safe Torque Off (STO) and Safe Stop 1 (SS1)

You acknowledge the fault by selecting and deselecting STO (or SS1). This works both via an F-DI as well as via bit 0 or bit 1 of the PROFIsafe telegram. The procedure is as follows:

- Select the safety function STO (or SS1) and then deselect it.
- Then, acknowledge the inverter with the "standard" acknowledgement signal.

Note

Discrepancy at the input for selecting STO (or SS1)

When you make use of "Extended Safety via F-DI", the following applies:

If the inverter detects a discrepancy on the F-DI that you use to select STO (or SS1), the inverter deactivates this input. In this case, you will either need to acknowledge the fault via PROFIsafe or by temporarily shutting off the power supply to the inverter and then switching it on again.

Other acknowledgement options

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

6.2.3 STOP reactions

The inverter responds to an "internal event" with a STOP (STOP A, STOP B or STOP F).

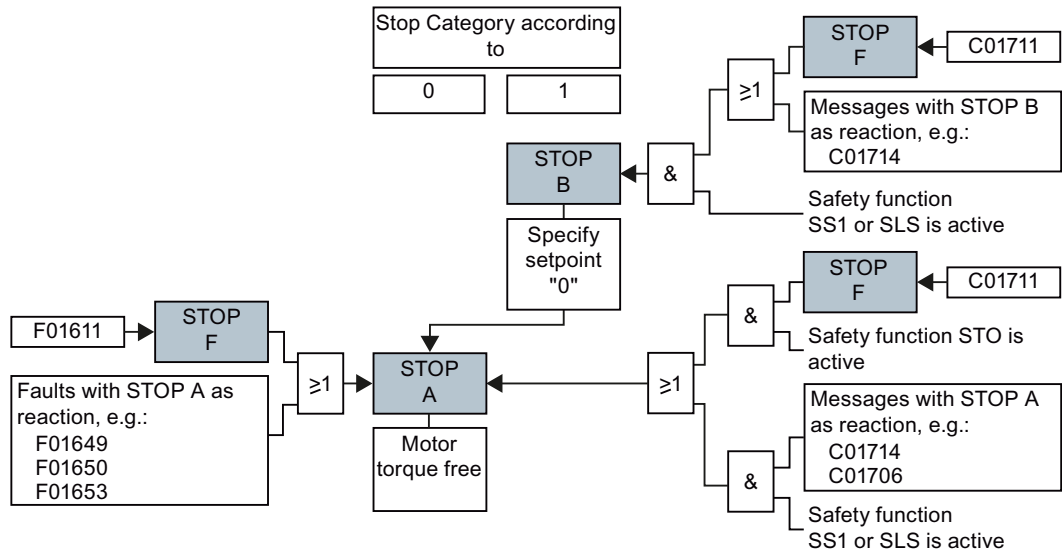


Figure 6-1 STOP reactions of the inverter

Response of the motor in the event of a STOP

STOP A

In the event of a STOP A, the inverter immediately cuts off the connected motor torque. This response corresponds to stop category 0, which is defined in EN 60204.

STOP B

In the event of a STOP B, the inverter decelerates the motor with the OFF3 ramp-down time until it detects the standstill in accordance with the Stop Category 1 as per EN 60204. Once the motor has been decelerated until a standstill, a STOP A follows.

The inverter monitors the braking of the motor. If the motor does not follow the defined brake ramp, the inverter interrupts the braking of the motor and responds with a STOP A.

STOP F

A STOP F does not immediately bring about a reaction of the motor, but instead it triggers another stop:

- If fault F01611 is the cause of the STOP F, the inverter immediately triggers a STOP A.

- If alarm C01711 is the cause of the STOP F, the reaction of the inverter depends on the active safety function:
 - If no safety function is active, the alarm stops and does not affect motor operation.
 - As soon as you select SS1 or SLS, the inverter will trigger a STOP B.
 - As soon as you select STO, the inverter will trigger a STOP A.

6.2.4 Disturbance characteristics of Safe Torque Off, STO

General fault response

If a fault occurs when STO is active, the motor is torque free.

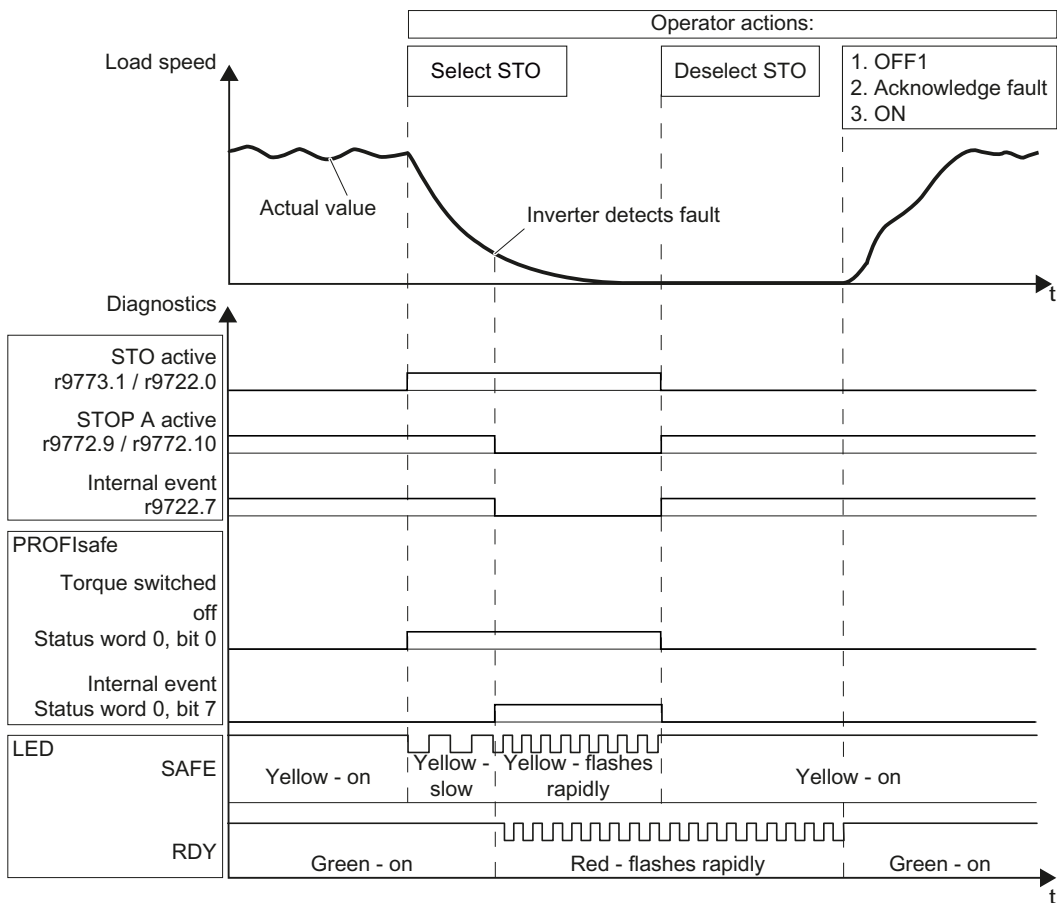


Figure 6-2 General fault response of safety function STO

Depending on whether you have enabled STO via "Basic Safety" or "Extended Safety", the inverter signals the status of STO via r9773.1 or r9722.0.

To switch the motor on again, proceed as follows:

1. Deselect STO.
2. Specify an OFF1 command.
3. Acknowledge the fault code (see Section Acknowledging faults using a fail-safe signal (Page 136)).
4. Switch the motor on again (ON command).

The message r9772.9 = 1 can only be acknowledged via a Power ON Reset.

Response in the event of a discrepancy

A discrepant signal at a fail-safe input, e.g. caused by a cable break, results in safety function STO being selected.

The signal characteristics vary depending on whether you use STO via "Basic Safety" or "Extended Safety".

Discrepancy during Basic Safety and Extended Safety (when activating both via F-DI and PROFIsafe)

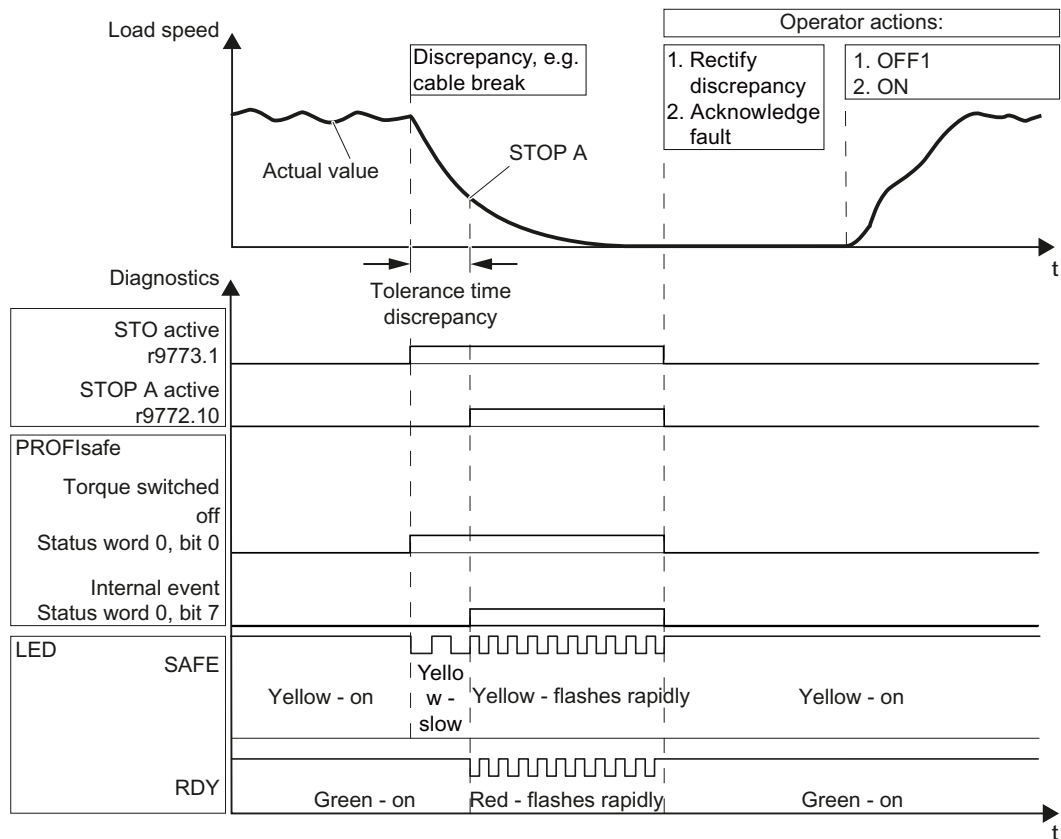


Figure 6-3 Response of safety function STO in the event of a discrepancy

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

To switch the motor on again, proceed as follows:

1. Rectify the discrepancy.
2. Acknowledge the active messages (see Section Acknowledging faults using a fail-safe signal (Page 136)).
3. Specify an OFF1 command.
4. Switch the motor on again (ON command).

Discrepancy during Extended Safety (activation via F-DI)

If you have selected activation both via F-DI and via PROFIsafe for Extended Safety , this section does not apply, but instead the section above.

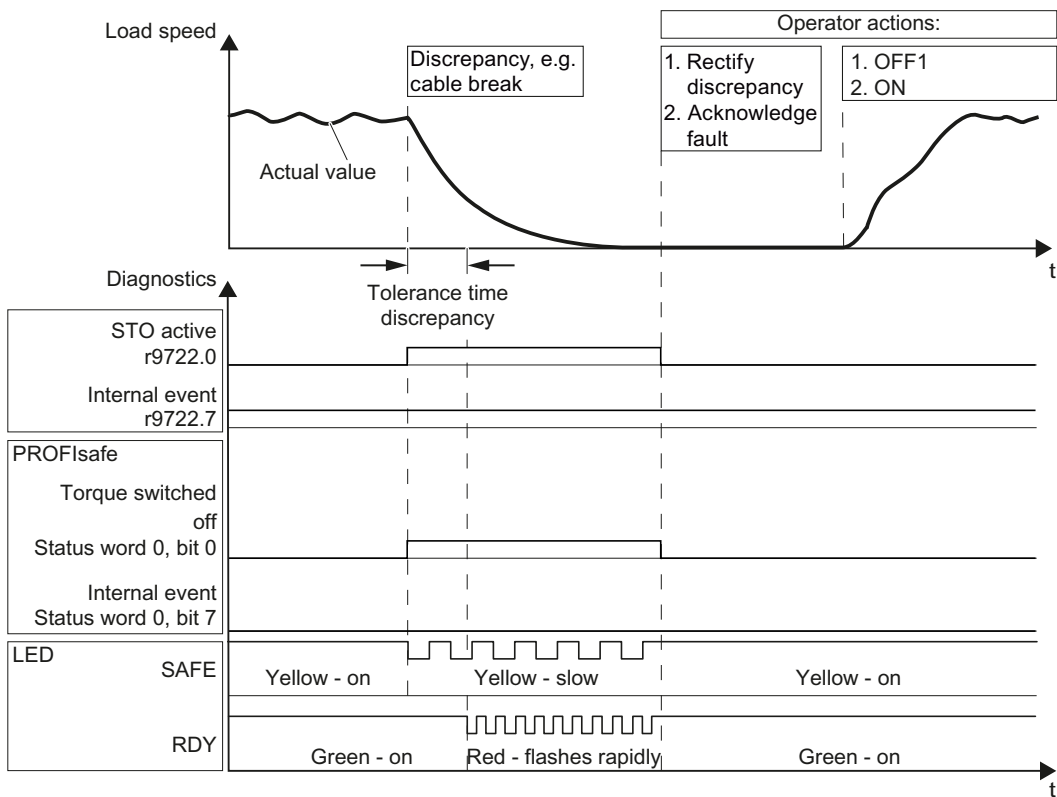


Figure 6-4 Response of safety function STO in the event of a discrepancy

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

To switch the motor on again, proceed as follows:

1. Rectify the discrepancy.
2. Acknowledge the active messages (see Section Acknowledging faults using a fail-safe signal (Page 136)).
 Note: In this case, it is not possible to acknowledge by selecting and deselecting STO.
3. Specify an OFF1 command.
4. Switch the motor on again (ON command).

6.2.5 Disturbance characteristics of Safe Stop 1, SS1

General fault response

If motion monitoring detects a fault when SS1 is active, the inverter cuts off the motor torque (STOP A).

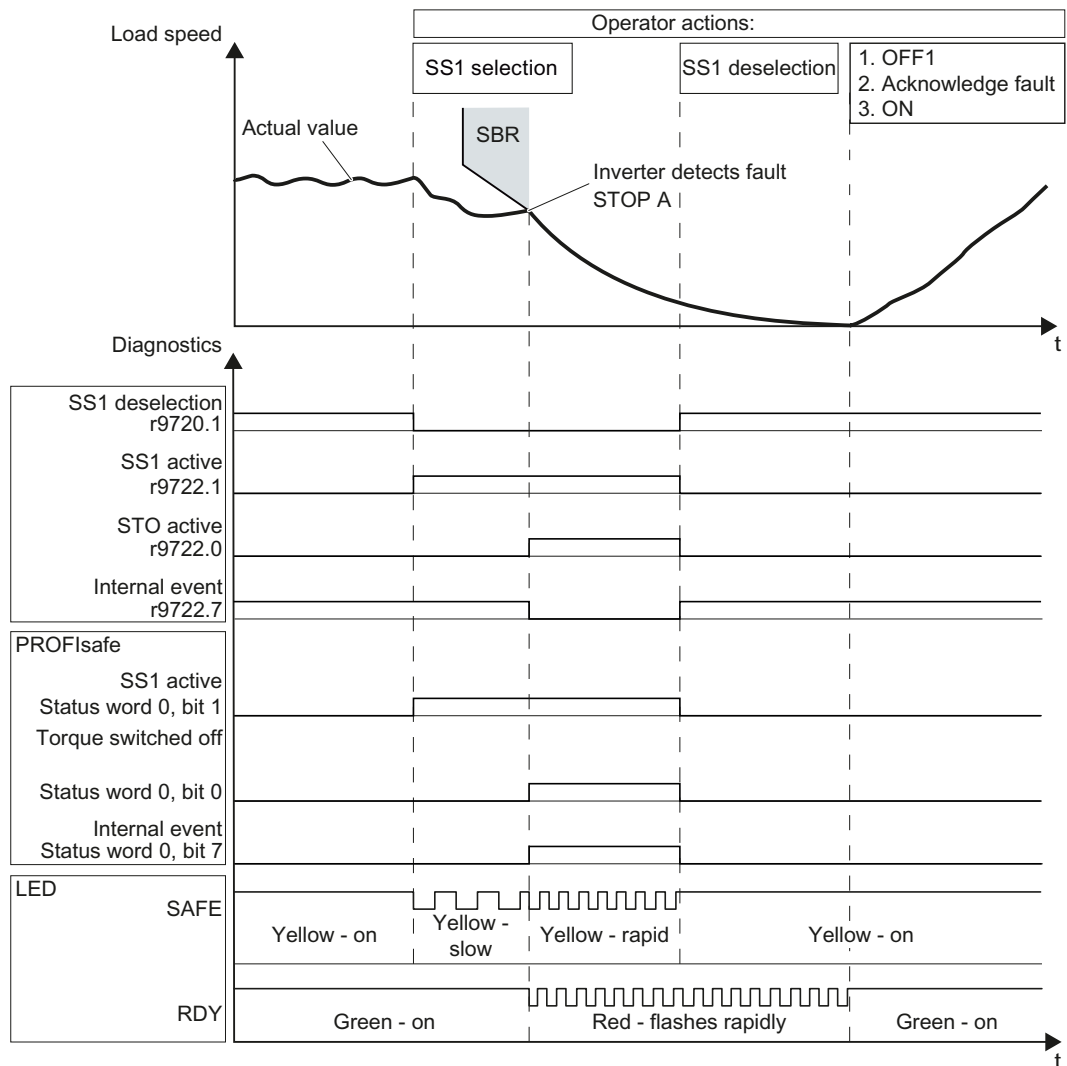


Figure 6-5 General fault response of safety function SS1

To switch the motor on again, proceed as follows:

1. Deselect SS1.
2. Specify an OFF1 command.
3. Acknowledge the fault code (see Section Acknowledging faults using a fail-safe signal (Page 136)).
4. Switch the motor on again (ON command).

Response in the event of a discrepancy

A discrepant signal at a fail-safe input, e.g. caused by a cable break, results in safety function SS1 being selected. After the tolerance time has expired, the inverter signals the discrepancy (alarm C01770 or C30770) but does not interrupt the braking operation for the motor.

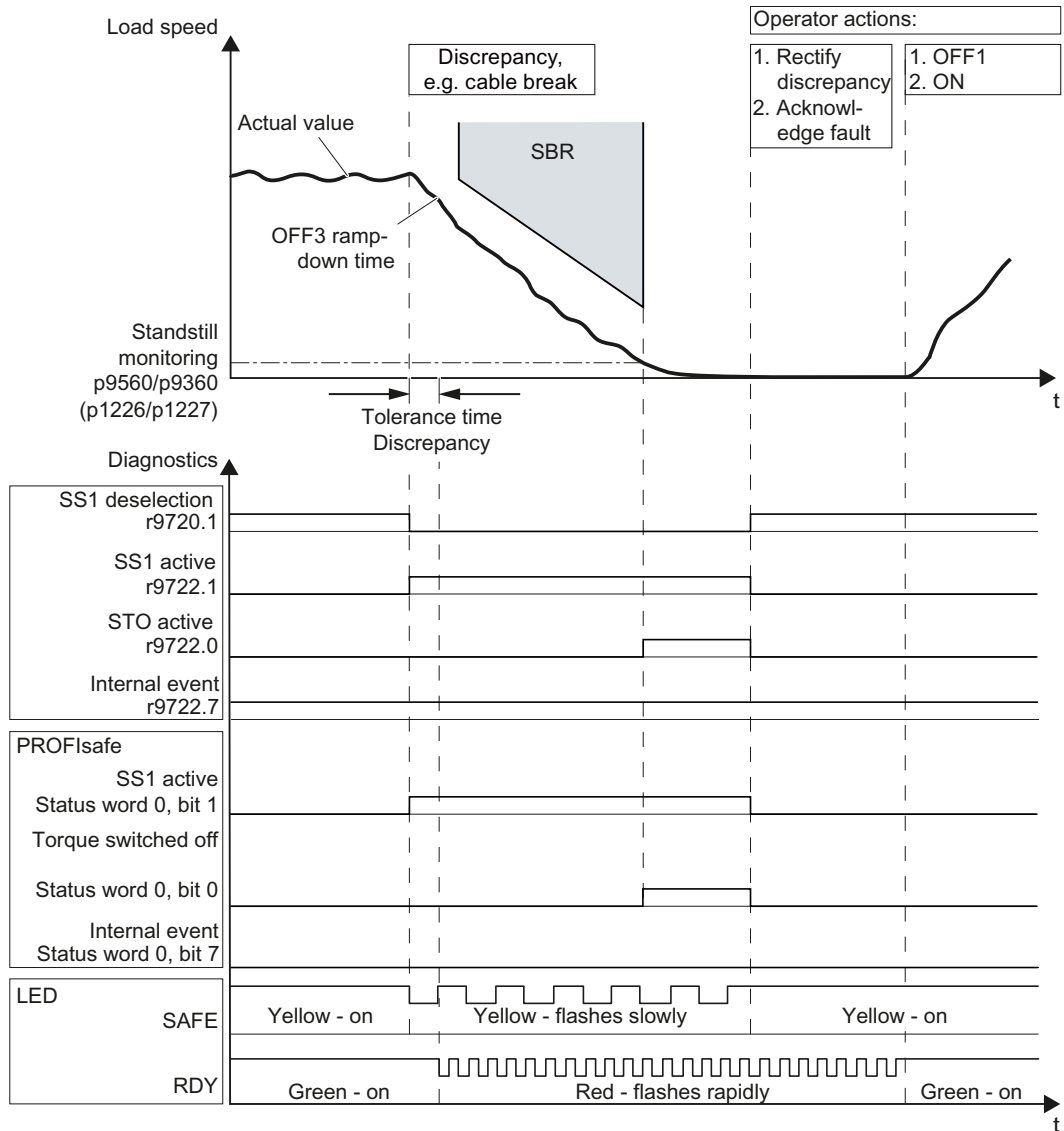


Figure 6-6 Response of safety function SS1 in the event of a discrepancy

To switch the motor on again, proceed as follows:

1. Rectify the discrepancy.
2. Acknowledge the active messages (see Section Acknowledging faults using a fail-safe signal (Page 136)).

Note: In this case, it is not possible to acknowledge by selecting and deselecting STO.

3. Specify an OFF1 command.
4. Switch the motor on again (ON command).

6.2.6 Disturbance characteristics of Safely Limited Speed, SLS

General fault response

When motion monitoring detects a fault when SLS is active, the inverter responds by triggering a STOP A or STOP B. The inverter response is parameterized during commissioning. The various STOP variants are described in the section STOP reactions (Page 137).

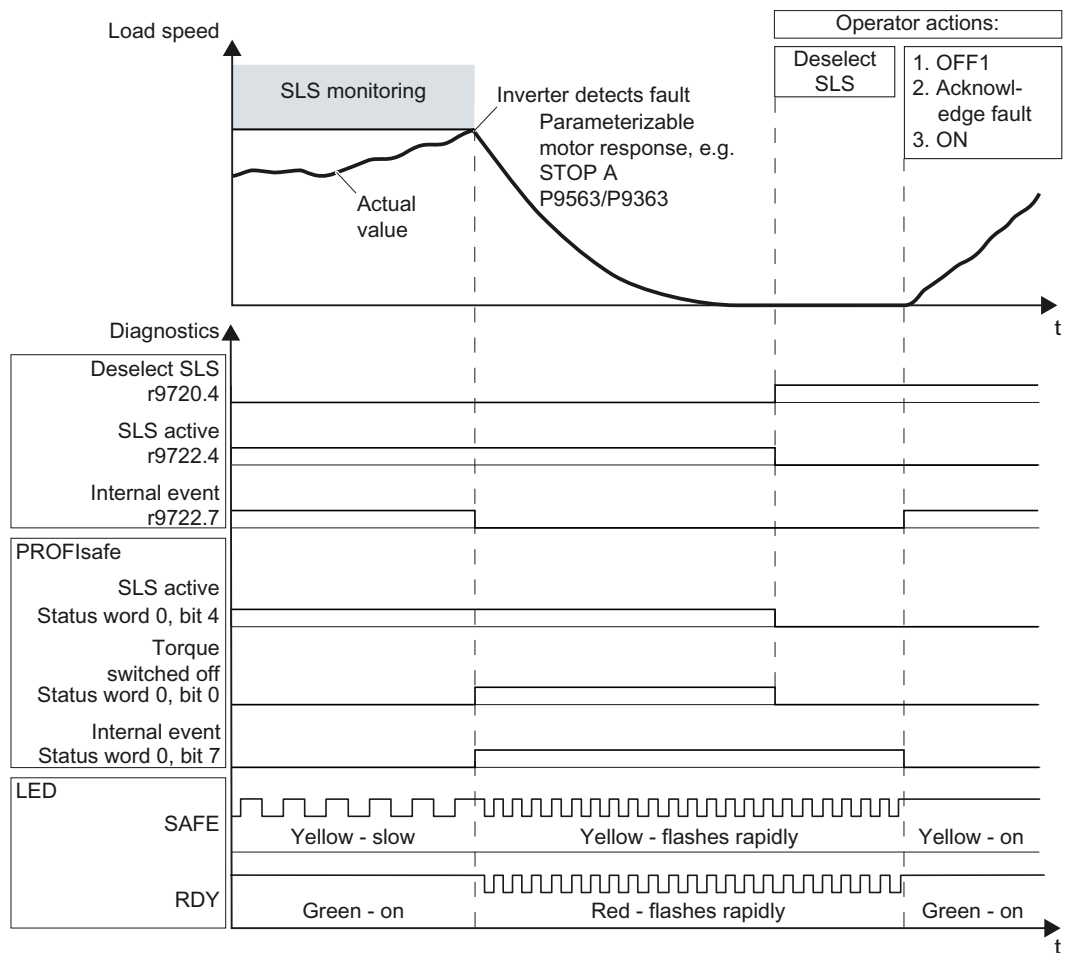


Figure 6-7 Fault response of safety function SLS

To switch the motor on again, proceed as follows:

1. Deactivate the SLS function.
2. Specify an OFF1 command.

3. Acknowledge the fault code (see Section Acknowledging faults using a fail-safe signal (Page 136)).
4. Switch the motor on again (ON command).

Response in the event of a discrepancy

A discrepant signal at a fail-safe input, e.g. caused by a cable break, results in safety function SLS being selected. After the tolerance time has expired, the inverter signals the discrepancy (alarm C01770 or C30770) but does not interrupt the SLS function.

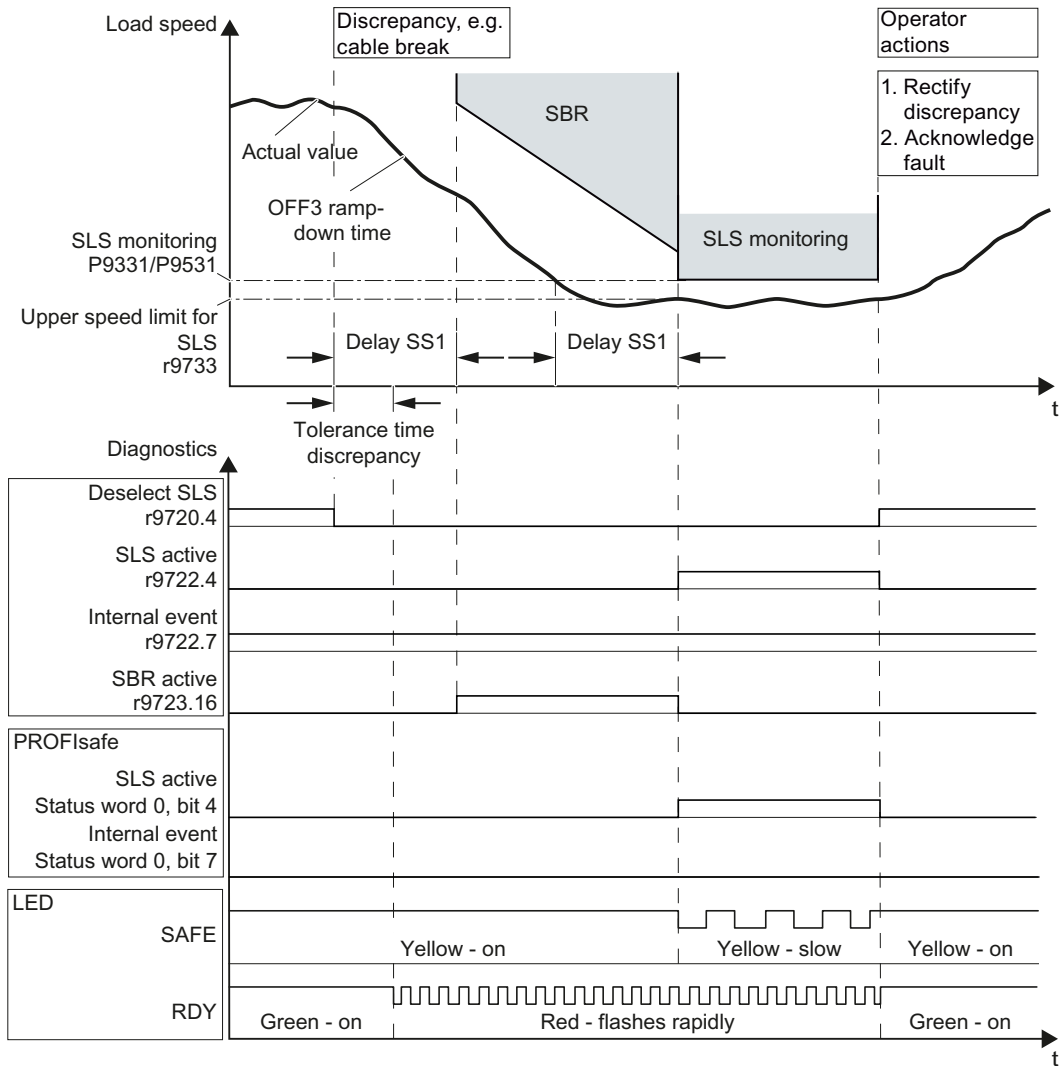


Figure 6-8 Response of safety function SLS in the event of a discrepancy

To switch the motor on again, you have to rectify the discrepancy and acknowledge the discrepancy message (see Section Acknowledging faults using a fail-safe signal (Page 136)).

6.3 List of alarms

The following table lists all alarms for the safety functions. The complete list of all alarms for the inverter can be found in the List Manual.

Alarm	Cause	Remedy
	Further information can be found in the online help of STARTER and the List Manual.	
A01620	Safe Torque Off active.	Not necessary
A01666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI for acknowledging the safety function to logical 0 signal.
A01693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Switch the Control Unit power supply off and then on again.
A01697	Motion monitoring test required.	Carry out forced dormant error detection. The signal source to initiate this is parameterized in p9705.
A01698	Commissioning mode active.	Not necessary.
A01699	Switch-off signal path test required.	Activate and then deactivate STO.
C01706	SBR limit exceeded.	Check the braking behavior of the motor and, if necessary, modify the tolerance for parameterizing the "safe braking ramp". ¹⁾
C01711	Defect in a monitoring channel.	Check the safety function parameters. Carry out an acceptance test. ¹⁾
C01712	Fault during F-IO processing.	Check the F-DI wiring. Check the safety function parameters. Carry out an acceptance test. ¹⁾
C01714	Safely limited speed exceeded.	Check the controller speed setpoint. Check and, if necessary, modify the SLS limits. ¹⁾
A30620	Safe Torque Off active.	Not necessary.
A30666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI for acknowledging the safety function to logical 0 signal.
A30693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Switch the Control Unit power supply off and then on again.
C30706	SBR limit exceeded.	Check the braking behavior of the motor and, if necessary, modify the tolerance for parameterizing the "safe braking ramp". ¹⁾
C30711	Defect in a monitoring channel.	Check the safety function parameters. Carry out an acceptance test. ¹⁾

6.3 List of alarms

Alarm	Cause	Remedy
Further information can be found in the online help of STARTER and the List Manual.		
C30712	Fault during F-IO processing.	Check the F-DI wiring. Check the safety function parameters. Carry out an acceptance test. ¹⁾
C30714	Safely limited speed exceeded.	Check the controller speed setpoint. Check and, if necessary, modify the SLS limits. ¹⁾
¹⁾ If the safety functions of the inverter have been enabled, this alarm results in the inverter triggering a stop response.		

6.4 List of faults

The following table lists all faults for the safety functions. The complete list of all faults for the inverter can be found in the List Manual.

Fault	Cause	Remedy
	Further information can be found in the online help of STARTER and the List Manual.	
F01600	STOP A triggered. More detailed information is provided by fault value r0949.	Activate and then deactivate STO. Replace the CU if the fault cannot be acknowledged.
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.
F01620	Safe Torque Off active.	Depends on the triggering message.
F01625	Sign-of-life error in the safety data.	Activate and then deactivate STO. 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 functions test, create 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.
F01666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI for acknowledging the safety function to logical 0 signal.
F01680	Checksum error safe monitoring functions.	Check the safety-relevant parameters. Switch the Control Unit power supply off and then on again.

6.4 List of faults

Fault	Cause	Remedy
	Further information can be found in the online help of STARTER and the List Manual.	
F01692	Parameter value not permitted for encoderless safety functions.	Correct the parameter value and acknowledge the fault.
F01693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Switch the Control Unit power supply off and then on again.
F01697	Motion monitoring test required.	Carry out forced dormant error detection. The signal source to initiate this is parameterized in p9705.
F01698	Commissioning mode active.	Not necessary.
F01699	Switch-off signal path test required.	Activate and then deactivate STO.
C01700	STOP A initiated.	Determine the reason why the "Safely limited speed" was exceeded and rectify the problem. Acknowledge the fault.
C01701	STOP B initiated.	Determine the reason why the "Safely limited speed" was exceeded and rectify the problem. Acknowledge the fault.
C01770	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.	Activate and then deactivate 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.
F30620	Safe Torque Off active.	Not necessary.
F30625	Sign-of-life error in the safety data.	Activate and then deactivate STO. 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 functions test, create 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.

Fault	Cause	Remedy
	Further information can be found in the online help of STARTER and the List Manual.	
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.
F30666	Static 1 signal at the F-DI for safe acknowledgement.	Set the F-DI for acknowledging the safety function to logical 0 signal.
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.
F30693	Safety parameter settings changed, warm restart/POWER ON required.	Save the parameters in a non-volatile memory (RAM → ROM). Switch the Control Unit power supply off and then on again.
C30700	STOP A initiated.	Determine the reason why the "Safely limited speed" was exceeded and rectify the problem. Acknowledge the fault.
C30701	STOP B initiated.	Determine the reason why the "Safely limited speed" was exceeded and rectify the problem. Acknowledge the fault.
C30770	Discrepancy error of the fail-safe inputs or outputs.	Check the F-DI wiring. Perform a fail-safe acknowledgement.

System properties

7

7.1 Response times

Response times following activation

The following table contains the response times as of the point at which the fail-safe input signal changes or the PROFIsafe telegram is received to initiation of the response.

Table 7- 1 Response times for "Basic Safety"

Function	Response	when activated via ...		
			Typical	Worst case
STO	Motor torque free	... PROFIsafe:	10 ms	10 ms
		... F-DI:	4 ms + t _E ¹⁾	14 ms + t _E ¹⁾
		... via PROFIsafe and F-DI		
		PROFIsafe:	10 ms	10 ms
		F-DI:	4 ms + t _E ¹⁾	14 ms + t _E ¹⁾

Table 7- 2 Response times for "Extended Safety"

Function	Response	when activated via ...		
			Typical	Worst case
STO	Motor torque free	... PROFIsafe:	34 ms	44 ms
		... F-DI:	34 ms + t _E ¹⁾	44 ms + t _E ¹⁾
		... via PROFIsafe and F-DI		
		PROFIsafe:	34 ms + t _E ¹⁾	44 ms + t _E ¹⁾
		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)

Information on the debounce time can be found in Section F-DI signal filtering (Page 57).

Response times when the monitoring threshold is exceeded

Table 7- 3 Response times until a response is initiated

Function	Response	Typical	Worst case
SLS	STOP A or STOP B	67 ms	113 ms

7.2 Certification

The safety functions of the inverter 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

7.3 Probability of failure of the safety functions (PFH value)

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 inverter safety functions are only ever part of a complete machine safety function. A complete safety function comprises the following components, for example:

- A dual-channel sensor for detecting an open protective door.
- A central fail-safe controller for processing the sensor signal further.
- An inverter for safely stopping (SS1) a motor on account of the open protective door.

IEC 62061 explains how to calculate the PFH value for the complete safety function from the PFH values of the components used for the safety function.

The following applies for the integrated inverter safety function:

Safety function	PFH	Accounted for in the PFH value
STO	5×10 ⁻⁸	Complete inverter comprising Control Unit and Power Module
SS1		
SLS		

If you need help when evaluating the safety functions of your machine, an online tool for calculating PFH values is available on the Internet: Safety Evaluation Tool (www.siemens.com/safety-evaluation-tool).

Appendix

A.1 Standards and regulations

A.1.1 General information

A.1.1.1 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 machinery construction company (OEM) is based in the European Economic Area (EEA).

A.1.1.2 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 13849-1:2006 "Categories" and "Performance Level" (PL).

A.1.2 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.1.2.1 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.1.2.2 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 standards regarding the safety of machines are structured in a hierarchical manner as follows:

- A standards (basic standards)
- B standards (group standards)
- C standards (product standards)

Type A standards/basic standards

A standards include basic terminology and definitions relating to all types of machine. This includes EN ISO 12100 (previously EN 292) "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 list requirements for specific machines. 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.1.2.3 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 13849-1:2006 (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.

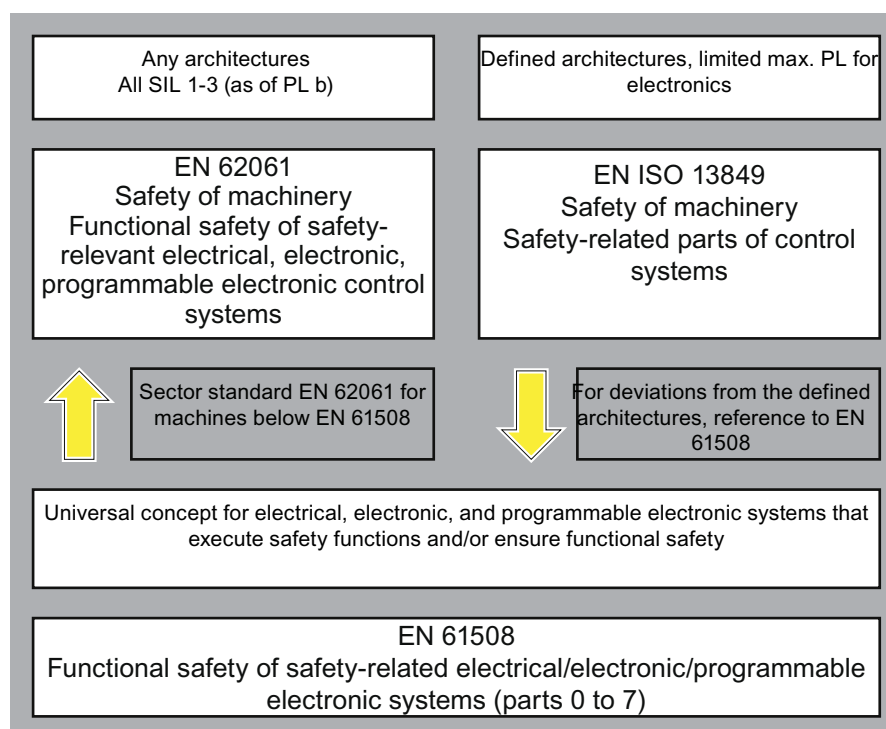


Figure A-1 Standards for implementing safety-related controllers

The application areas of EN ISO 13849-1:2006, 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 13849-1:2006 or EN 62061 is applied, depending on the technology (mechanical, hydraulic, pneumatic, electrical, electronic, programmable electronic), risk classification, and architecture.

	Systems for executing safety-related control functions	EN ISO 13849-1:2006	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
<p>"X" indicates that the point is covered by this standard.</p> <p>Comment 1: Designated architectures are described in Annex B of EN ISO 13849-1:2006 and provide a simplified basis for quantification.</p> <p>Comment 2: For complex electronics: Use designated architectures in compliance with EN ISO 13849-1:2006 up to PL = d or every architecture in compliance with EN 62061</p> <p>Comment 3: For non-electrical systems: Use parts that comply with EN ISO 13849-1:2006 as sub-systems.</p>			

A.1.2.4 EN ISO 13849-1 (previously EN 954-1)

A qualitative analysis (to EN 954-1) is not sufficient for modern controllers due to their technology. Among other things, EN 954-1 does not take into account time behavior (e.g. test interval and/or cyclic test, lifetime). This led to the probability-based approach of EN ISO 13849-1:2006 (probability of failure per time unit).

EN ISO 13849-1:2006 is based on the familiar categories used in EN 954-1. It now also takes into account complete safety functions and all the devices required to execute these. In addition to the qualitative approach of EN 954-1, EN ISO 13849-1:2006 now includes a quantitative analysis of the safety functions. 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 13849-1:2006 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, EN ISO 13849-1:2006 has been harmonized as part of the Machinery Directive. EN 954-1 will continue to apply until 30.12.2011.

A.1.2.5 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 13849-1:2006, 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 13849-1:2006 must be applied for non-electrical 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.1.2.6 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 13849:2006, 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 (electrical, electronic, and programmable electronic System) are used in order to execute safety functions and/or to ensure the appropriate level of functional safety. Other hazards (e.g. electric shock) are, as in EN ISO 13849:2006, 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.1.2.7 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 13849-1:2006 (successor to EN 954-1) "Safety of machinery"
- 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.

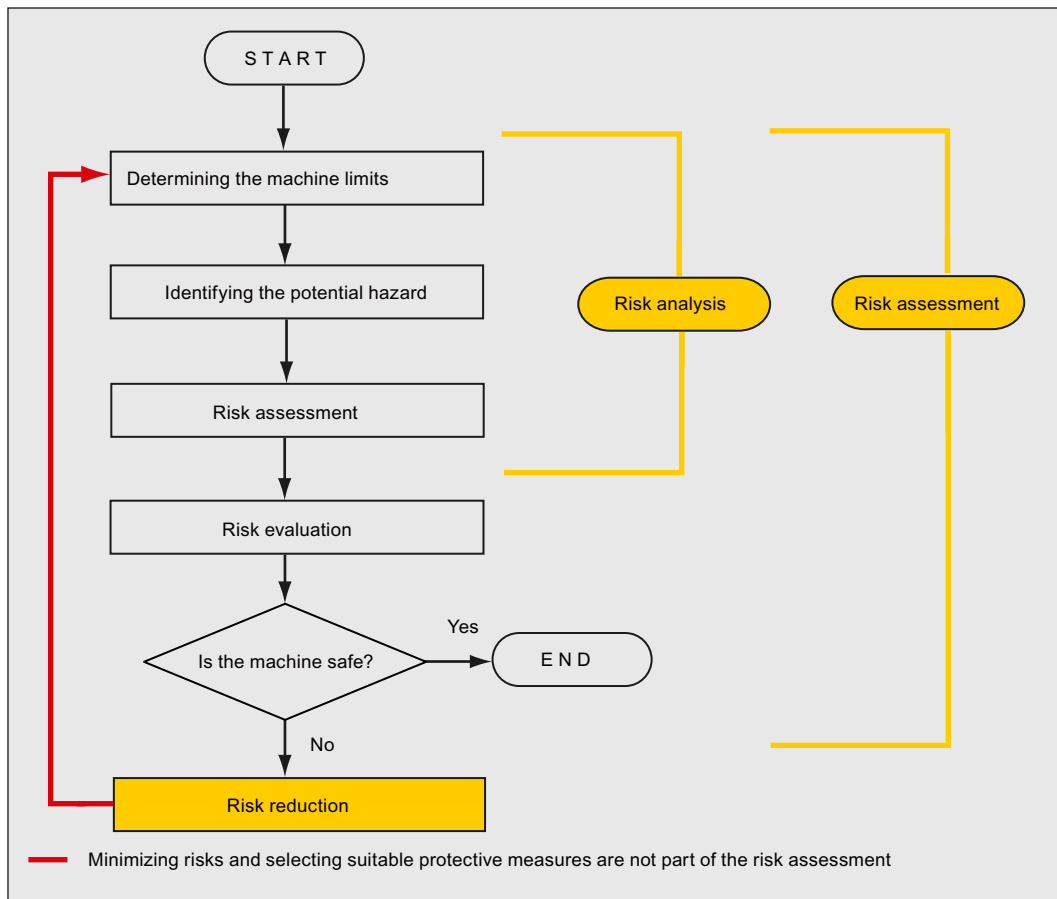


Figure A-2 Iterative process to achieve the required level of safety to ISO 14121-1

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 13849-1:2006. For electrical and electronic controllers, EN 62061 can be used as an alternative to EN ISO 13849-1:2006. Electronic controls and bus systems must also comply with IEC/EN 61508.

A.1.2.8 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 graded according to the magnitude of the risk must be taken into account. These are described in EN ISO 13849-1:2006 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 13849-1:2006 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.1.2.9 Residual risk

In today's technologically advanced world, the concept of safety is relative. In practice, the ability to ensure safety to the extent that risk is permanently excluded – "zero-risk guarantee" – is 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.

Machine/plant documentation must always refer to the residual risk (user information to EN ISO 12100-2).

A.1.3 Machine safety in the USA

A key difference in the legal requirements regarding safety at work between the USA and Europe 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 manufacturers/supplier. A general requirement exists stating that employers must ensure a safe workplace.

A.1.3.1 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.1.3.2 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.1.3.3 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, electronic controls and communication buses can also be used for the emergency stop functions of the 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/-2:200, 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.1.3.4 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. 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.1.4 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- 1 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	
ISO13849-1:2006	JIS B 9705-1	
ISO13849-2:2006	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.1.5 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.1.6 Other safety-related issues

A.1.6.1 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.1.6.2 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/>

Click the "Downloads" quick link and select the category "Informationblätter der Fachausschüsse".

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