Options for ABB drives

User's manual
FSO-21 safety functions module

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List of related manuals and guides

Drive hardware manuals	Code (English)
Drive/converter/inverter safety instructions	*3AXD50000037978*
ACS880-01 hardware manual	*3AUA0000078093*
ACS880-04 hardware manual	*3AUA0000128301*
ACS880-04 single drive module packages hardware manual	*3AUA0000138495*
ACS880-14 and -34 single drive module packages hardware manual	*3AXD50000022021*
ACS880-04XT drive modules (500 to 1200 kW) hardware manual	*3AXD50000025169*
ACS880-07 (45 to 630 kW) hardware manual	*3AUA0000105718*
ACS880-07 (560 to 2800 kW) hardware manual	*3AUA0000143261*
ACS880-17 (160 to 3200 kW) hardware manual	*3AXD50000020436*
ACS880-37 (160 to 3200 kW) hardware manual	*3AXD50000020437*
ACS880-17 (132 to 355 kW) hardware manual	*3AXD50000035158*
ACS880-37 (132 to 355 kW) hardware manual	*3AXD50000035159*
ACS880-104 inverter modules hardware manual	*3AUA0000104271*
ACS880-107 inverter units hardware manual	*3AUA0000102519*

Drive firmware manuals	
ACS880 primary control program firmware manual	*3AUA0000085967*

Drive option manuals	
ACX-AP-x assistant control panels user's manual	*3AUA0000085685*
FSO-21 safety functions module user's manual	*3AXD50000015614*
FSE-31 pulse encoder interface module user's manual	*3AXD50000016597*
FENA-01/-11/-21 Ethernet adapter module user's manual	*3AUA0000093568*
Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.	

Drive PC tool manuals	
Drive composer start-up and maintenance PC tool user's manual	*3AUA0000094606*
Functional safety design tool user's manual	*3AXD10000102417*

General safety guides	
Functional safety; Technical guide No. 10	*3AUA0000048753*
Safety and functional safety; A general guide	*1SFC001008B0201*
ABB Safety information and solutions	www.abb.com/safety

Safety system manuals	
AC500-S Safety User Manual	*3ADR025091M0204*
AC500 Control Builder PS501 Complete English documentation	*3ADR025078M0204*

You can find manuals and other product documents in PDF format on the Internet. See section *Document library on the Internet* on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.

User’s manual

FSO-21 safety functions module

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1

Safety

Contents of this chapter

The chapter contains the warning symbols used in this manual and the safety instructions which you must obey when you install or connect an option module to a drive or inverter. If you ignore the safety instructions, injury, death or damage can occur. Read this chapter before you start the installation.

Use of warnings

Warnings tell you about conditions which can cause injury or death, or damage to the equipment. They also tell you how to prevent the danger. The manual uses these warning symbols:

Electricity warning tells you about hazards from electricity which can cause injury or death, or damage to the equipment.

General warning tells you about conditions, other than those caused by electricity, which can cause injury or death, or damage to the equipment.

Safety in installation and maintenance

These instructions are for all who install or connect an option module to a drive or inverter and need to open its front cover or door to do the work.

WARNING! Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

- If you are not a qualified electrician, do not do installation or maintenance work.
- Disconnect the drive or inverter from all possible power sources. After you have disconnected the drive or inverter, always wait for 5 minutes to let the intermediate circuit capacitors discharge before you continue.
- Disconnect all dangerous voltages connected to other control signal connectors in reach. For example, it is possible that 230 V AC is connected from outside to a relay output of the drive or inverter.
- Always use a multimeter to make sure that there are no parts under voltage in reach. The impedance of the multimeter must be at least 1 Mohm.

2

Introduction to the manual

Contents of this chapter

This chapter states exclusion of liability and describes the applicability, compatible products, supported safety functions, target audience and purpose of the manual.

The chapter also lists contents of this manual, recommended reading as well as related standards and directives, and explains used definitions, terms and abbreviations. The safety certificate is included at the end of the chapter.

Exclusion of liability

This manual is an informative aid only. It contains information needed to use the FSO-21 safety functions module when implementing safety systems. The information and examples given are for general use only. They do not describe all the necessary details for implementing a safety system. The manufacturer of the machinery always remains ultimately responsible for the product safety and compliance with applicable laws. ABB does not accept any liability for direct or indirect injury or damage caused by the information contained in this document. ABB hereby disclaims all liabilities that may result from this document.

Do not open the FSO module, otherwise the safety classification will become invalid and the warranty cease to be in effect.

Applicability

This manual applies to the FSO-21 safety functions module, revision G.

Compatible products

Check the compatibility of the earlier versions with your local ABB representative. See also section *FSO module version handling* on page *37*.

Drives and option modules

- ACS880 series
- ACS880 primary control program: version 2.21 or later
- FSE-31 pulse encoder interface module: revision D or later
- FENA-21 Ethernet adapter module: version 3.05 or later

Note: If you want to use the possibility to switch the motor speed feedback between encoder and estimate, ACS880 primary control program version 2.51 or later is required. See section *Switching between the measured and estimated speed values* on page *44*.

Controller stations

For example the following controller stations are supported. Check the compatibility of the controller station in its manual.

- ABB AC500-S Safety PLC. For more information, see *AC500-S Safety User Manual* (3ADR025091M0202 [English])
- Siemens SIMATIC Fail-safe S7 PLC

Tools

- Drive composer pro PC tool: version 1.8 or later

Note: This manual applies to the Drive composer pro PC tool versions until 1.12. If you use a later version, the menus and button names can differ from the ones used in this manual. For more information, see the documentation of the tool.

Supported safety functions

This manual provides instructions for creating the following safety functions (according to EN/IEC 61800-5-2) for the ACS880 drives:

- Safe torque off (STO) – standard feature in the ACS880 drives, see page *57*
- Safe brake control (SBC), see page *42*
- Safe stop 1 (SS1), see page *68*
- Safely-limited speed (SLS), see page *127*
- Variable Safely-limited speed (SLS), with PROFIsafe only, see page *137*.
- Safe speed monitor (SSM), see page *147*.
- Safe direction (SDI), see page *151*.

Additional safety functions (not specified in EN/IEC 61800-5-2):

- Safe stop emergency (SSE), see page *93*
- Safe maximum speed (SMS), see page *142*
- Prevention of unexpected start-up (POUS), see page *145*.

Target audience

The manual is intended for qualified persons who design the safety application, plan the installation as well as install and commission the safety application. Read the manual before starting work on the safety application. You must know the fundamentals of safety technology, electricity, wiring, electrical components and electrical schematic symbols.

Purpose of the manual

The manual explains how to install the FSO safety functions module and configure and commission the supported safety functions. It describes how to meet and maintain safety life cycle requirements of the FSO module to ensure required safety performance and specified safety integrity.

Drive-specific technical, configuration and installation details are in the drive hardware manual (see *List of related manuals and guides* on page *2*).

Contents

Chapter *Safety* (page *13*) explains the usage of warning symbols in this manual and the safety instructions which you must obey when you install or connect an option module to a drive or inverter.

Chapter *Introduction to the manual* (this chapter, page *15*) states exclusion of liability and describes the applicability, compatible products, supported safety functions, target audience and purpose of the manual.

It also lists contents of this manual and recommended reading and explains used definitions, terms and abbreviations. The safety certificate is included at the end of the chapter.

Chapter *Safety information and considerations* (page *29*) contains general safety considerations and information to be taken into account when applying the FSO safety functions.

Chapter *Overview* (page *35*) briefly describes the FSO module with safety system components as well as the FSO layout, connections, type designation label and operational characteristics.

Chapter *Safety functions* (page *47*) describes how the safety functions of the FSO module operate.

Chapter *PROFIsafe* (page *161*) describes the safety system when the FSO module is connected to a safety PLC through the FENA Ethernet adapter module using the PROFIsafe profile of PROFINET. It describes the FSO module states and transitions and the contents of the PROFIsafe messages. The chapter also includes installation instructions, configuration instructions for the ABB AC500-S Safety PLC and Siemens SIMATIC Fail-safe S7 PLC as well as fault tracing tips.

Chapter *Planning for installation* (page *229*) gives instructions and references to instructions in other manuals for planning the safety system installation, as well as the requirements for installation in the applicable safety standards.

Chapter *Installation* (page *237*) gives examples of how to connect the FSO module to the ACS880.

Chapter *Installation checklists* (page *245*) contains a checklist for checking the mechanical and electrical installation of the FSO module and refers to common cause failure checklists in standards.

Chapter *Configuration* (page *247*) describes the password usage, outlines the configuration process and gives examples of how to configure the FSO module to implement the safety functions described in chapter *Safety functions*.

Chapter *Parameters* (page *321*) lists the FSO parameters.

Chapter *Start-up* (page *373*) describes the general precautions to be taken before starting up the safety system for the first time.

Chapter *Verification and validation* (page *375*) describes verification and validation procedures of the implemented safety functions.

Chapter *Fault tracing* (page *403*) describes the status LEDs and provides generic diagnostics and troubleshooting tips for FSO related faults generated by the drive.

Chapter *Maintenance* (page *417*) explains the replacement of the FSO and FSE modules in case of a module failure, gives instructions for reinstalling the FSO module to another drive and updating the firmware of the drive where the FSO is installed. It also gives instructions for the replacement of the FENA Ethernet adapter module, FSO factory reset, safety system update and decommissioning as well as proof tests.

Chapter *Technical data* (page *427*) contains the technical specifications of the FSO module, for example, electrical data, sizes and safety data. It also lists related standards and directives.

Chapter *Dimension drawings* (page *441*) shows the dimension drawings of the FSO module.

Recommended reading

This manual is based on the following standards. It is recommended that you are familiar with these standards before implementing safety-related systems.

- EN/IEC 61800-5-2: *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*. (Includes safety function definitions.)
- EN ISO 13849-1: *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*
- EN/IEC 62061: *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
- EN 60204-1: *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*.
- *PROFIsafe System Description – Safety Technology and Application. Version November 2010. Order Number 4.342.*

Before starting the implementation of safety-related systems, it is highly recommended to read and understand the following manuals, which will also be referred to in the later chapters of this manual.

- *Functional safety; Technical guide No. 10* (3AUA0000048753 [English])
- *Safety and functional safety; A general guide* (1SFC001008B0201 [English])
- firmware and hardware manuals of the drive.

For a complete list of related standards and directives, see section *Related standards and directives* on page *439*.

Terms and abbreviations

The terms and abbreviations used in this manual are defined in the table below.

Term / Abbreviation	Description
Acknowledgement	Acknowledges an event when the FSO module is in use. See section *Acknowledgement methods* on page *48*. See also term *Reset* on page *22*.
AWG	American wire gauge
B_{10d}	Number of cycles until 10% of the components fail dangerously (for pneumatic and electromechanical components). (EN ISO 13849-1)
Black channel	Communication channel that is not safe as it has not been designed and/or validated according to IEC 61508. The reliability of the connection can be secured with an additional security protocol, for example PROFIsafe, on top of the black channel.
Cat.	Classification of the safety-related parts of a control system. The categories are: B, 1, 2, 3 and 4. (EN ISO 13849-1)
CCF	Common cause failure (EN ISO 13849-1)

Term / Abbreviation	Description
Common cause failure (CCF)	Failure, which is the result of one or more events, causing coincident failures of two or more separate channels in a multiple channel (redundant architecture) subsystem, leading to failure of a Safety related electronic control function (SRCF).
Communication module	Communication module is a name for a device (eg, a fieldbus adapter) through which the drive is connected to an external communication network (eg, a fieldbus). The communication with the module is activated with a drive parameter.
Controller	Control system with bus initiative (master). In PROFINET IO terminology, controller stations are also called active stations.
Control word	16-bit word from controller to device with bit-coded control signals (sometimes called the Command word).
CRC	Cyclic redundancy check
Cyclic communication	Communication in which parameter/process data objects are sent cyclically at pre-defined intervals
DAT	Device acknowledgement time
DC	Diagnostic coverage (%) (EN ISO 13849-1), Direct current
Device	Passive bus participant. In PROFINET IO terminology, device stations (or slaves) are also called passive stations. Also referred to as nodes.
DI	Digital input
DO	Digital output
E-stop	Emergency stop
ELV	Extra-low voltage
EMC	Electromagnetic compatibility
External active load	Load in systems where the motor speed does not decrease when the motor control is stopped.
Fail-safe mode	The FSO module has activated the drive STO function as a result of an error (in some cases, after a delay). To exit this mode and continue normal operation, reboot the FSO module.
FbEq16	16-bit fieldbus equivalent: The scaling between the value shown on the panel and the integer used in communication when a 16-bit value is selected for transmission to an external system.
FbEq32	32-bit fieldbus equivalent: The scaling between the value shown on the panel and the integer used in communication when a 32-bit value is selected for transmission to an external system.
F-Device	Device that is able to communicate using PROFIsafe, eg, the FSO module.
F-Host	Programmable logic controller (PLC) that is able to communicate using PROFIsafe.
F-Input	PROFIsafe frame user data from that is sent from the F-Device (FSO) to the F-Host (PLC).

Term / Abbreviation	Description
F-Output	PROFIsafe frame user data from that is sent from the F-Host (PLC) to the F-Device (FSO).
F-Parameter	Parameter that belongs to the F-Parameters (see below).
F-Parameters	Set of PROFIsafe parameters that all PROFIsafe devices support. F-Parameters are sent from the F-Host (PLC) to the F-Device (FSO) when the PROFIsafe connection is created.
FB	Fieldbus
FBA	Fieldbus adapter
FENA-21	Optional Ethernet adapter module for EtherNet/IP™, Modbus TCP and PROFINET IO protocols
FIT	Failure in time: 1E-9 hours. Expected failure rate of semiconductors and other electronic devices. (IEC 61508)
FSE-31	Pulse encoder interface module which can be used in safety applications
FSO-12	Safety functions module which does not support the use of encoders
FSO-21	Safety functions module which supports which supports the FSE-31 module and the use of safety encoders
Functional safety	Functional safety is part of the overall safety that depends on a system or equipment operating correctly in response to its inputs.
GND	Ground
GSD file	General Station Description file that describes the basic capabilities of a device in a specified form. PROFINET uses GSDML files which are GSD files written in XML format.
HAT	Host acknowledgement time
Hazard	Potential source of harm (physical injury, or damage to health or equipment)
HFT	Hardware fault tolerance (IEC 61508)
hi-Z state	In digital outputs, the signal is neither driven to a logical high nor low level. It is “floating”.
HTL	High-threshold logic
IGBT	Insulated gate bipolar transistor
I/O	Input/output
Life time	The period of time for which a device is designed to remain within it's specifications
LSB	Least significant byte
MAC address	Media access control address. A unique identifier of a network node in an communication network.
MSB	Most significant byte
modoff	No modulation (the control of inverter IGBTs is off)

Term / Abbreviation	Description
$MTTF_D$	Mean time to dangerous failure: (The total number of life units) / (the number of dangerous, undetected failures) during a particular measurement interval under stated conditions (EN ISO 13849-1)
N/A	Not applicable
NC	Normally closed. Break contact. Normally closed contacts disconnect the circuit when the relay is energized; the circuit is connected when the relay is de-energized.
NO	Normally open. Make contact. Normally open contacts connect the circuit when the relay is energized; the circuit is disconnected when the relay is de-energized.
OEM	Original equipment manufacturer
PCB	Printed circuit board
PELV	Protected extra-low voltage (IEC 60364-4-41)
PFD_{avg}	Average probability of dangerous failure on demand (IEC 61508)
PFH	Average frequency of dangerous failures per hour (IEC 61508)
PL	Performance level (a-e) (EN ISO 13849-1)
PLC	Programmable logic controller
POUS	Prevention of unexpected start-up
Power drive systems (Safety related), PDS(SR)	Adjustable speed electrical power drive system suitable for use in safety-related applications
Profile	Adaptation of the protocol for certain application field, for example, drives.
PROFINET	An open standard for industrial communication systems that uses the Ethernet standard. Registered trademark of PROFIBUS and PROFINET International (PI) community.
PROFIsafe	An additional layer on top of the PROFINET protocol for safety-related communication. Registered trademark of PROFIBUS and PROFINET International (PI) community.
Proof test	Test that can detect faults and degradation in a Safety related electronic control system (SRECS) and its subsystems so that, if necessary, the SRECS and its subsystems can be restored to an "as new" condition or as close as practical to this condition.
Protective measure	Measure intended to achieve risk reduction
PZD	Process data (*Prozessdaten*)
Reasonably foreseeable misuse	Use of a machine in a way not intended by the designer, but which may result from readily predictable human behavior
Reset	Factory reset. Clears the configuration and sets the parameters to their factory default values.
Residual risk	Risk remaining after protective measures have been taken

Term / Abbreviation	Description
Response time of FSO	The internal response time of the FSO, that is, the time in which the STO control output of the FSO reacts after receiving a request. (Usually this is not the same as the time from the request to the safe state of the machine application.) See also term *Safety function response time (SFRT)* on page *23*.
Risk	Combination of the probability of occurrence of harm and the severity of that harm
Safe state	STO activated. The STO circuit in the drive is open. **Note**: When the drive STO is activated in the POUS function, the FSO is in the Operational state. See also section *FSO states* on page *53*.
Safety fieldbus	Communication system used in safety-related applications. In the safety system described in this manual, safe communication is secured with the PROFIsafe application layer. See also term *PROFIsafe* on page *22*.
Safety function	Function, with a specified safety performance, which is intended to maintain the safe condition of the installation or prevent hazardous conditions arising at the installation. Example: Safe torque off (STO)
Safety function response time (SFRT)	Worst case elapsed time following an actuation of a safety sensor connected to a fieldbus before the corresponding safe state of its safety actuator(s) is achieved in the presence of errors or failures in the safety function channel. Response time of the combination of the drive and the FSO. See also term *Response time of FSO* on page *23*.
Safety module	Part of a safety system, physical entity. Example: FSO safety functions module.
Safety related control function (SRCF)	Control function implemented by a SRECS with a specified integrity level that is intended to maintain the safe condition of the machine or prevent an immediate increase of the risk(s)
Safety related electrical control system (SRECS)	Electrical control system of a machine whose failure can result in an immediate increase of the risk(s)
Safety system	Whole safety system including for example human interface, FSO safety functions module, drive, sensors and machine.
SAR	Safe acceleration range. In the FSO module, there are two sets of SAR parameters (SAR0 and SAR1) that are used to define and/or monitor the deceleration ramp in safety functions. SAR0 parameters are used in the SSE function. SAR1 parameters are used in the SS1 and SLS functions.
SBC	Safe brake control
SC	Systematic capability (IEC 61508)
Scaling speed	A user-defined reference value the FSO module uses as a reference point in ramp time calculations. See parameter *200.202 SAR speed scaling* on page *324*.
SDI	Safe direction

Term / Abbreviation	Description
SELV	Safety extra-low voltage
SFF	Safe failure fraction (%) (IEC 61508)
SFRT	Safety function response time (see page *23*)
SIL	Safety integrity level (1-3) (IEC 61508)
SILCL	SIL claim limit. Maximum SIL that can be claimed for a safety function or subsystem (EN 62061)
SLS	Safely-limited speed
SMS	Safe maximum speed
SS1	Safe stop 1
SS1-r	Safe stop 1 ramp monitored
SS1-t	Safe stop 1 time controlled
SSE	Safe stop emergency
SSM	Safe speed monitor
SRECS	Safety related electrical control system (see page *23*).
Status word	16-bit word from device to controller with bit-coded status messages.
STO	Safe torque off (EN/IEC 61800-5-2). In this manual, this term is used in two different contexts: • the STO circuit in the drive (the drive STO function) • the STO safety function in the FSO module. Safety functions in the FSO module (eg, STO, SSE, SS1 and POUS) activate the drive STO function, that is, open the drive STO circuit. In addition, some safety functions can activate the STO safety function in the FSO module, which in turn opens the drive STO circuit. See section *Dependencies between safety functions* on page *158*.
Stop category	There are three categories of stop functions: • stop category 0: an uncontrolled stop where power to the machine actuators is removed immediately • stop category 1: a controlled stop where the machine actuators have power for stopping, after which the power is removed • stop category 2: a controlled stop where the machine actuators continue to have power. Stop category 0 and 1 definitions also apply to Emergency stop categories.
T1	Proof test interval (IEC 61508). T1 is a parameter used to define the probabilistic failure rate (PFH or PFD_{avg}) for the safety function or subsystem. Performing a proof test at a maximum interval of T1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. Note that any T1 values stated cannot be regarded as a guarantee or warranty. See also section *Proof tests* on page *424*.
Telegram	Message

Term / Abbreviation	**Description**
TP	Test pulse. Term diagnostic pulse is used in this manual.
TWCDT	Total worst case delay time
Validation	Confirmation by, for example, analysis that the safety system meets the functional safety requirements of the specific application.
Verification	Confirmation by, for example, testing that the safety system meets the requirements set by the specification.
WCDT	Worst case delay time
WD	Watchdog
ZCU-xx	Drive control unit type (xx = version number)
Zero speed	Speed below the value given with parameter *FSOGEN.51 Zero speed without encoder* on page *327* or, when an encoder is used, *FSOGEN.52 Zero speed with encoder* on page *328*.

Certificates

TÜV Nord certificate for the FSO-21 and ACS880 drive series is attached below. Check the validity of the certificate with a specific drive variant from the ABB library.

DAkkS
Deutsche
Akkreditierungsstelle
D-ZE-11074-01-00

TÜV NORD

Certificate

No. SEBS-A.102621/15 V1.0

TÜV NORD Systems GmbH & Co. KG hereby certifies

ABB Oy
Hiomotie 13
00381 Helsinki
Finland

that the safety modules

FSO-21 with FSE-31

as plug-in modules for the ABB industrial drive ACS880 series

are capable for safety related applications up to SIL 3, SIL_{CL} 3 and PL e and meets the requirements listed in the following standards:

- **IEC 61508 part 1, part 2, part 3: 2010**
- **IEC 61800-5-2: 2007**
- **ISO 13849 part 1: 2015, part 2: 2012**
- **IEC 62061: 2015**

Beneath the integrated "Safe Torque Off (STO)" function within the industrial drive ACS880 series, the additional safety functions "(variable) Safely Limited Speed (SLS)", "Safe Maximum Speed (SMS)", "Safe Stop Emergency (SSE)", "Safe Stop 1 (SS1)", "Prevention Of Unexpected Start-up (POUS)", Safe Direction (SDI), "Safe Speed Monitor (SSM)" and "Safe Brake Control (SBC)" can be realized with the plug-in safety functions modules FSO-21 with FSE31.

The whole assembly can be used in safety applications up to SIL 3 according to IEC 61511.

Base of certification is the report SEBS-A.102621/15TB in the valid version.

This certificate entitles the holder to use the pictured safety approved mark.

Valid until: 2021-01-18
File reference: 8112485797

Hamburg, 2016-01-18

B. Pfuff

Bianca Pfuff

Voluntary Certification

TÜV NORD
TÜV NORD Systems GmbH & Co. KG
Safety Approved
FSO-21, FSE31
IEC 61508:2010 SIL 3
IEC 61800-5-2:2007 SIL 3
ISO 13849-1:2015 PL e
ISO 13849-2:2012 PL e
IEC 62061:2015 SIL_{CL} 3
SEBS-A.102621/15

Certification Body SEECERT
TÜV NORD Systems GmbH & Co. KG
Große Bahnstraße 31, 22525 Hamburg, Germany

The PROFIsafe certificate for the FSO-21 module is attached below.

PROFIBUS • PROFINET

Certificate

PROFIBUS Nutzerorganisation e.V. grants to

ABB Technology Oy
Valimopolku 4 A, 00380 Helsinki, Finland

the Certificate No: **Z20147** for the PROFIsafe Module:

Model Name:	**FENA FSO-21**
Order-Number:	**3AXD50000012090**
Revision:	**SW: V3.2.0; HW: 1**
Application CRC:	**Channel A: 0x0785E4F4**
	Channel B: 0x4709FF7F

This certificate confirms that the product has successfully passed the certification tests with the following PROFIsafe scope:

☑ PROFIsafe_V2 functionality on PROFINET IO

Test Report Number:	**PS087-1**
Authorized Test Laboratory:	**SIEMENS AG, Fürth, Germany**

The tests were executed in accordance with the following documents:
"PROFIsafe - Test Specification for F-Slaves, F-Devices, and F-Hosts, Version 2.1, March 2007".
This certificate is granted according to the document:
"Framework for testing and certification of PROFIBUS and PROFINET products".
For all products that are placed in circulation by July 02, 2018 the certificate is valid for life.

(Official in Charge)

Board of PROFIBUS Nutzerorganisation e. V.

(Karsten Schneider)

(K.-P. Lindner)

PROFIsafe

3

Safety information and considerations

Contents of this chapter

This chapter contains general safety considerations and information to be taken into account when applying the FSO safety functions.

WARNING! The FSO safety functions module is delivered with the safety functions bypassed by jumper wires in connectors X:113 and X:114 to allow initial drive commissioning without the need to configure safety functions first. The safety system must always be properly commissioned and verified/validated before it can be considered safe.

Meeting the requirements of the Machinery Directive

In order to fulfill the requirements of the Machine directive, the requirements in the applicable standards must be met and the FSO module must be used according to all instructions provided in this manual.

Implementing safety functions requires following a process, which is introduced for example in *Functional safety; Technical guide No. 10* (3AUA0000048753 [English]). The process includes a risk assessment, and residual risks, as well as any foreseeable misuse, must be documented in the user instructions of the machinery.

Responsibilities

It is the responsibility of the machine builder / OEM / system integrator to make sure that the essential health and safety requirements specified in the Machinery Directive are met.

If you detect any failure in safety functions, contact your local ABB representative.

Intentional misuse

Use the FSO and FSE modules according to the instructions given in the user's manuals. ABB is not responsible for any damage caused by the misuse of the modules.

The FSO and FSE modules are not designed to protect a machine against intentional misuse or sabotage.

Safety considerations

Note: After you initially start up the FSO module and also after you later modify any application parameters or the configuration, you must check the safety of the entire system by doing a verification according to the system safety verification plan and by doing a validation of the correct operation of the safety application. See chapter *Verification and validation*.

Response times

Safety function response time and FSO response times are specified in section *Response times* on page *437*.

The acceptable speed limits must be configured so that the speed cannot accelerate/decelerate from an acceptable speed to a dangerous speed faster than the response time of the FSO module.

FSO diagnostics

The FSO module performs extensive auto diagnostics tests during the runtime operation on FSO internal parts as well as the communication and STO connection between the FSO and the drive. The FSO goes into the Fail-safe mode if it detects a fault.

- The communication between the FSO and the drive is diagnosed continuously.
- The STO connection between the FSO and the drive STO connector is diagnosed during the power-up and periodically during the runtime.

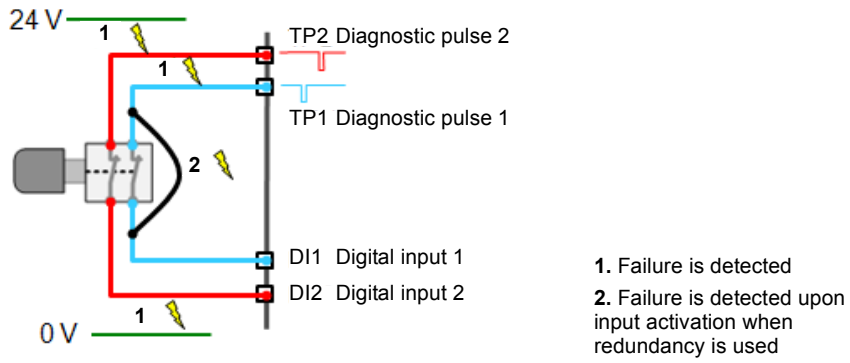
If an FSO I/O or a safety fieldbus failure occurs, the FSO module activates the SSE function (or the STO function, if an STO request is connected to the I/O). In other internal failure situations, the FSO module activates the STO function. Depending on parameter settings, the SSE function can be similar to the STO function (when configured as “Immediate STO”, for more information see section *Configuring SSE* on page *284*).

I/O

The FSO module supports input and output redundancy.

The FSO module provides an option for applying diagnostic pulsing for its inputs and outputs. When applied, the pulsing enables the FSO diagnostics to detect cable failures as follows:

- **Inputs**: Open-circuiting and short-circuiting failures are detected with diagnostic pulsing. The failures that short-circuit the sensor are detected upon input activation when redundant connection is used.



Note: If only one of the redundant inputs is activated upon a safety function request, the FSO module activates the safety function but it cannot be acknowledged before the failure has been repaired. To acknowledge the safety function, you must set both input channels down and up at the same time or, switch the power off and on.

- **Outputs**: If diagnostic pulsing is used, failures that short-circuit the signal to the voltage supply or the ground potential are detected. Failures that open-circuit the actuator are not detected.

Acknowledgement

Safety functions have four acknowledgement methods for entering the Operational state (during the first start-up or after a safety function request is removed):

- **Manual** (recommended)**:** The user must first acknowledge the FSO locally from the FSO I/O to allow the drive to restart.
- **Automatic:** The FSO grants the drive permission to restart after a safety function request is removed or the start-up is complete. If the drive is in the automatic start mode, it starts automatically, which may cause danger.
- **From a safety PLC**: The FSO module expects an external acknowledgement signal from a safety PLC via the PROFIsafe communication bus.
- **Manual or from a safety PLC:** The FSO module expects an external acknowledgement signal either from the FSO I/O or from a safety PLC.

The acknowledgement method can be selected separately for the start-up, the STO (SSE and SS1 always end in drive STO), SLS, SDI and POUS safety functions.

For more information, see section *Acknowledgement methods* on page *48*.

WARNING! If the FSO module is used in the automatic start mode, make sure that the system is designed so that this does not cause unacceptable risk.

Safety encoders

Safety pulse encoders are connected to the FSE-31 pulse encoder interface module. The safety encoders supported by the FSE module must fulfill these requirements:

- It must have differential outputs (two quadrature-signals and one rotation mark signal, each in its normal and complement format).
- It must have sufficient auto-diagnostics and mitigations against environmental variations for the intended PL and/or SIL.
- It must indicate its faults either by setting its outputs to the hi-Z state (“floating” the outputs) or by setting its complement outputs to identical states.

Note: It can be useful for the argumentation for the validity of the above that the encoder is approved for safety applications.

Encoderless mode

You can use the FSO-21 module either with or without an encoder (encoderless mode).

In the encoderless mode, the FSO-21 module uses the drive output frequency measurement to estimate the motor speed instead of measuring the motor speed with an encoder. You must take this into consideration when designing safety functions, that is, whether this type of speed estimation is suitable for the application. For example, you cannot use the encoderless mode in very low speeds (below 2 Hz).

Note: Observe restrictions for use. Perform at least the Standstill Identification run (preferably the Normal Identification run).

In the encoderless mode,

- the motor must decelerate when the power is switched off – for example, in a crane application, the hanging load would potentially cause an accelerating motion, thus the encoderless mode cannot be used for these types of applications.
- the drive cannot be used in generator mode (torque limit) operation where an external force is rotating the motor faster than the drive controls the motor.
- depending on the load, the frequency estimation of an encoderless drive may not be equal to the actual induction motor speed.

⚠ **WARNING!** Do not use the encoderless mode in applications in which the external load of the application can rotate the motor driven shaft (active load). In this case, you must use an encoder.

Speed estimation

In the encoderless mode, the FSO module monitors the frequency with which the drive rotates the magnetic field in the motor. The FSO module has no way of detecting the actual speed with which the motor shaft rotates.

Note: “Speed” is used in this manual instead of “frequency”.

Note: You must take into account in the system design that in the encoderless mode, the FSO speed estimation and the actual motor speed differ by the motor slip, which is dependent on the load of the motor among other things.

Note: The motor speed references in the drive refer to the mechanical axle speed but the monitoring limits set in the FSO safety functions refer to the electrical frequencies present in modulation. These two differ by the slip, which is dependent on the operating point of the motor. You must take this into account when you define monitoring limits for safety functions. Otherwise it is possible that unnecessary monitoring limit hits occur.

Note: In the encoderless mode, the FSO module and the drive motor control system calculate a speed estimation independently from each other. This is why the two estimations can differ slightly.

Characteristics

The allowed speed range depends on the used motor.

$$\text{Max. speed range} = \frac{\text{-30000…+30000 rpm}}{\text{Number of motor pole pairs}}$$

Proof testing

Periodic proof testing of, for example, electromechanical parts of the safety system may be required in order to maintain the claimed SIL / PL level of the system. In this case proof testing must be taken into consideration in the safety calculations and it must be properly documented in the user documentation. Proof testing has to be verified in the acceptance testing during the commissioning phase.

The FSO module itself does not require periodic proof testing.

External contactors, relays and mechanical actuators must be sized correctly for safety use as the automatic diagnostics only monitors the electrical connections; the mechanical final elements like brakes are not diagnosed.

Failure of a mechanical actuator, for example a brake, could lead up to an undetected fault, and a possible loss of the load control.

Safety separation

The FSO module and the drive Safe torque off (STO) channel/function are safety relevant, and the rest of the drive is considered as not safety relevant, for example, the drive regular I/O cannot be used for requesting safety functions on the FSO.

⚠ **WARNING!** The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the drive. Therefore maintenance work on electrical parts of the drive or the motor can only be carried out after isolating the drive system from the main supply, from rotating permanent magnet motors and from rotating motors equipped with sine filters; asserting the STO is not sufficient.

Note: The Safe torque off function can be used for stopping the drive in the operational mode. If a running drive is stopped by using the STO function, the drive stops by coasting.

ACS880 drives with separate inverter and supply units

In the ACS880 multidrives and high power ACS880-07/17/37 single drives, there are separate inverter, supply and brake units. The FSO module is connected to the inverter unit. It cannot be connected to supply or brake units.

4

Overview

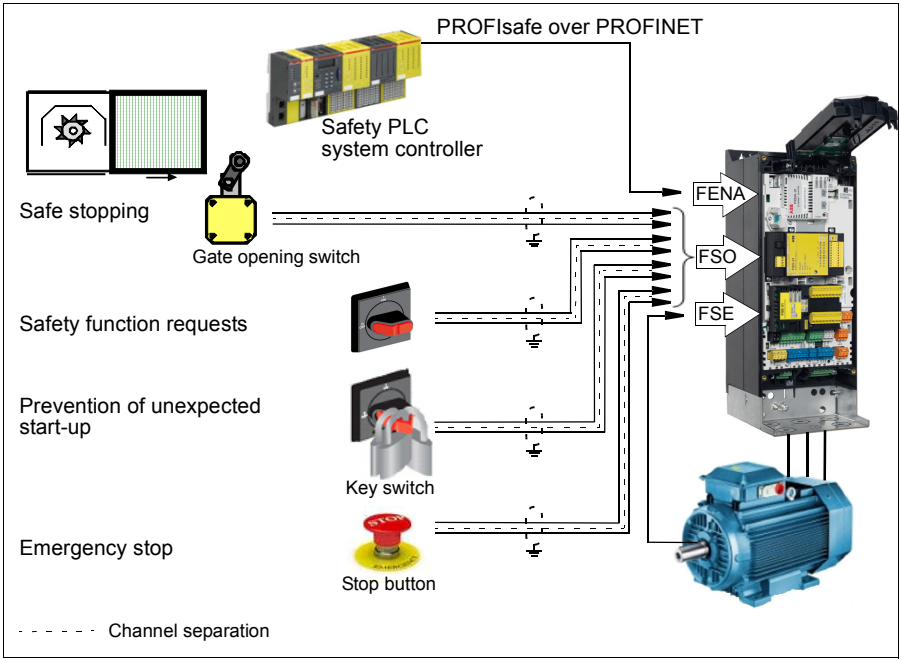
Contents of this chapter

This chapter briefly describes the FSO module with safety system components as well as the FSO module layout, connections, type designation label and operational characteristics.

System description

FSO module and safety system components

Example figure of a safety system with the FSO-21 safety functions module, the ACS880-01 drive, a safety PLC, the FENA-21 module, the FSE module, switches and buttons.



The FSO safety functions module is an option for the ACS880 drives. The Safe torque off (STO) function is a standard feature on the ACS880 drives.

The FSO module does not operate the drive; it only monitors the actions of the drive and commands safety functions to be executed. The request for safety functions can come from an external safety system, for example, a push button, a safety PLC, or from an FSO internal fault. Some safety functions can be permanently active. If the drive does not fulfill the commands of the FSO, the FSO shuts down the drive using the Safe torque off (STO) function.

If the drive is connected to a safety PLC, the safety of the fieldbus communication can be secured with the PROFIsafe over PROFINET technology. The safety PLC is connected to the FENA-21 fieldbus adapter module, which communicates with the FSO module. For more information, see chapter *PROFIsafe*.

If a pulse encoder is used in the safety system, it is connected to the FSE-31 module, which communicates with the drive and the FSO-21 module.

Safety functions supported by the FSO module are presented in chapter *Safety functions*.

FSO module version handling

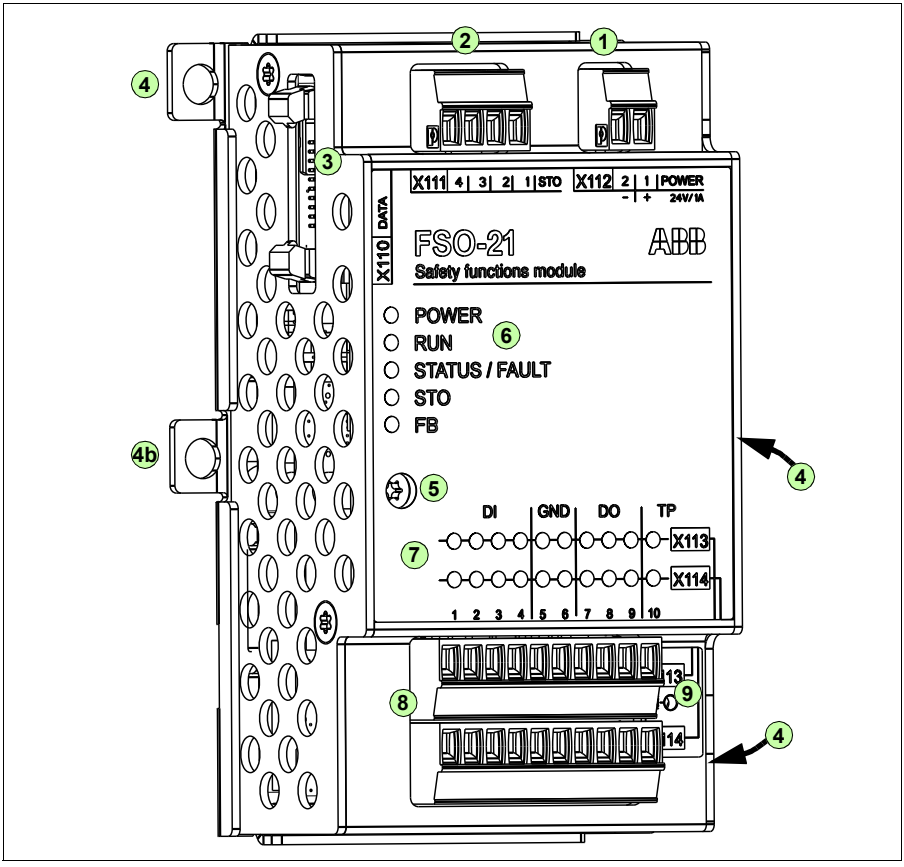
To ensure backward and forward compatibility with the ACS880 drives, the FSO-21 module has a version handling system. Both the FSO module and the ACS880 drive firmware must support the used safety functions.

You can always replace the FSO-21 module with a newer revision and use the same configuration file with the new revision. If you replace an FSO-12 module with an FSO-21 module, you have to re-configure the FSO module and safety functions. Each time you make any changes in the safety system, you must do the acceptance test to each safety function using the checklists described in chapter *Verification and validation*.

Each new revision of the FSO-21 module supports all functions of previous FSO-21 module revisions and it can be used together with previous ACS880 drive firmware versions. In addition, previous FSO-21 module revisions can be used together with new ACS880 drive firmware versions. In this case, the drive supports only the functions of the previous FSO-21 module revision.

Each safety function and parameter group has a separate version parameter. With these parameters, the user selects the desired versions according to the drive firmware and FSO-21 module combination at the start-up. Only the versions that both the used ACS880 drive firmware and the FSO-21 module support are shown in the Drive composer pro PC tool.

Layout



No	Description
1	24 V DC input connection
2	Safe torque off (STO) connection
3	Data connection
4, 4b	Mounting for drives with ZCU-12 control unit shown. Two mounting points on each side. The screw fixed at 4b also grounds the enclosure of the FSO. Mounting points for drives with other control units may vary.
5	FSO grounding screw, grounds the electronics
6	FSO status LEDs, see section *Status LEDs* on page *403*.
7	Input / output status LEDs, one for each I/O connector. The LEDs are in two rows above the corresponding two rows of I/O connectors. The LED is lit if the state of the corresponding I/O is ON (24 V in the input or output). The data shown by LEDs is only indicative and cannot be considered safe.

No	Description
8	Input / output connections • 4 redundant or 8 single digital inputs, or combinations of redundant and single inputs. Possible redundant pairs: X113:1 & X114:1, X113:2 & X114:2, X113:3 & X114:3 and X113:4 & X114:4. • 3 redundant or 6 single digital outputs, or combinations of redundant and single outputs. Possible redundant pairs: X113:7 & X114:7, X113:8 & X114:8 and X113:9 & X114:9. • two 24 V DC reference outputs with configurable diagnostic pulses.
9	Factory reset button (under the label)

Connections

The FSO module has several safety I/Os for external safety devices, for example buttons, gates and indicators.

When you use the Safe brake control (SBC) function, the FSO module controls the mechanical brake. For more information on the SBC function, see chapter *Safety functions*.

One FSO module is needed for each drive/inverter to be monitored.

Connection details are described in section *Terminals* on page *240*.

Type designation label

The type designation label is attached on the top of the FSO module. An example label and description of the label contents are shown below.

No	Description
1	Type
2	Serial number of format RYWWSSSS, where R: Component revision: A, B, C, … Y: Last digit of the manufacturing year: 4, 5, … for 2014, 2015, … WW: Manufacturing week: 01, 02, … for week 1, week 2, … SSSS: Integer starting every week from 0001
3	ABB MRP code of the FSO module
4	Combined ABB MRP code, serial number and manufacturing location
5	RoHS mark

Operational characteristics

The FSO module monitors that the drive operates within the configured operating limits, and if the limits are exceeded, activates a safe stopping in the drive within the response time. The safe stopping function activates the drive STO function either immediately or after an emergency ramp. Activation of the drive STO function removes the torque and, if configured, applies the brake.

WARNING! The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the drive. See the warning on page *34*.

Prevention of unexpected start-up is also handled by the FSO module.

The supported functions are preprogrammed in the FSO firmware; they cannot be programmed in any way.

Authorized personnel configure the FSO module with the Drive composer pro PC tool. The FSO checks the authorization with a password before it is possible to edit the FSO parameters. The user sends parameters from the tool to the drive, and after the tool has displayed the CRC values of the parameters, the user must validate the feedback values.

The FSO module goes into the Fail-safe mode if it detects an internal fault during its diagnostics tests (see section *FSO modes* on page *53*).

You must reboot the FSO module after the drive has recovered from a power failure, normally by switching the power off and on. It is also possible to reboot the FSO with drive parameter *96.09 FSO reboot* or by pressing the **Boot FSO** button on the Safety view of the Drive composer pro PC tool. The FSO accepts this 'soft boot' only if it is in the Fail-safe mode and the motor is stopped.

Overview of safety functions

This section gives a short overview of the safety functions and gives references to the detailed descriptions. For a description of the dependencies between the safety functions, see section *Dependencies between safety functions* on page *158*.

Safe torque off (STO)

This safety function activates the STO function in the drive, this is, opens the STO circuit in the drive. The motor coasts to a stop (stop category 0). See section *STO function* on page *58*.

Safe stop 1 (SS1)

This safety function stops the motor safely by ramping down the motor speed to zero speed (stop category 1). The FSO monitors the stop ramp either with the time or ramp monitoring method (SS1 function types SS1-t and SS1-r, respectively). See sections

- *SS1 with time monitoring (SS1-t)* on page *69* and
- *SS1 with ramp monitoring (SS1-r)* on page *73*.

Safe stop emergency (SSE)

You can configure this safety function to be similar to the STO (SSE with immediate STO, stop category 0) or SS1 function (SSE with emergency ramp, stop category 1). Only the parameters are different from the parameters in the STO and SS1 functions. See sections

- *SSE with immediate STO* on page *94*,
- *SSE with time monitoring* on page *103* and
- *SSE with ramp monitoring* on page *107*.

Safe brake control (SBC)

This safety function provides a safe output for controlling external (mechanical) brakes. When you use the SBC function with other safety functions of the FSO module, it is always combined with the drive STO function. That is, the SBC function is activated before, at the same time with or after the drive STO function.

STO function and SSE with immediate STO

In these safety functions, you can configure the SBC function to be activated before, at the same time with or after the drive STO function. See sections

- *SBC after STO* on page *60*,
- *SBC before STO* on page *63*,
- *SSE with immediate STO, SBC after STO* on page *96* and
- *SSE with immediate STO, SBC before STO* on page *99*.

When you use an encoder, you can also configure the SBC function to be activated at a user-defined speed limit. See sections

- *STO with speed limit activated SBC* on page *66* and
- *SSE with immediate STO, with speed limit activated SBC* on page *111*.

Note: When you use the SBC function together with the STO function, the SBC is activated also when the drive STO is activated at zero speed in the SSE and SS1 functions.

Note: The FSO module activates the SSE function after trip limit hits in the SLS and SMS functions. As a result, this activates the drive STO and SBC functions (for more information, see section *Safe stop emergency (SSE)* on page *93*). Make sure that you dimension the brake correctly for these situations.

SS1 function and SSE with emergency ramp

In these safety functions, you can configure the SBC and STO combination to be activated at a user-defined speed limit while ramping down to zero speed. See sections

- *SS1 with speed limit activated SBC* on page *77* and
- *SSE with speed limit activated SBC* on page *111*.

You can also define a delay so that the SBC is activated first at the user-defined speed limit and the drive STO after the delay. See sections

- *SS1 with speed limit activated SBC, SBC before STO* on page *77* and
- *SSE with speed limit activated SBC, SBC before STO* on page *119*.

Safely-limited speed (SLS)

This safety function prevents the motor from exceeding user-defined speed limits. If the motor speed reaches the positive or negative SLS trip limit, the FSO module activates the SSE function and the motor stops. See section *Safely-limited speed (SLS)* on page *127*.

Variable Safely-limited speed (SLS)

This safety function prevents the motor from exceeding user-defined speed limits. With the Variable SLS function, the speed limits can be changed on the fly. The speed limits are controlled from a safety PLC via the PROFIsafe communication bus. See section *Variable Safely-limited speed (SLS)* on page *137* and chapter *PROFIsafe*.

Safe maximum speed (SMS)

This safety function is used to protect the machine from too high speeds/frequencies. You can configure it to be permanently on or off. If the motor speed reaches the minimum or maximum SMS trip limit, the FSO module activates the SSE function and the motor stops. There are two different versions of the SMS function. See sections

- *SMS function, version 1* on page *143* and
- *SMS function, version 2* on page *143*.

Prevention of unexpected start-up (POUS)

This safety function prevents the machine from starting accidentally. The POUS function activates the drive STO function. See section *Prevention of unexpected start-up (POUS)* on page *145*.

Safe speed monitoring (SSM)

This safety function provides a safe output signal to indicate whether the motor speed is between user-defined limits. See section *Safe speed monitor (SSM)* on page *147*.

Safe direction (SDI)

This safety function monitors that the motor rotates into the correct direction. If the motor rotates into the forbidden direction more than the user-defined SDI tolerance limit allows, the FSO module activates the SSE function and the motor stops. This safety function requires that you use an encoder in the safety application. See section *Safe direction (SDI)* on page *151*.

Measured and estimated motor speed

You can use the FSO-21 module either with or without an encoder. When an encoder is used, the FSO module uses the exact value of the motor speed in the safety functions. Without an encoder, the FSO module uses an estimated value of the motor speed. This affects how the safety functions operate (for example, when indications turn on and off) and how they must be configured. The detailed descriptions of the safety functions include a separate description when an encoder is used and when it is not used (encoderless mode).

In some applications, you must always use an encoder, for example, in very low motor speeds (below 2 Hz). See also section *Encoderless mode* on page *32*.

Switching between the measured and estimated speed values

You can configure how the FSO module reacts when the exact motor speed value from the encoder is lost (failure in FSE module, safety encoder or its wiring). The reaction depends also on the status of safety functions:

- **Case 1**: There are active safety functions in the FSO module.
  A monitoring safety function (SLS, SMS, SSM, SDI) is active when the safety function request is active. A stopping safety function (STO, SS1, SSE) is active, when the safety function request is active and the safety function is not completed yet, that is, the completed indication is off.
  In this case, the FSO module needs the motor speed value to perform the safety function correctly and safely.
- **Case 2**: There are no active safety functions in the FSO module.
  There are no active safety function requests, or all stopping safety functions are in the completed status, that is, the completed indications are on.
  In this case, the FSO module does not need the motor speed value to perform the safety function correctly and safely.

With the POUS and SSM functions, the FSO does not need the motor speed value to perform safely. The POUS function can be activated only when the motor is stopped. The SSM function is only for indication purposes. Therefore, the status of these safety functions does not affect how the FSO module reacts when the motor speed data is lost.

Use parameter *FSE diagnostic failure reaction* to define the correct FSO reaction. There are three alternatives:

1. *FSE diagnostic failure reaction* = *STO*

   Case 1 and **Case 2**: With this selection, the FSO module goes into the Fail-safe mode and actives the FSO STO function immediately when the encoder is lost. For more information, see section *FSO modes* on page *53*.

2. *FSE diagnostic failure reaction* = *No STO*

   This selection gives the user the possibility to fix the cause of the failure before a safety function is activated.

   - **Case 1:** The FSO module goes into the Fail-safe mode and actives the FSO STO function.
   - **Case 2:** The FSO module generates a warning. If the failure is not fixed before a safety function is activated, the FSO module goes into the Fail-safe mode and actives the FSO STO function.

3. *FSE diagnostic failure reaction* = *Est switch not active load*

   With this selection, the application/process can continue operation and the FSO module keeps the monitoring safety functions (SLS, SMS, SSM) active even if the encoder data is lost. The FSO module uses the estimated motor speed instead of the exact motor speed from the encoder until the failure is fixed.

WARNING! You can use this feature only if the estimated motor speed value is sufficient from the application and risk assessment point of view.

WARNING! Do not use this feature in applications in which the external load of the application can rotate the motor driven shaft (active load). In this case, you must always use an encoder. See also section *Encoderless mode* on page *32*.

- **Case 1** and **Case 2:** The FSO module continues operation by using the estimated motor speed until the failure is fixed and the exact motor speed is available again. The FSO sends a warning to the drive.
  There are two exceptions:

  1. The STO, SSE or SS1 function is active, that is, the stopping function has been started, but it is not completed yet when the encoder failure occurs.

  2. The SDI function is active when the encoder failure occurs or it is activated after the failure. This safety function always requires the exact motor speed value and cannot be used without an encoder.

  If an encoder failure occurs in these two situations, the FSO goes into the Fail-safe mode and activates the FSO STO function. To continue operation, you must fix the failure and reboot the FSO module.

If you want to use the possibility to switch the motor speed feedback between encoder and estimate, you must configure and validate the FSO module and all safety functions so that they operate correctly both with and without an encoder. For more information, see section *Configuring the FSO for FSE or encoder failure situations* on page *320*.

Note: This feature requires ACS880 primary control program 2.51 or later.

5

Safety functions

Contents of this chapter

This chapter describes how the safety functions of the FSO module operate.

The FSO-21 module supports these safety functions:

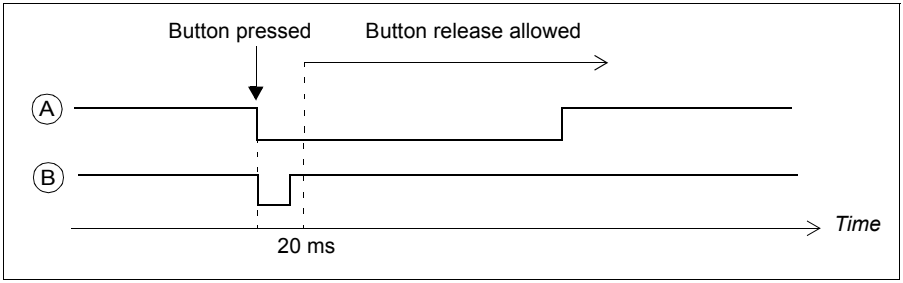
Safety function	Stop category	Information	Page
Safe torque off (STO)	Stop category 0	STO: standard drive feature	*57*
Safe stop 1 (SS1)	Stop category 1	With time (SS1-t) or ramp monitoring (SS1-r)	*68*
Safe stop emergency (SSE)	Stop category 0 or 1	With immediate STO or emergency ramp	*93*
Safe brake control (SBC)		With STO, SSE and SS1 functions	*42*
Safely-limited speed (SLS)		With time or ramp monitoring	*127*
Variable Safely-limited speed (SLS)		Only with PROFIsafe	*137*
Safe maximum speed (SMS)		Function permanently on/off Two different versions	*142*
		Version 1	*143*
		Version 2	*143*
Prevention of unexpected start-up (POUS)			*145*
Safe speed monitor (SSM)			*147*
Safe direction (SDI)		With time or ramp monitoring Only with an encoder	*151*

General

Safety function request

A safety function can be activated locally from FSO digital inputs, from a safety PLC, in FSO internal fault situations or by another safety function (see section *Dependencies between safety functions* on page *158*).

If you want to control a safety function with a push button, connect an activation button to an FSO digital input. 24 V in the input is the standby (negative) state and 0 V is the positive (request) state.



ID	Description
A	Normal request: The request is recognized when the button is pressed. The pressing time of the button must be at least 20 ms. **Note**: The safety function request must be removed before the acknowledgement is accepted.
B	Short low signals (less than 20 ms) are ignored.

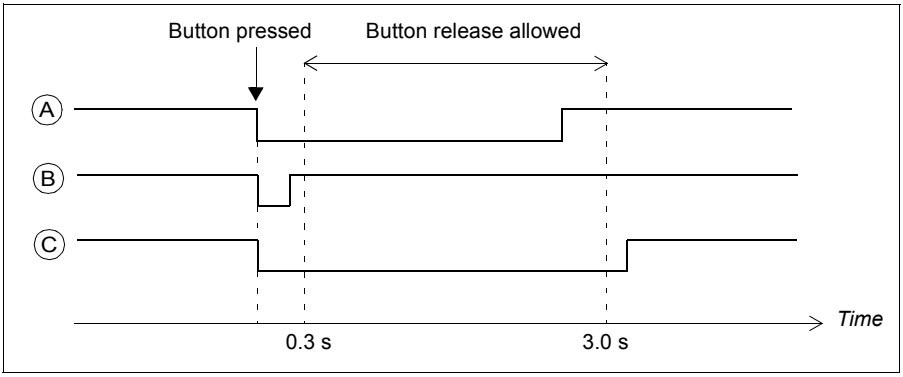
Acknowledgement methods

You can configure the acknowledgement method separately for the start-up, STO (SSE and SS1 always end in drive STO), SLS, SDI and POUS safety functions.

The acknowledgement method can be manual or automatic, from a safety PLC via the PROFIsafe communication bus, or either manual or from a safety PLC.

- **Automatic**: The FSO module acknowledges the start-up and/or safety functions automatically when this has completed successfully and the safety function request has been removed.
- **From a safety PLC:** The FSO module expects an external acknowledgement signal from a safety PLC via the PROFIsafe communication bus. The PROFIsafe profiles include the acknowledgement bits (see section *FSO PROFIsafe profiles* on page *166*).
- **Manual**: You must connect an acknowledgement button to the FSO module. The user must push the button to acknowledge the start-up and/or safety functions.

You can connect only one acknowledgement button to the FSO module. The acknowledgement button must be of type “normally closed” (NC). The acknowledgement button is connected like a normal safety input. 24 V in the input is the standby (negative) state and 0 V is the positive (acknowledge) state.



ID	Description
A	Normal acknowledgement: The acknowledgement is recognized when the button is released after pressing it; the system must detect both falling and rising edge changes for successful acknowledgement triggering. The pressing time of the button must be between 0.3 s…3.0 s.
B	Short low signals (less than 0.3 s) are ignored.
C	Too long interruptions (signal low longer than 3.0 s) on the signal are ignored and a warning message (A7D0) is generated to the drive. If there is something to acknowledge, it is ignored and the user must press the acknowledgement button again.

Acknowledgement cannot be performed if

- a safety function request is active
- STO: delay defined by parameter *STO.13 Restart delay after STO* has not passed,
  Note: If an SSE or SS1 request is received while the STO function is active, the STO function must be completed before the acknowledgement is allowed. For more information see section *Safe torque off (STO)* on page *57*.
- SSE, SS1: safety function is not completed
- SLS, Variable SLS, SDI: the monitoring has not started.

When automatic acknowledgement is used, the FSO module acknowledges the safety function immediately after the safety function request has been removed and the above requirements are met.

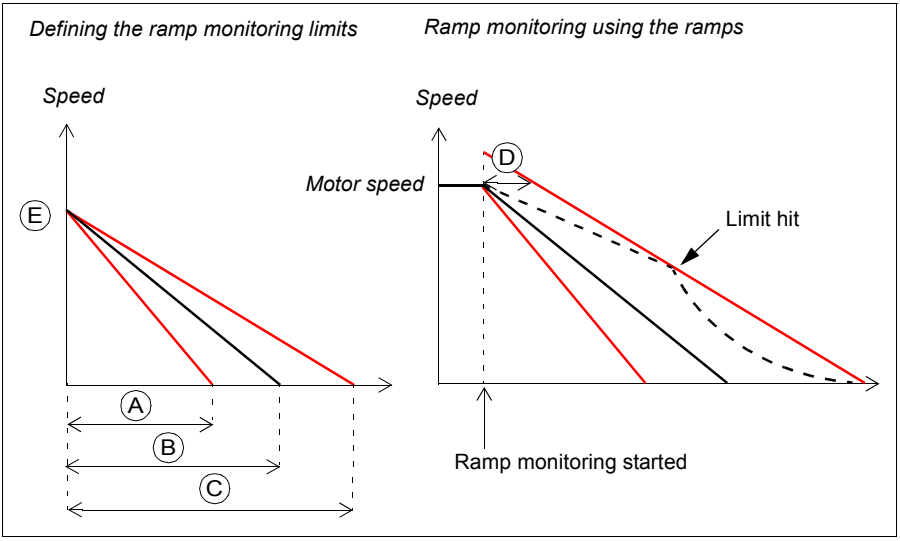
When manual or acknowledgement from a safety PLC is used, the FSO module waits for an external acknowledgement signal (either from the FSO I/O or from a safety PLC) before it can acknowledge the safety function(s). After the FSO module has received the signal, it acknowledges all active safety functions that can be acknowledged with the same acknowledgement.

When several safety functions are active at the same time, the priorities described in section *Priorities between safety functions* (page *158*) apply.

Note: If the FSO module is rebooted after a safety function request has been removed but before it has been acknowledged, the FSO reboot acknowledges the safety function.

Ramp monitoring

The ramp monitoring is configured with five parameters as described below.



ID	Description
A	Ramp minimum time from the Scaling speed to zero. Configured for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *SARx.11 SAR0 min ramp time to zero*.
B	Target time for the ramp down from the Scaling speed to zero. Configured for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *200.102 SAR0 ramp time to zero*.
C	Ramp maximum time from the Scaling speed to zero. Configured for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *SARx.12 SAR0 max ramp time to zero*.
D	Initial allowed range for the SARn ramp: value of parameter *SARx.02 SAR initial allowed range*. This parameter moves the location of the maximum ramp forward on the time axis, when monitoring is started. Common for all ramps SARn, n = 0…1.
E	Scaling speed: value of parameter *200.202 SAR speed scaling*. Speed value that the FSO module uses as a reference point in ramp time calculations. This value and the minimum (A), target (B) and maximum (C) ramp times define fixed slopes for the deceleration ramps that are used in ramp monitoring. Common for all ramps SARn, n = 0…1.

Limit hit: If the motor speed hits a ramp monitoring limit, the FSO module activates the STO function and generates an event. The user can select the event type (warning, fault or event) with parameter *FSOGEN.62 STO indication safety limit*.

Function indications

The logic state of output indication signals can be configured to be active low or active high.

STO, SS1, SSE, POUS

States of the configured and connected functions are indicated with FSO digital outputs and fieldbus status signals when the function is started:

- Stopping functions (SSE and SS1) are always started and indicated immediately (the monitoring method depends on the configuration) (parameters *SSE.21 SSE output* and *SS1.21 SS1 output*).
- The drive STO state is indicated when the drive STO circuit is open (parameter *STO.21 STO output*).
  Note: When the SBC is activated before the drive STO, the drive STO is indicated after a delay (parameter *SBC.12 STO SBC delay*).
- POUS function is indicated immediately when requested from an input (*POUS.21 POUS output*).
- Ramp monitoring (SAR0 and SAR1, see section *Configuring SAR* on page *294*) is not indicated.

The FSO module switches off the digital output indications (SSE, SS1 and POUS functions) when the function is acknowledged.

Stop completed indications are activated when the stopping function has completed, but is not yet acknowledged. There are separate indications for each stopping function STO, SSE and SS1 (parameters *STO.22 STO completed output*, *SSE.22 SSE completed output*, *SS1.22 SS1 completed output*) and one common for all of them (parameter *FSOGEN.11 Stop completed output*). The FSO module switches off the indications when the function is acknowledged.

The completed indication of the POUS function (parameter *POUS.22 POUS completed output*) is activated after the time defined by parameter *POUS.13 POUS delay for completion* has passed. The FSO module switches off the completed indication when the POUS request is removed.

SLS, Variable SLS

- SLS indication starts when the motor speed is in the monitored range. The FSO module switches off the indication when the function is acknowledged or the monitored speed exceeds the user-defined limit (this also causes the SLS to trip, that is, the FSO module activates the SSE function).

SSM

- SSM indication starts when the motor speed is in the monitored range. The FSO module switches off the indication when the monitored speed exceeds the configured limit.

SDI

- SDI indication starts when the motor rotates in the correct direction. The FSO module switches off the indication when the function is acknowledged or the rotation direction changes to the forbidden direction (this also causes the SDI to trip, that is, the FSO module activates the SSE function).

FSO modes

The FSO can be in one of the following modes:

- **Power down:** The power to the FSO is off. The drive STO circuit is open. The POWER LED is off.
- **Start-up**: The FSO is starting up after power-up. Indicated with a blinking green RUN LED.
- **Running**: The FSO is up and running. It can be in different states (see section *FSO states* on page *53*) depending on the status of safety functions and the safety fieldbus communication. Indicated with a green RUN LED.
- **Fail-safe**: There is a failure in the FSO. The drive STO is active. Indicated with a red STATUS/FAULT LED. You have to reboot the FSO to exit the Fail-safe mode.
- **Configuration**: Parameters are uploaded from the FSO module. The drive STO is active. Indicated with blinking RUN and STATUS/FAULT LEDs. You can exit the Configuration mode by downloading the new configuration to the FSO or by rebooting the FSO.

For more information on the FSO LEDs, see section *Status LEDs* on page *403*.

FSO states

When the FSO is up and running, it can be in one of the following states depending on the drive STO status:

- **Safe**: STO active, that is, the drive STO circuit is open and the motor is stopped. The SBC is active (if used).
- **Operational**: STO inactive.

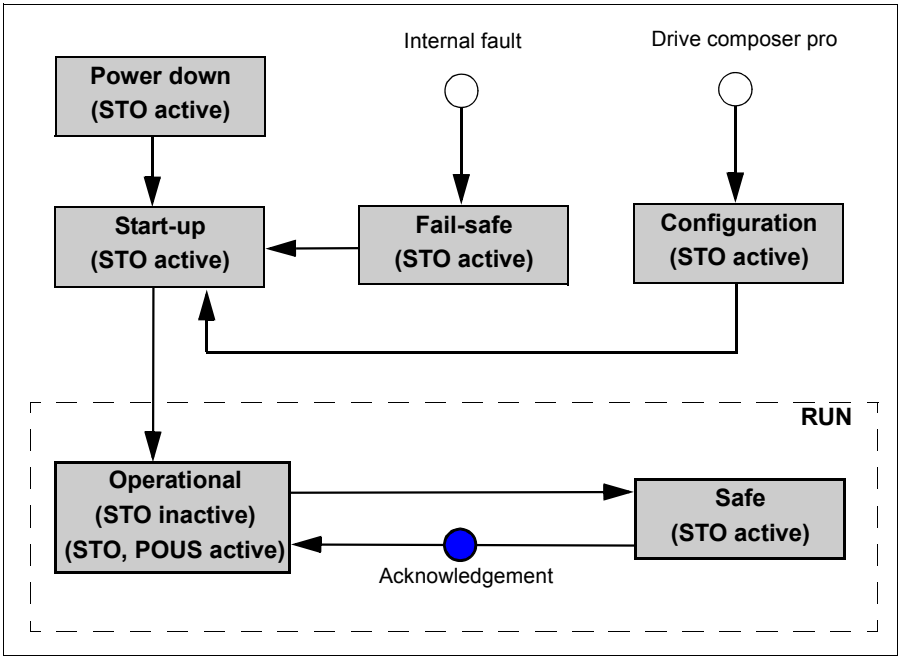
In the Operational and Safe states, the FSO can execute the safety functions.

Note: When the POUS function is active, the FSO module is in the Operational state and the drive STO is active.

Transitions between FSO modes and states

The following diagram shows the possible transitions during normal operation of the FSO module.

- Power down: STO active, power off (below 19 V)
- Start-up: STO active, power on (above 19 V), start-up checks performed
- Configuration: STO active, setting of parameters
- Operational: STO inactive, FSO running
- Operational: STO active, POUS active, FSO running
- Safe: STO active, FSO running
- Fail-safe: STO active, I/O, FSO or communication fault detected.



At power-up, the FSO goes into the Start-up mode; it performs start-up checks and, according to the configuration, enters the Operational state either automatically or after an acknowledgement request from the FSO I/O or from a safety PLC.

The Drive composer pro PC tool can request the Configuration mode, when the FSO is in the Start-up, Operational, Safe or Fail-safe mode and the drive is in the Torque off mode (not modulating). The FSO exits the Configuration mode into the Start-up mode when the user either:

- downloads the new configuration to the FSO,
- switches the power off and on (through the Power down state),
- reboots the FSO with the **Boot FSO** button in the Drive composer pro PC tool, or
- reboots the FSO with drive parameter *96.09 FSO reboot* (see the drive firmware manual).

If there is an internal fault, the FSO enters the Fail-safe mode. The FSO exits the Fail-safe mode into the Start-up mode when the user either:

- switches the power off and on (through the Power down state),
- reboots the FSO with the **Boot FSO** button in the Drive composer pro PC tool, or
- reboots the FSO with drive parameter *96.09 FSO reboot* (see the drive firmware manual).

When the FSO is in the Power down, Start-up, Configuration, Safe or Fail-safe mode, the drive STO function is always active. When the FSO is in the Operational state, the drive STO function is inactive (except when the POUS function is active, the drive STO function is also active).

Note: When the drive is connected to a safety PLC via the PROFIsafe over PROFINET communication bus, see the states diagrams in section *FSO module modes and states* on page *177* in chapter *PROFIsafe*.

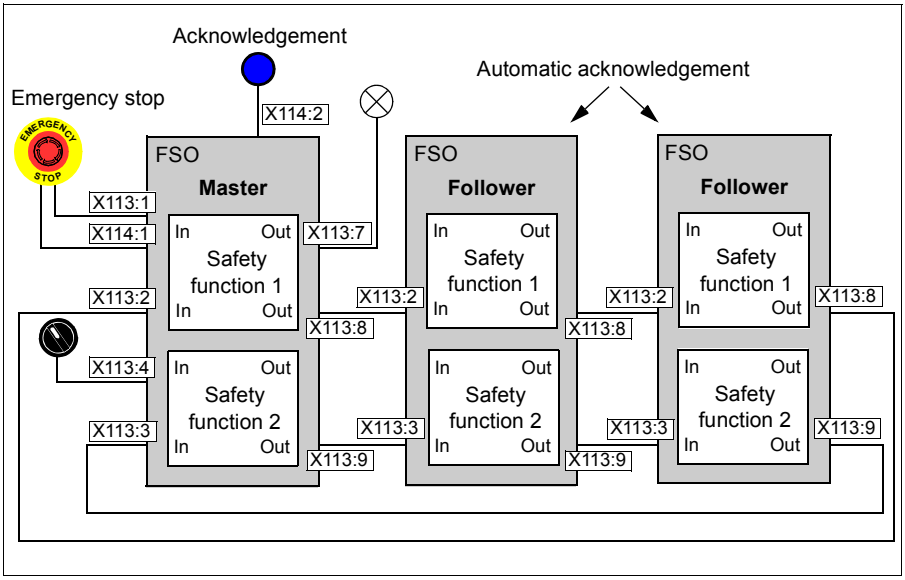
Cascade

It is possible to cascade up to six FSO modules into a daisy-chain type network (resembles somewhat an I/O master/follower system): If an FSO triggers a cascaded safety function, it passes the triggering information to the next FSO, which triggers the next one, and so on, until the last FSO again triggers the first one.

Without a PROFIsafe communication bus, you can cascade only safety functions which have a primary and a secondary digital input: STO, SS1, SSE, SLS1, SDI positive and SDI negative.

For detailed configuration instructions, see section *How to configure a cascaded system* on page *257*.

This figure shows an example cascade configuration. Two different safety functions are cascaded in the same cascaded system.



The inputs and outputs of the FSO module are defined as pairs. In this example, single input X113:2 is cascaded with single output X113:8. When Emergency stop (Safety function 1) is activated in the master FSO module (from redundant digital input X113:1&X114:1), it is also activated in the follower FSO modules. Safety function 2 is cascaded with single input X113:3 and single output X113:9.

You must configure one of the cascaded FSO modules as the master and the others as followers.

You must configure all follower FSO modules to use the automatic acknowledgement method. The master FSO module can have an acknowledgement button (manual acknowledgement). The acknowledgement starts always from the master.

You can configure one or two safety functions in the same cascaded system. If the whole cascaded system must trip after reaching a limit of any safety function, you must have the SSE function in the cascaded system.

If an FSO module activates the STO function (after a limit hit, an STO request from the I/O or the safety fieldbus, or after an internal fault), also the cascaded SSE output is triggered.

Note: When several drives are linked together in a master/follower system and the follower drive is in the torque control mode, stopping functions with a deceleration ramp (SSE with emergency ramp and SS1) will turn the follower drive to the speed control mode. For more information on the master/follower functionality in the drive, see the firmware manual.

Safe torque off (STO)

The STO function brings the machine safely into a no-torque state and/or prevents it from starting accidentally. The STO function in the FSO module activates the drive STO function, that is, opens the STO circuit in the drive. This prevents the drive from generating the torque required to rotate the motor. If the motor is running when the STO function is activated, it coasts to a stop.

You can configure the SBC function to be activated before, at the same time with, or after the drive STO function. When you use an encoder, you can also configure the SBC function to be activated at a user-defined speed limit.

This section describes the different versions of the STO function separately without and with an encoder.

For more information on the STO function in the ACS880 drives, see the drive hardware manual.

Note: For the encoderless mode, you have to set parameters *STO.14* and *SBC.13* so that the motor has enough time to stop from full speed when modulation is stopped. (excluding applications where fly-start is possible and the free rotation of the motor axle does not cause any harm to the surroundings).

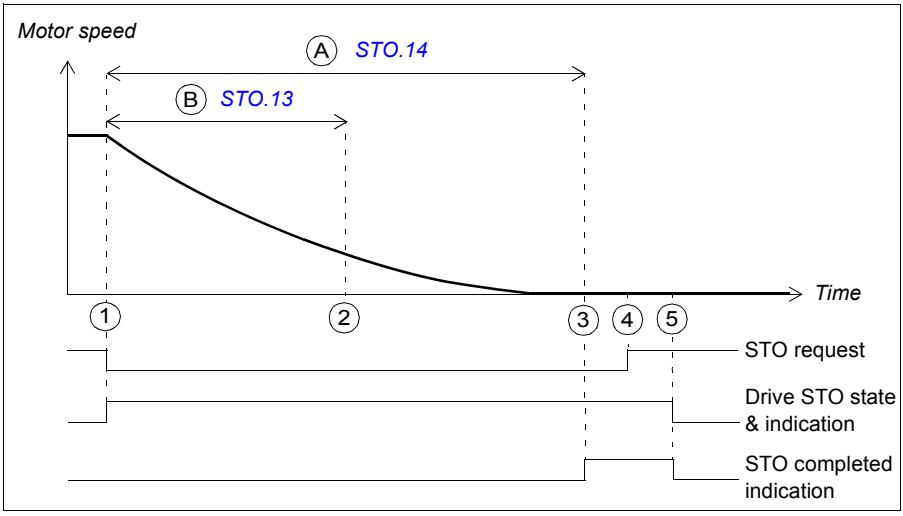
Note: If the SSE is cascaded, STO activation also activates the SSE cascade indication signal (output). See sections *Safe stop emergency (SSE)* on page *93* and *Cascade* on page *55*.

Note: Always set the parameters related to the STO function to have the correct monitoring limit hit and fault reaction behavior. An internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal.

STO function

The operation of the STO function when the SBC is not used is described in the time diagrams and tables below. For configuration, see section *How to configure STO* on page *264*.

Without an encoder

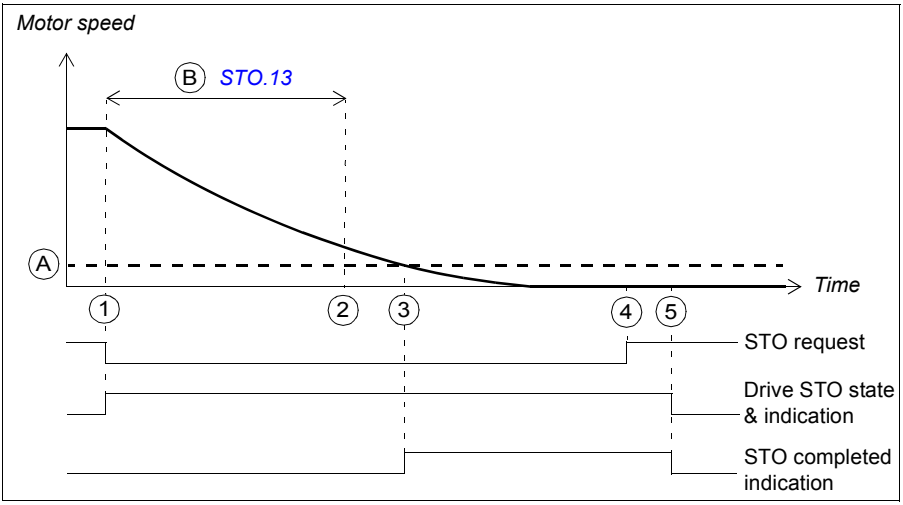


A Time to zero speed (parameter *STO.14*): Time from the STO activation to the moment when the safety function is completed and the STO completed indication (parameter *STO.22*) goes on. You must set this to the estimated time in which the motor coasts to a stop from the maximum speed.

B Restart delay after STO (parameter *STO.13*): Time from the STO activation to the moment when the acknowledgment becomes allowed. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). You can use this feature only in certain applications. This parameter is relevant only when an external request activates the STO function.

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the drive STO function and starts counters for times A and B.
2	After time B has elapsed, the acknowledgement becomes allowed as soon as the STO request has been removed (step 4). **Note**: If an SSE or SS1 request is received while the STO function is active, the STO function must be completed before the acknowledgement is allowed.
3	After time A has elapsed, the FSO module defines the motor as stopped and the STO completed indication goes on.
4	The STO request is removed.
5	After the acknowledgement, the STO function is deactivated and the indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the STO completed indication (parameter *STO.22*) goes on.

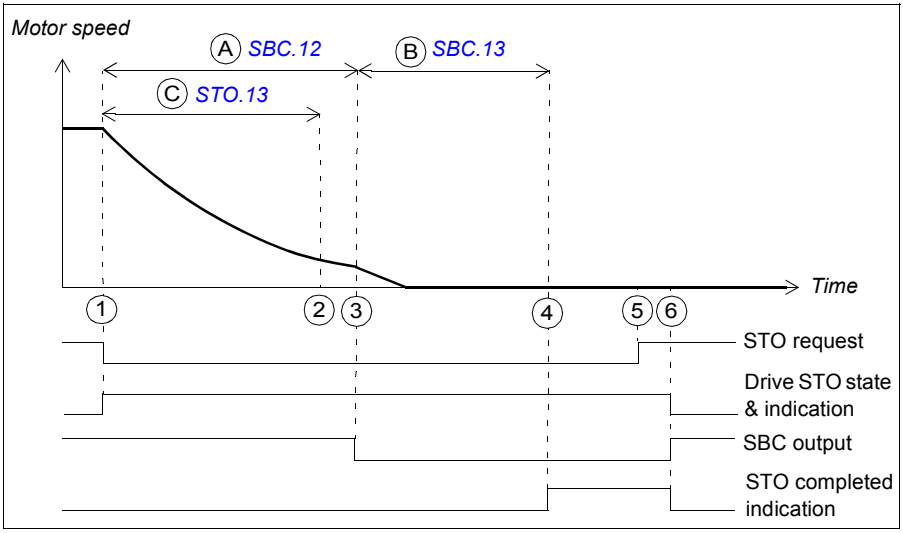
B Restart delay after STO (parameter *STO.13*): Time from the STO activation to the moment when the acknowledgment becomes allowed. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). You can use this feature only in certain applications. This parameter is relevant only when an external request activates the STO function.

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the drive STO function and starts a counter for time B.
2	After time B has elapsed, the acknowledgement becomes allowed as soon as the STO request has been removed (step 4). **Note**: The acknowledgement becomes allowed already at the zero speed limit (A) if it is reached before time B has elapsed. **Note**: If an SSE or SS1 request is received while the STO function is active, the STO function must be completed before the acknowledgement is allowed.
3	The motor speed goes below the zero speed limit (A), the FSO module defines the motor as stopped and the STO completed indication goes on.
4	The STO request is removed.
5	After the acknowledgement, the STO is deactivated and the indications go off.

SBC after STO

The operation of the SBC after the STO function (positive SBC delay) is described in the time diagrams and tables below. For configuration, see section *How to configure SBC after STO* on page *266*.

Without an encoder



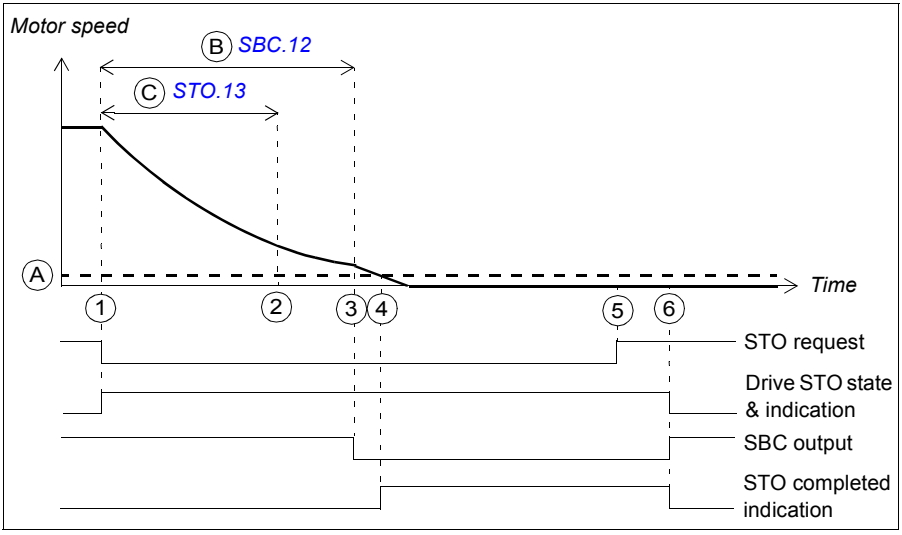
A SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case the value is positive and the FSO activates the SBC after the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time. **Note**: It is possible to set the SBC delay so that the SBC is activated while the motor is still rotating.

B SBC time to zero speed (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the STO completed indication (parameter *STO.22*) goes on. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

C Restart delay after STO (parameter *STO.13*): Time from the STO activation to the moment when the acknowledgment becomes allowed. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). You can use this feature only in certain applications. This parameter is relevant only when an external request activates the STO function.

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the drive STO and starts counters for times A and C.
2	After time C has elapsed, the acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
3	After time A has elapsed, the FSO activates the SBC (brake) and starts a counter for time B.
4	After time B has elapsed, the FSO module defines the motor as stopped and the STO completed indication goes on.
5	The STO request is removed.
6	After the acknowledgement, the STO and SBC functions are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and STO completed indication (parameter *STO.22*) goes on.

B SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case, the value is positive and the FSO activates the SBC after the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time. **Note**: It is possible to set the SBC delay so that the SBC is activated while the motor is still rotating.

C Restart delay after STO (parameter *STO.13*): Time from the STO activation to the moment when the acknowledgment becomes allowed. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). You can use this feature only in certain applications. This parameter is relevant only when an external request activates the STO function.

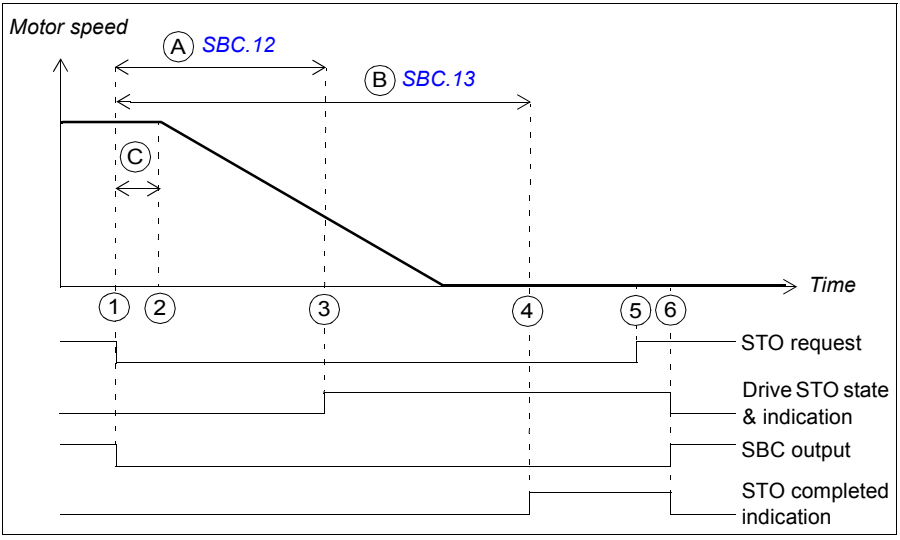
Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the drive STO function and starts counters for times B and C.
2	After time C has elapsed, the acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
3	After time B has elapsed, the FSO activates the SBC function (brake). **Note**: If zero speed limit A is reached before time B has elapsed, the FSO activates the SBC function immediately when the motor has stopped.
4	The motor speed goes below the zero speed limit (A), the FSO module defines the motor as stopped and the STO completed indication goes on.
5	The STO request is removed.
6	After the acknowledgement, the STO and SBC are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

SBC before STO

The operation of the SBC before the STO function (negative SBC delay) is described in the time diagrams and tables below. For configuration, see section *How to configure SBC before STO* on page *268*.

The reason to use a negative SBC delay is to have the mechanical brake closed just before the drive STO circuit is opened.

Without an encoder



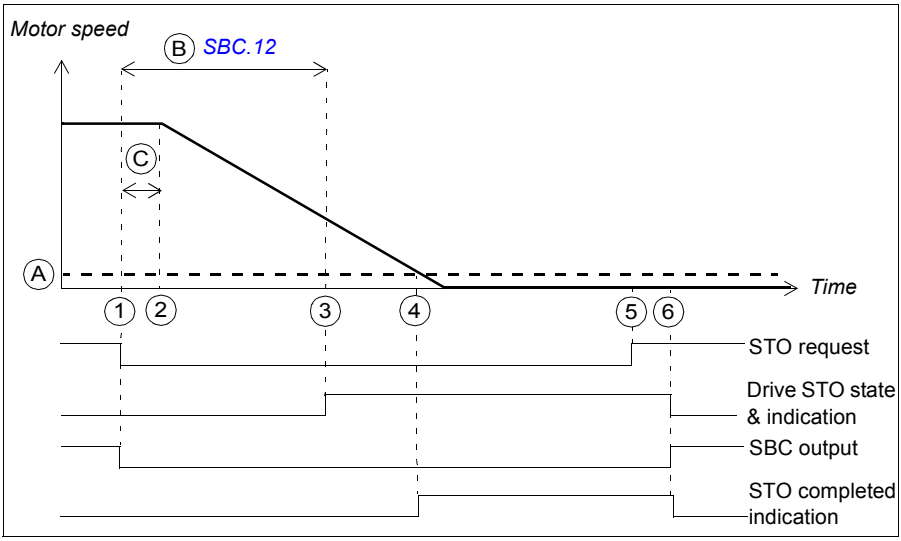
A SBC delay (parameter *SBC.12*): Time from the activation of the drive STO to the moment when the FSO activates the SBC function (brake). In this case the value is negative and the FSO activates the SBC before the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time.

B SBC time to zero speed (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the STO completed indication (parameter *STO.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

C Response time (depends on system configuration, see page *437*)

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the SBC function (brake) and starts counters for times A and B.
2	After time C has elapsed, the SBC starts to brake the motor.
3	After time A has elapsed, the FSO activates the drive STO.
4	After time B has elapsed, the FSO module defines the motor as stopped and the STO completed indication goes on. The acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
5	The STO request is removed.
6	After the acknowledgement, the STO and SBC functions are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the STO completed indication (parameter *STO.22*) goes on. The acknowledgment becomes allowed.

B SBC delay (parameter *SBC.12*): Time from the activation of the drive STO to the moment when the FSO activates the SBC function (brake). In this case the value is negative and the FSO activates the SBC before the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time.

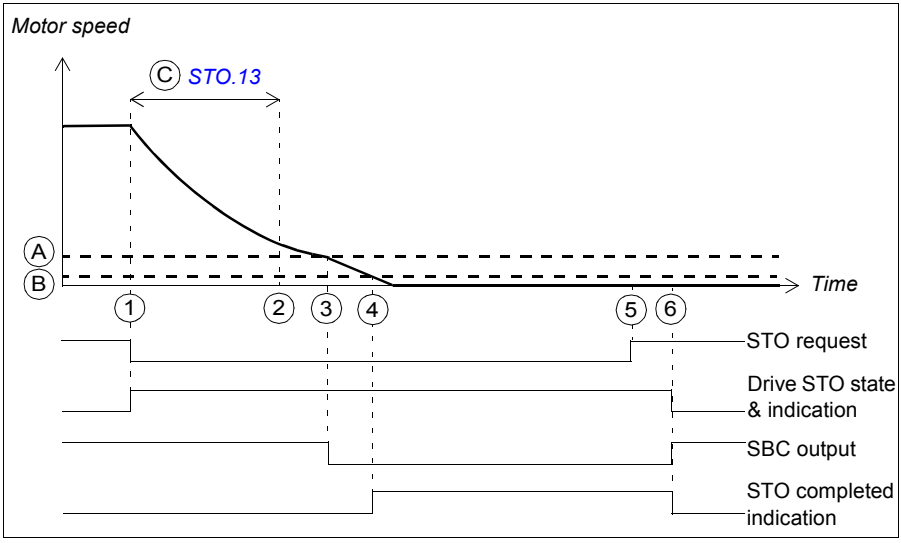
C Response time (depends on system configuration, see page *437*)

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the SBC function (brake) and starts a counter for time B.
2	After time C has elapsed, the SBC starts to brake the motor.
3	After time B has elapsed, the FSO activates the drive STO.
4	The motor speed goes below the zero speed limit (A), the FSO module defines the motor as stopped and the STO completed indication goes on. The acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
5	The STO request is removed.
6	After the acknowledgement, the STO and SBC functions are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

STO with speed limit activated SBC

This safety function requires that you use an encoder in the safety application.

The operation of the STO with speed limit activated SBC is described in the time diagram and table below. For configuration, see section *How to configure STO with speed limit activated SBC* on page *270*.



A STO SBC speed (parameter *SBC.14*): Speed limit at which the FSO activates the SBC function (brake).

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the STO completed indication (parameter *STO.22*) goes on. The acknowledgment becomes allowed.

C Restart delay after STO (parameter *STO.13*): Time from the STO activation to the moment when the acknowledgment becomes allowed. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). You can use this feature only in certain applications. This parameter is relevant only when an external request activates the STO function.

Step	Description
1	The STO request is received (for example, from the I/O). The FSO activates the drive STO function.
2	After time C has elapsed, the acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
3	The motor speed goes below the SBC speed limit (A) and the FSO activates the SBC function (brake).
4	The motor speed goes below the zero speed limit (B), the FSO module defines the motor as stopped and the STO completed indication goes on. The acknowledgement becomes allowed as soon as the STO request has been removed (step 5).
5	The STO request is removed.
6	After the acknowledgement, the STO and SBC functions are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

Safe stop 1 (SS1)

The SS1 function stops the motor safely by ramping down the motor speed. The FSO activates the drive STO function below a user-defined zero speed limit.

The FSO monitors the stop ramp either with the time or ramp monitoring method (SS1 function types SS1-t and SS1-r, respectively). If the motor speed does not follow the monitoring limit(s), the FSO activates the STO function and the motor coasts to a stop.

The SS1 function uses SAR1 parameters to define and/or monitor the stop ramp.

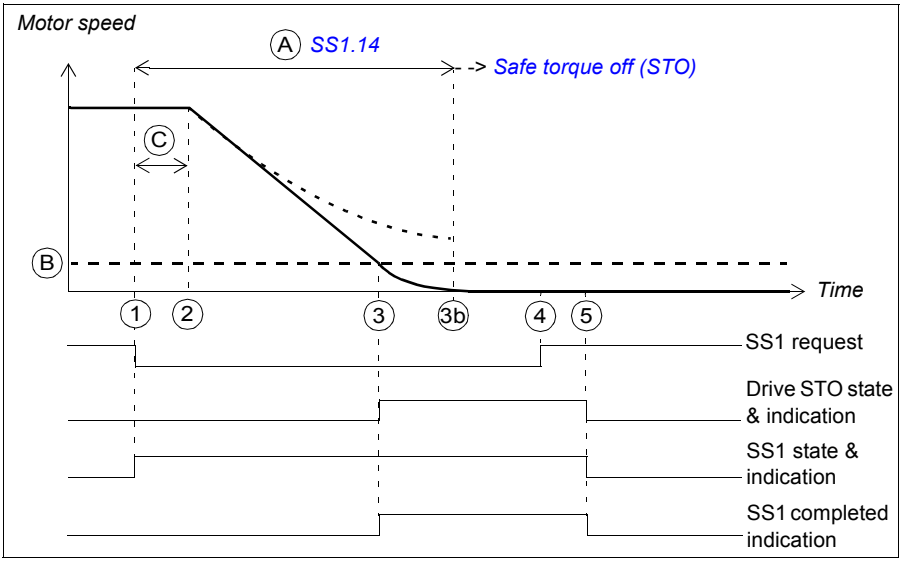
When you use the SBC function with the SS1 function, you can configure the SBC and drive STO combination to be activated at a user-defined speed limit while ramping down to zero speed. You can also define a delay so that the SBC is activated first at the user-defined speed limit and the drive STO after the delay.

This section describes the different versions of the SS1 function separately without and with an encoder.

SS1 with time monitoring (SS1-t)

The operation of the SS1 with time monitoring (SS1-t) is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with time monitoring (SS1-t)* on page *273*.

Without an encoder



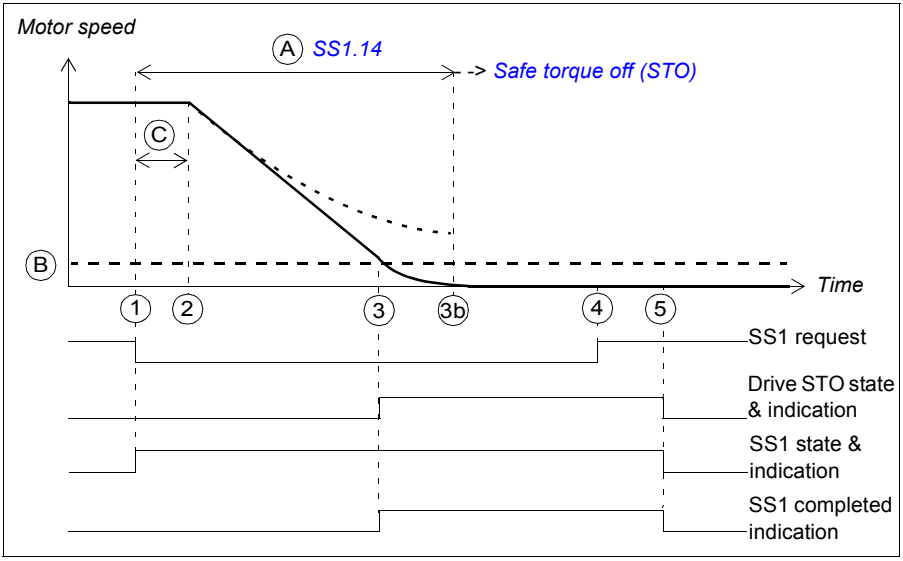
A SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

B Zero speed (parameter *FSOGEN.51*): Speed limit for activating the drive STO function. The safety function is completed and the SS1 completed indication (parameter *SS1.22*) goes on.

C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example, from the I/O). The FSO starts a counter for time A.
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the zero speed limit (B) and the FSO activates the drive STO function. The SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. • The SS1 completed indication goes on after the delay defined with parameter *SBC.13* has elapsed from the SBC activation. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the drive STO function (not shown in the figure).
3b	If the drive has not ramped down fast enough when time A has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The SS1 request is removed.
5	After the acknowledgement, the STO and SS1 functions are deactivated. The indications go off.

With an encoder



A SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit for activating the drive STO function. The safety function is completed and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

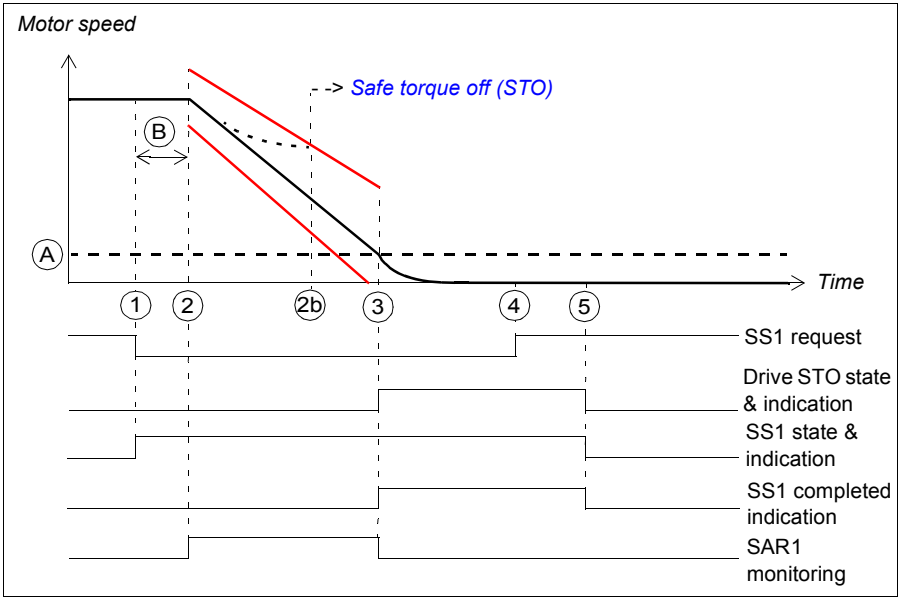
C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example from the I/O). The FSO starts a counter for time A.
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the zero speed limit (B) and the FSO activates the drive STO function. The SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the drive STO function (not shown in the figure).
3b	If the drive has not ramped down fast enough when time A has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The SS1 request is removed.
5	After the acknowledgement, the STO and SS1 functions are deactivated. The indications go off.

SS1 with ramp monitoring (SS1-r)

The operation of the SS1 with ramp monitoring (SS1-r) is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with ramp monitoring (SS1-r)* on page *275*.

Without an encoder



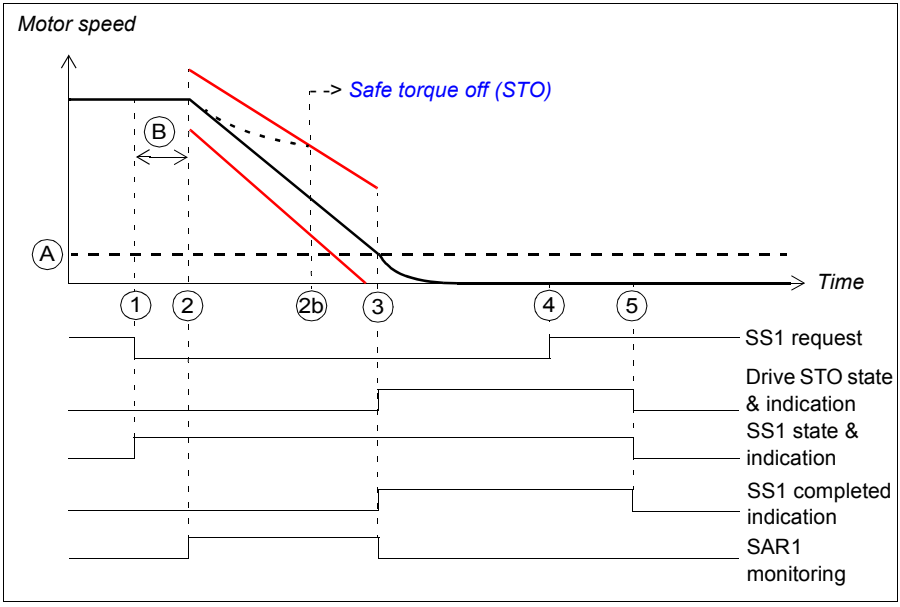
A Zero speed (parameter *FSOGEN.51*): Speed limit for activating the drive STO function. The safety function is completed and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

B Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time B has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
2b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The motor speed goes below the zero speed limit (B), the FSO stops the SAR1 monitoring and activates the drive STO function. The SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. • The SS1 completed indication goes on after the delay defined with parameter *SBC.13* has elapsed from the SBC activation. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the drive STO function (not shown in the figure).
4	The SS1 request is removed.
5	After the acknowledgement, the STO and SS1 functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit for activating the drive STO function. The safety function is completed, ramp monitoring is stopped and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

B Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time B has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
2b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The motor speed goes below the zero speed limit (A), the FSO stops the SAR1 monitoring and activates the drive STO function. The SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the drive STO function (not shown in the figure).
4	The SS1 request is removed.
5	After the acknowledgement, the STO and SS1 functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

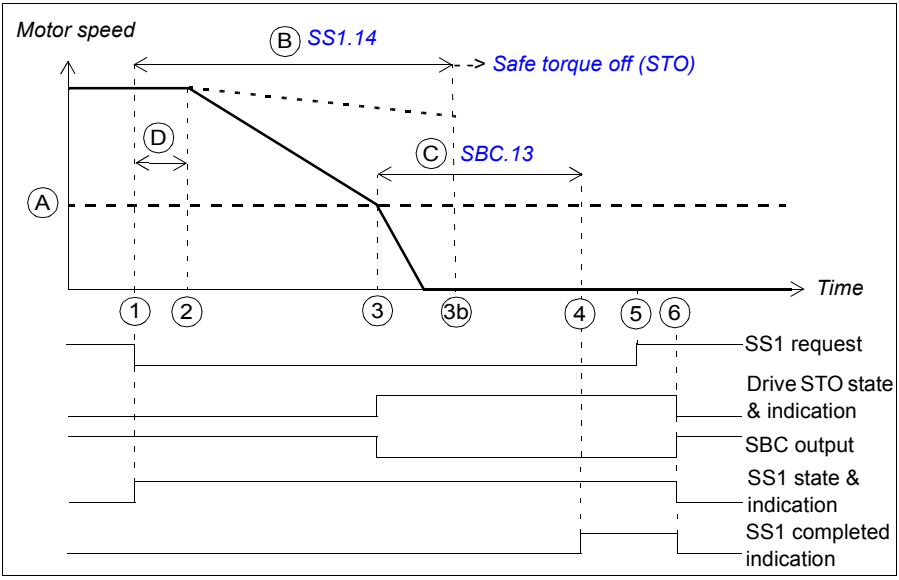
SS1 with speed limit activated SBC

In these examples, the SBC and drive STO functions are activated at a user-defined speed limit.

With time monitoring (SS1-t)

The operation of the SS1-t function with speed limit activated SBC is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with speed limit activated SBC* on page *276*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) and drive STO functions while ramping.

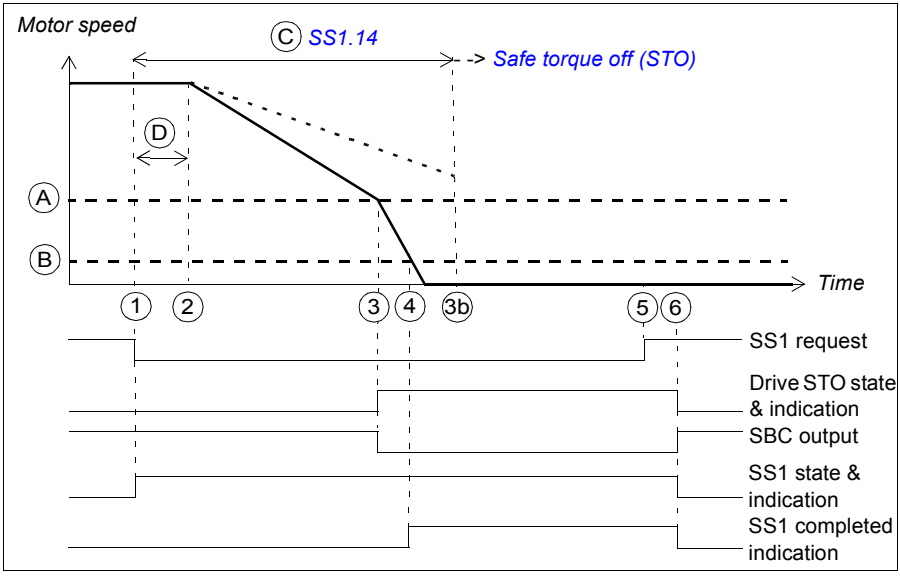
B SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

C SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SS1 completed indication (parameter *SS1.21*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

D Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example, from the I/O). The FSO starts a counter for time B.
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SS1 with speed limit activated SBC, SBC before STO* on page *85*). The FSO starts a counter for time C. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the drive has not ramped down fast enough when time B has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5).
5	The SS1 request is removed.
6	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) and drive STO functions while ramping.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

C SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

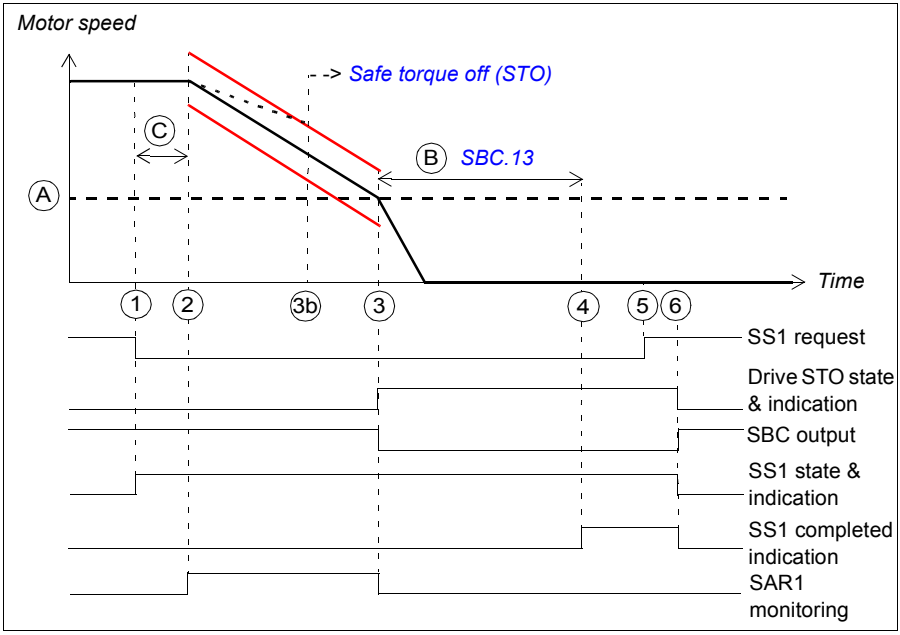
D Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example, from the I/O). The FSO starts a counter for time C.
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SS1 with speed limit activated SBC, SBC before STO* on page *85*). **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the drive has not ramped down fast enough when time C has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5).
5	The SS1 request is removed.
6	After the acknowledgement, the SS1, STO and SBC functions are deactivated, and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With ramp monitoring (SS1-r)

The operation of the SS1-r function with speed limit activated SBC is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with speed limit activated SBC* on page *276*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) and drive STO functions while ramping.

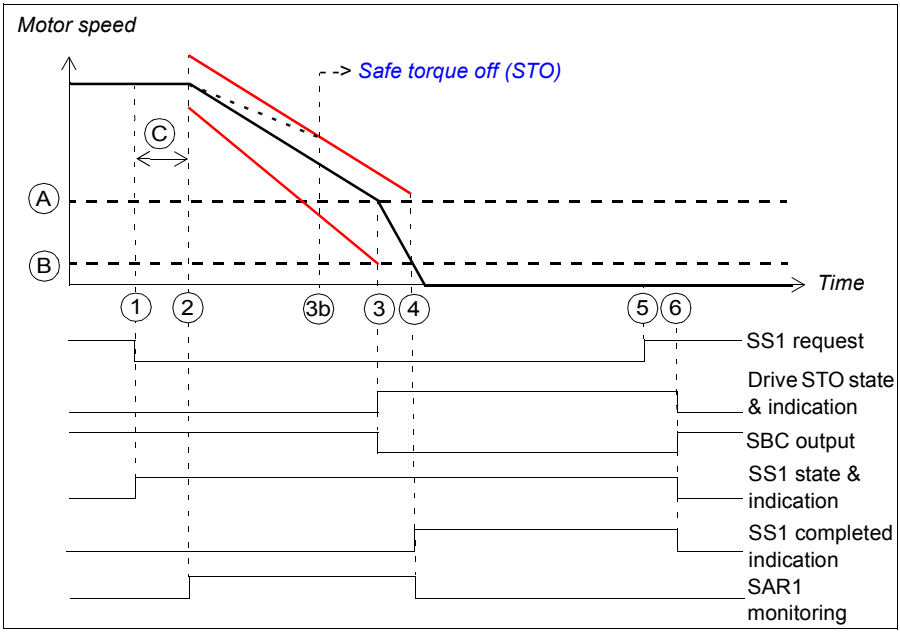
B SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SS1 completed indication (parameter *SS1.21*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

C Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO stops the SAR1 monitoring. The FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SS1 with speed limit activated SBC, SBC before STO* on page *85*.) The FSO starts a counter for time B. **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time B has elapsed, the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5).
5	The SS1 request is removed.
6	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which FSO activates the SBC (brake) and drive STO functions while ramping.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed, the ramp monitoring is stopped and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

C Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time B has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A). The FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SS1 with speed limit activated SBC, SBC before STO* on page *85*). **Note**: You can define an extra delay (parameter *SS1.15*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5). The FSO stops the SAR1 monitoring.
5	The SS1 request is removed.
6	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

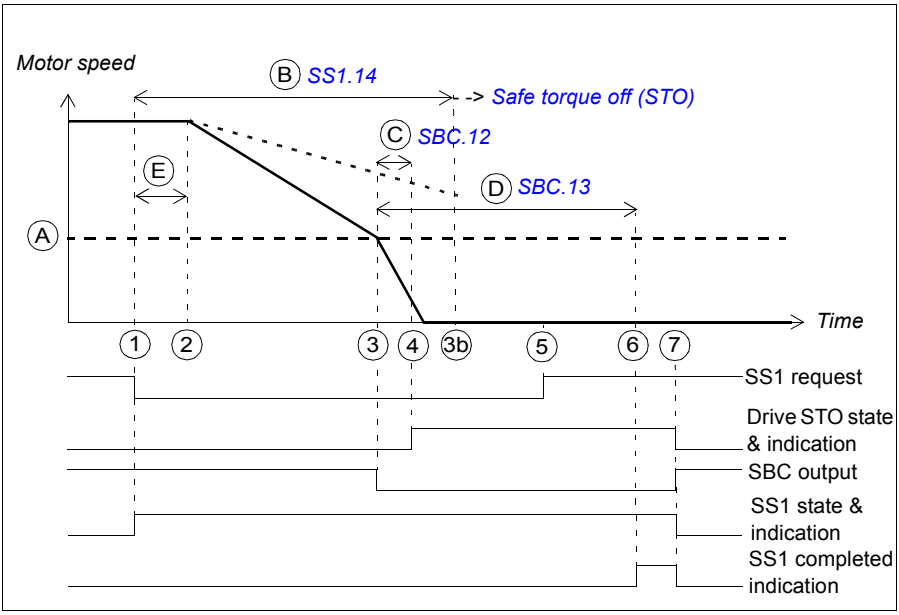
SS1 with speed limit activated SBC, SBC before STO

In these examples, the SBC function is activated at a user-defined speed limit and drive STO function after a user-defined delay (negative SBC delay). The reason to use a negative SBC delay (parameter *SBC.12*) is to have the mechanical brake closed just before the drive STO circuit is opened.

With time monitoring (SS1-t)

The operation of the SS1-t function with speed limit activated SBC, SBC before STO is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with speed limit activated SBC, SBC before STO* on page *280*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake).

B SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

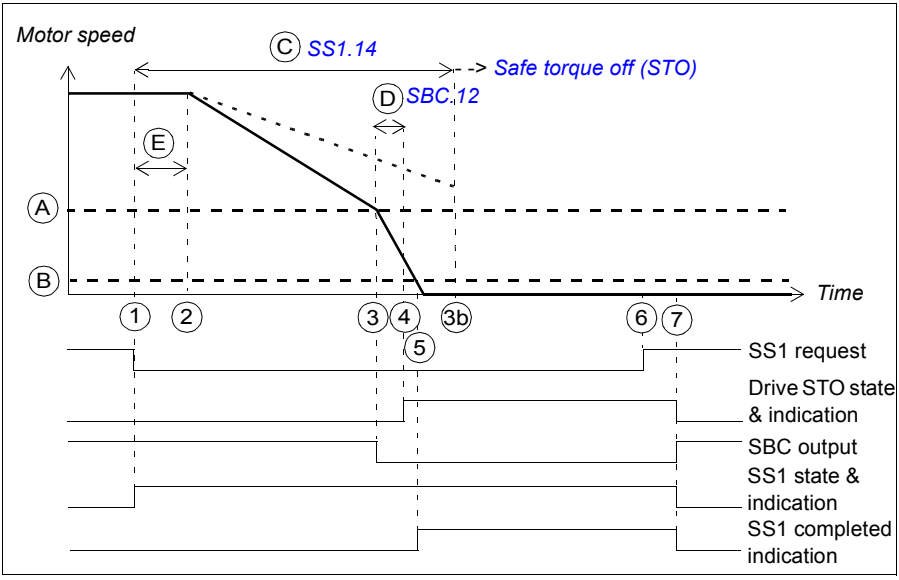
C SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

D SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SS1 completed indication (parameter *SS1.21*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

E Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example, from the I/O). The FSO starts a counter for time B.
2	After time E has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO activates SBC function. The FSO starts counters for times C and D. **Note**: You can define an extra delay (parameter *SS1.15*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the drive has not ramped down fast enough when time B has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO activates the drive STO function.
5	The SS1 request is removed.
6	After time D has elapsed, the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5).
7	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake).

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

C SS1-t delay for STO (parameter *SS1.14*): Time after which the FSO activates the STO function regardless of the motor speed.

D SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

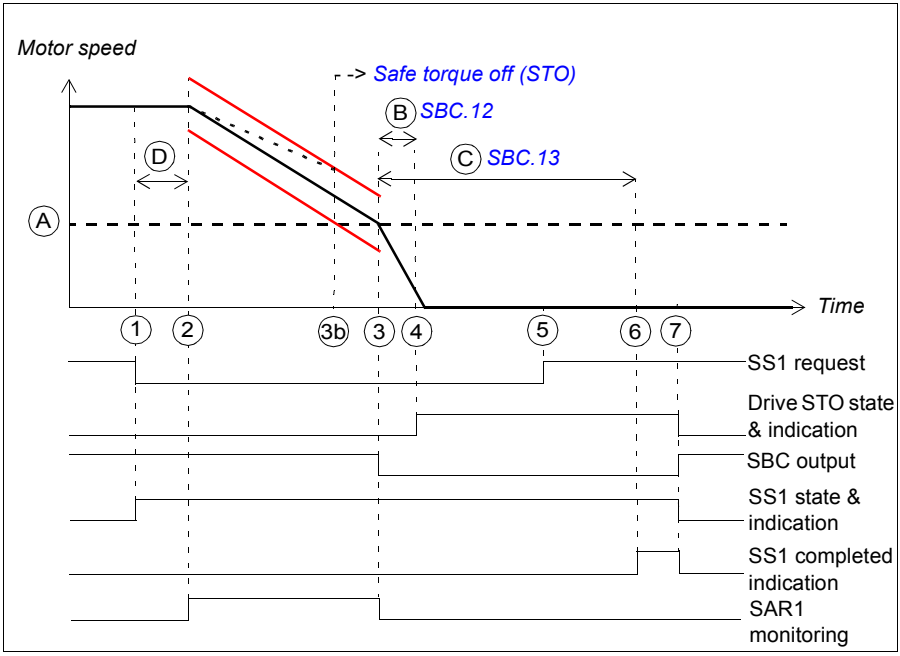
E Response time (depends on system configuration, see page *437*)

Step	Description
1	The SS1 request is received (for example, from the I/O). The FSO starts a counter for time C.
2	After time E has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO activates SBC function. The FSO starts a counter for time D. **Note**: You can define an extra delay (parameter *SS1.15*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the drive has not ramped down fast enough when time C has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time D has elapsed, the FSO activates the drive STO function.
5	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 6).
6	The SS1 request is removed.
7	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With ramp monitoring (SS1-r)

The operation of the SS1-r function with speed limit activated SBC, SBC before STO is described in the time diagrams and tables below. For configuration, see section *How to configure SS1 with speed limit activated SBC, SBC before STO* on page *280*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC function (brake) while ramping. The SAR1 ramp monitoring is stopped.

B SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

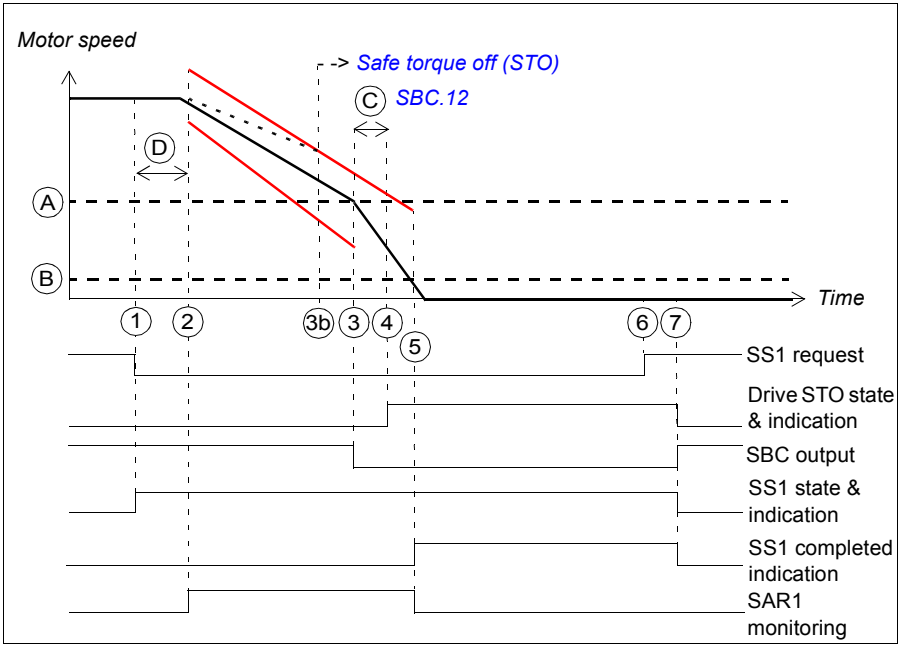
C SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SS1 completed indication (parameter *SS1.21*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

D Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO stops the SAR1 monitoring and activates the SBC function. The FSO starts counters for times B and C. **Note**: You can define an extra delay (parameter *SS1.15*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time B has elapsed, the FSO activates the drive STO function.
5	The SS1 request is removed.
6	After time C has elapsed, the FSO defines the motor as stopped, the SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 5).
7	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which FSO activates the SBC function (brake) while ramping.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed, the SAR1 ramp monitoring is stopped and the SS1 completed indication (parameter *SS1.22*) goes on. The acknowledgment becomes allowed.

C SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

D Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SS1 request is received (for example, from the I/O).
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts the SAR1 ramp monitoring (parameters *SARx.21* and *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
3	The motor speed goes below the SBC speed limit (A). The FSO activates the SBC function. The FSO starts a counter for time C. **Note**: You can define an extra delay (parameter *SS1.15*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO activates the drive STO function.
5	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped and stops the SAR1 monitoring. The SS1 completed indication goes on and the acknowledgement becomes allowed as soon as the SS1 request has been removed (step 6).
6	The SS1 request is removed.
7	After the acknowledgement, the SS1, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

Safe stop emergency (SSE)

The SSE function can be configured either with immediate STO or with emergency ramp.

With immediate STO

The behavior of the SSE with immediate STO is identical to the STO function (see section *Safe torque off (STO)* on page *57*) except that parameter *Restart delay after STO* is not used.

You can configure the SBC function to be activated before, at the same time with, or after the drive STO function. When you use an encoder, you can also configure the SBC function to be activated at a user-defined speed limit.

With emergency ramp

The behavior of the SSE with emergency ramp is identical to the SS1 function (see section *Safe stop 1 (SS1)* on page *68*) except that different time and ramp monitoring parameters are used. The SSE function uses SAR0 parameters to monitor and/or define the emergency ramp. Drive ramp parameters cannot be used.

When you use the SBC function with the SSE function, you can configure the SBC and drive STO combination to be activated at a user-defined speed limit while ramping down to zero speed. You can also define a delay so that the SBC is activated first at the user-defined speed limit and the drive STO after the delay.

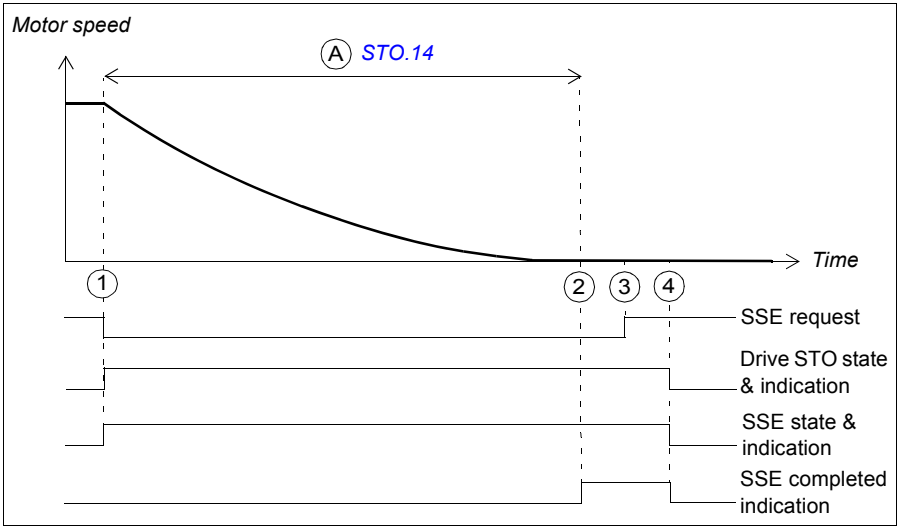
This section describes the different versions of the SSE function separately without and with an encoder.

Note: Always set the parameters related to the SSE function to have the correct trip limit hit and fault reaction behavior. An internal monitoring of the FSO module can trigger the SSE function even if you have not defined an external request signal.

SSE with immediate STO

The operation of the SSE with immediate STO function is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with immediate STO* on page *284*.

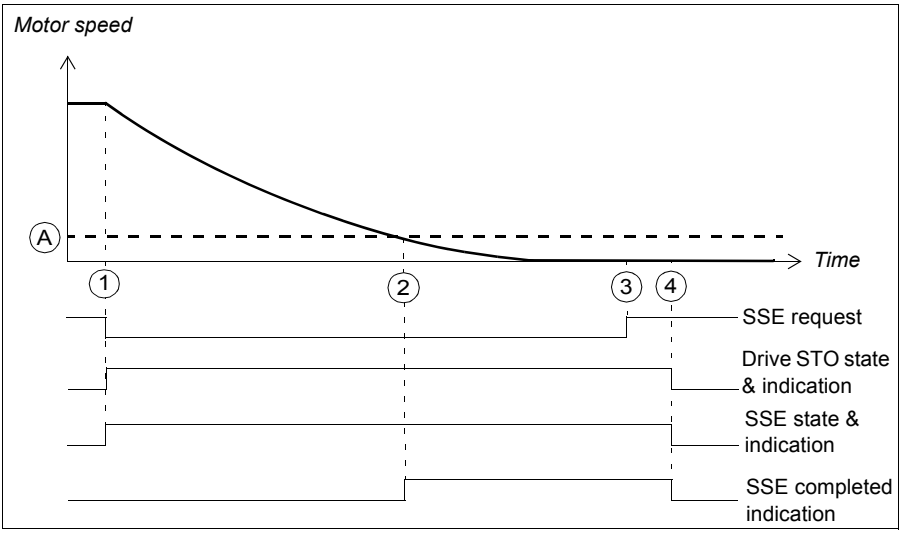
Without an encoder



A Time to zero speed (parameter *STO.14*): Time from the STO activation to the moment when the safety function is completed, the SSE completed indication (parameter *SSE.22*) goes on and the acknowledgment becomes allowed. You must set this to the estimated time in which the motor coasts to a stop from the maximum speed.

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the drive STO function and starts a counter for time A.
2	After time A has elapsed, the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 3).
3	The SSE request is removed.
4	After the acknowledgement, the SSE and STO functions are deactivated, and the control is given back to the drive. The indications goes off.

With an encoder



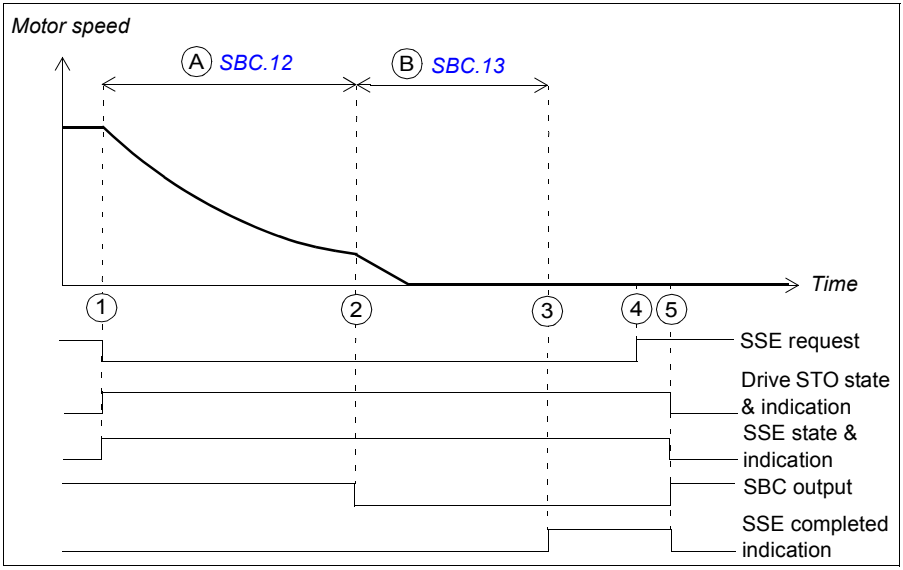
A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the drive STO function.
2	The motor speed goes below the zero speed limit (A), the FSO defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 3).
3	The SSE request is removed.
4	After the acknowledgement, the SSE and STO functions are deactivated, and the control is given back to the drive. The indications goes off.

SSE with immediate STO, SBC after STO

The operation of the SSE with immediate STO, SBC after STO (positive SBC delay) is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with immediate STO, SBC after or before STO* on page *286*.

Without an encoder

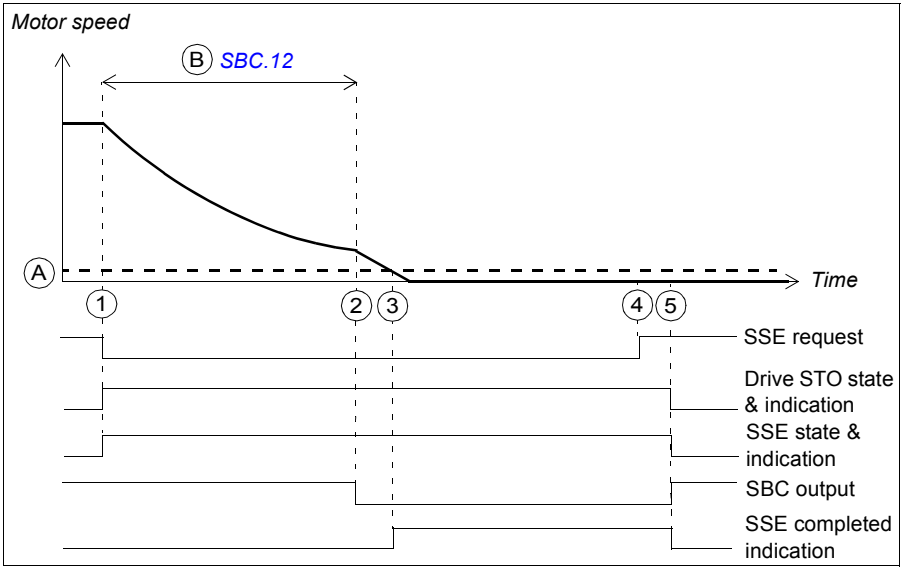


A SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case, the value is positive and the FSO activates the SBC after the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time. **Note**: It is possible to set the SBC delay so that the SBC is activated while the motor is still rotating.

B SBC time to zero speed (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the drive STO function and starts a counter for time A.
2	After time A has elapsed, the FSO activates the SBC and starts a counter for time B.
3	After time B has elapsed, the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 4).
4	The SSE request is removed.
5	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which controls the brake from now on. The indications goes off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the SSE completed indication (parameter *SSE.22*) goes on and the acknowledgment becomes allowed.

B SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case, the value is positive and the FSO activates the SBC after the drive STO. If the value is zero, the FSO activates the SBC and drive STO at the same time. **Note**: It is possible to set the SBC delay so that the SBC is activated while the motor is still rotating.

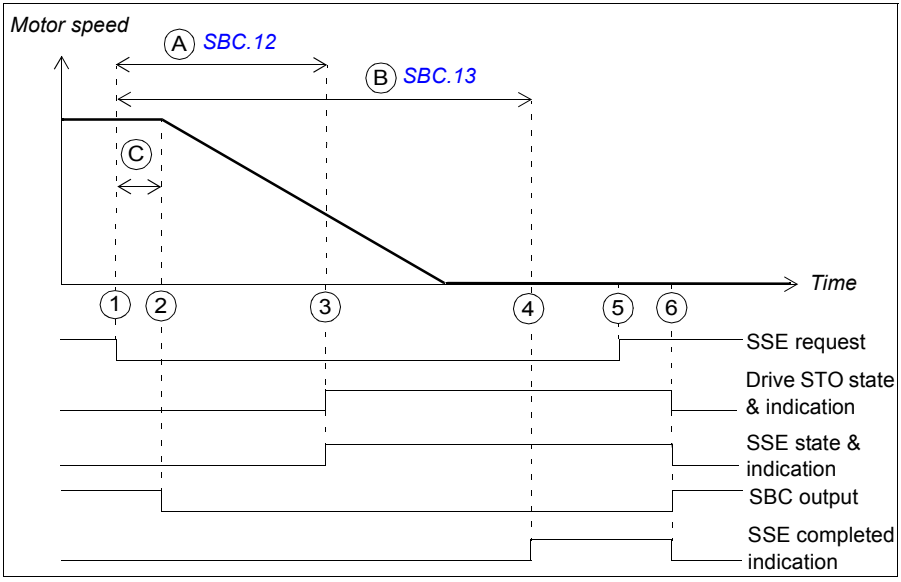
Step	Description
1	SSE request is received (for example, from the I/O). The FSO activates the drive STO and starts a counter for time B.
2	After time B has elapsed, the FSO activates the SBC function (brake). **Note**: If speed limit A is reached before time B has elapsed, the FSO activates the SBC immediately when the motor has stopped.
3	The motor speed goes below the zero speed limit (A), the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 4).
4	The SSE request is removed.
5	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which controls the brake from now on. The indications go off.

SSE with immediate STO, SBC before STO

The operation of the SSE with immediate STO, SBC before the STO (negative SBC delay) is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with immediate STO, SBC after or before STO* on page *286*.

The reason to use a negative SBC delay is to have the mechanical brake closed just before the drive STO circuit is opened.

Without an encoder



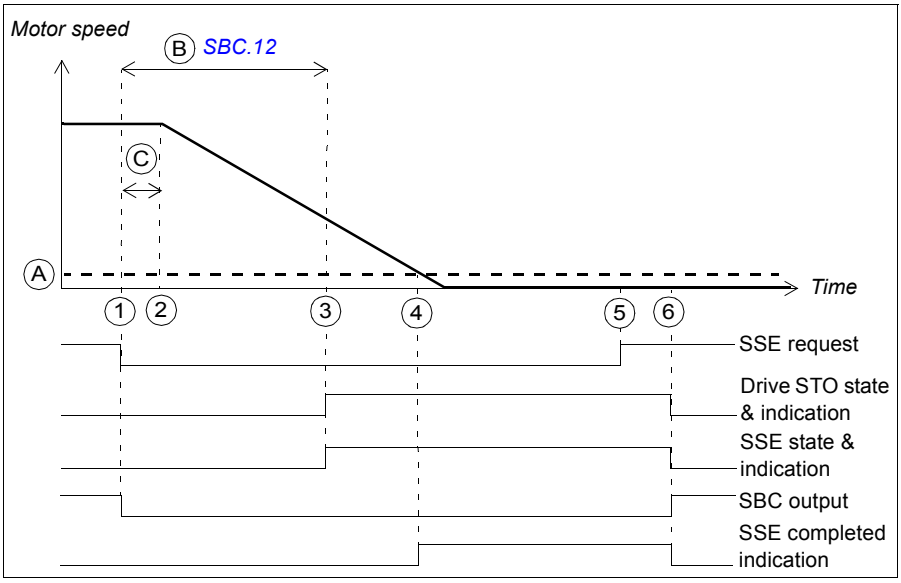
A SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case, the value is negative and the FSO activates the SBC before the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time.

B SBC time to zero speed (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the SBC function (brake) and starts counters for times A and B.
2	After time C has elapsed, the SBC starts to brake the motor.
3	After time A has elapsed, the FSO activates the drive STO function.
4	After time B has elapsed, the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which controls the brake from now on. The indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

B SBC delay (parameter *SBC.12*): Time from the activation of the drive STO function to the moment when the FSO activates the SBC function (brake). In this case, the value is negative and the FSO activates the SBC before the drive STO. If the value is zero, the FSO activates the SBC and drive STO functions at the same time.

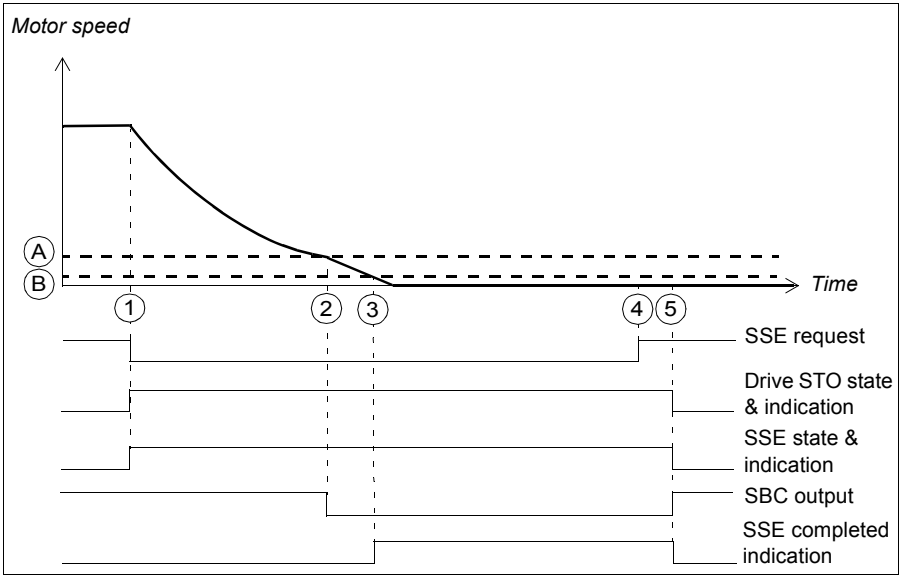
C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the SBC and starts a counter for time B.
2	After time C has elapsed, the SBC starts to brake the motor.
3	After time B has elapsed, the FSO activates the drive STO function.
4	The motor speed goes below the zero speed limit (A), the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated, and the control is given back to the drive, which controls the brake from now on. The indications go off.

SSE with immediate STO, with speed limit activated SBC

This safety function requires that you use an encoder in the safety application.

The operation of the SSE with immediate STO with speed limit activated SBC is described in the time diagram and table below. For configuration, see section *How to configure STO with speed limit activated SBC* on page *270*.



A STO SBC speed (parameter *SBC.14*): Speed limit at which the FSO activates the SBC function (brake).

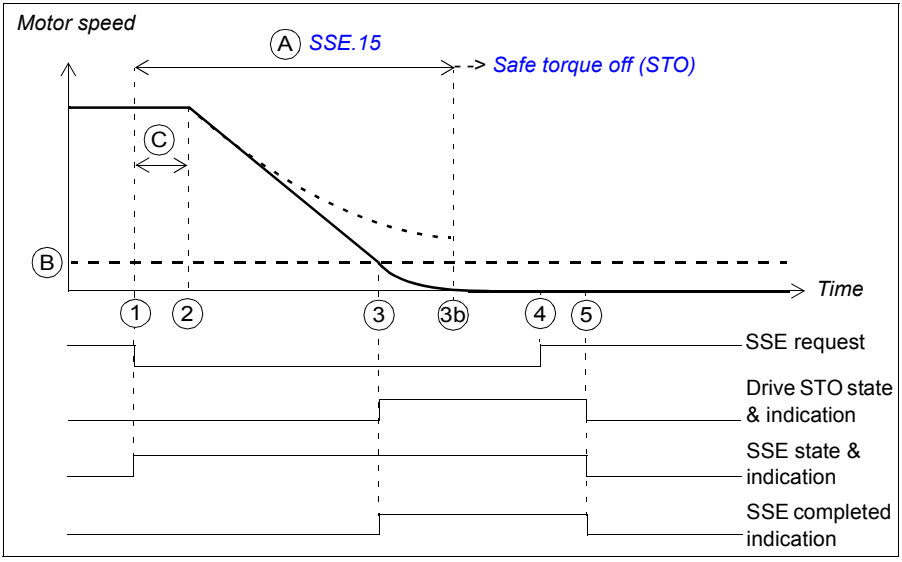
B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit at which the motor has stopped, the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO activates the drive STO function.
2	The motor speed goes below the SBC speed limit (A) and the FSO activates the SBC function (brake).
3	The motor speed goes below the zero speed limit (B), the FSO module defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 4).
4	The SSE request is removed.
5	After the acknowledgement, the STO, SSE and SBC functions are deactivated and the control is given back to the drive, which controls the brake from now on. The indications go off.

SSE with time monitoring

The operation of the SSE with time monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with time monitoring* on page *287*.

Without an encoder



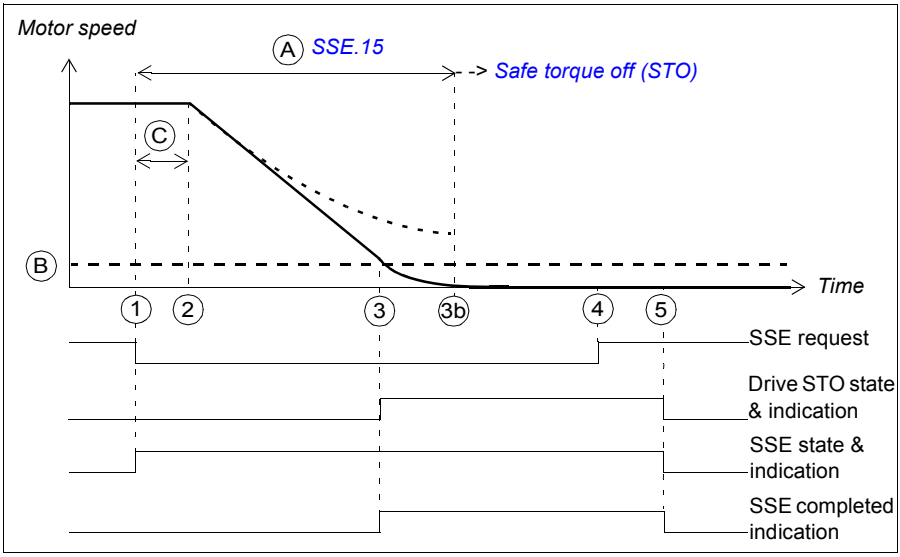
A SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the STO function regardless of the motor speed.

B Zero speed (parameter *FSOGEN.51*): Speed limit for activating the drive STO function. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time A.
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the zero speed limit (B) and the FSO activates the drive STO function. The SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. • The SSE completed indication goes on after the delay defined with parameter *SBC.13* has elapsed from the SBC activation. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the drive STO function (not shown in the figure).
3b	If the drive has not ramped down fast enough when time A has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The SSE request is removed.
5	After the acknowledgement, the STO and SSE functions are deactivated. The indications go off.

With an encoder



A SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the STO function regardless of the motor speed.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit for activating the drive STO function. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

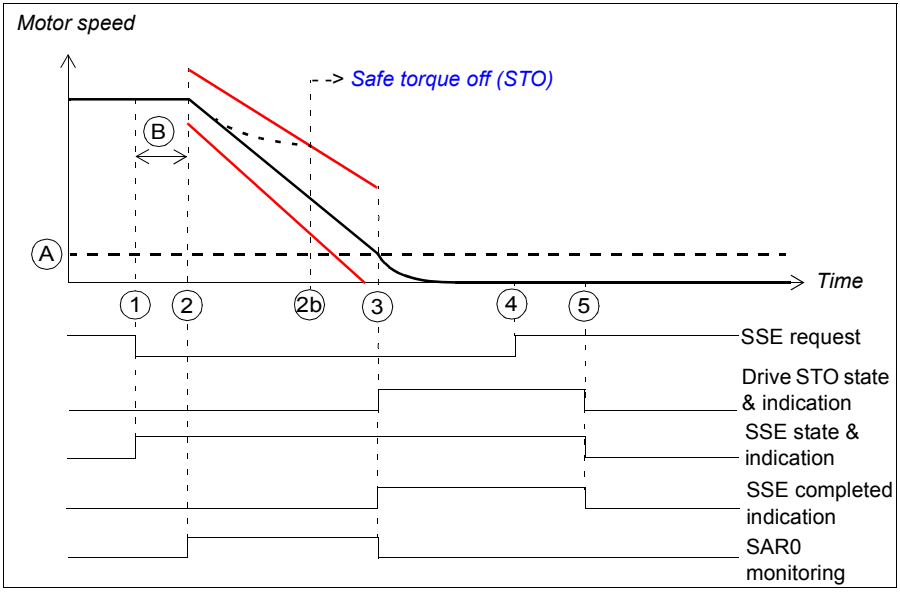
C Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time A.
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the zero speed limit (B) and the FSO activates the drive STO function. The SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the drive STO function (not shown in the figure).
3b	If the drive has not ramped down fast enough when time A has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The SSE request is removed.
5	After the acknowledgement, the STO and SSE functions are deactivated. The indications go off.

SSE with ramp monitoring

The operation of the SSE with ramp monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with ramp monitoring* on page *288*.

Without an encoder



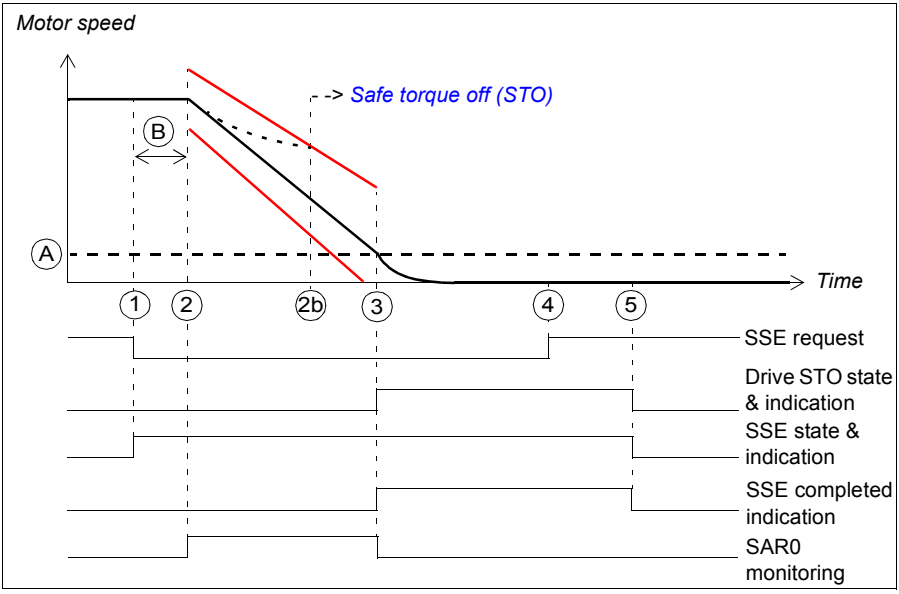
A Zero speed (parameter *FSOGEN.51*): Speed limit for activating the drive STO function. The safety function is completed, ramp monitoring is stopped and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

B Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
2b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The motor speed goes below the zero speed limit (B), the FSO stops the SAR0 monitoring and activates the drive STO function. The SSE completed indication goes on the acknowledgement becomes allowed as soon as the SSE request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. The SSE completed indication goes on after the delay defined with parameter *SBC.13* has elapsed from the SBC activation. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the drive STO function (not shown in the figure).
4	The SSE request is removed.
5	After the acknowledgement, the STO and SSE functions are deactivated and the control is given back to the drive, which can modulate again. The indications go off.

With an encoder



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit for activating the drive STO function. The safety function is completed, ramp monitoring is stopped and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

B Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time B has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
2b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The motor speed goes below the zero speed limit (A), the FSO stops the SAR0 monitoring and activates the drive STO function. The SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 4). **Note**: If the SBC is configured in the STO function (see section *Safe torque off (STO)* on page *57*), also the SBC is activated (not shown in the figure). • If the *STO SBC delay* (parameter *SBC.12*) is negative, the SBC is activated here and the drive STO after this delay. If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the drive STO function (not shown in the figure).
4	The SSE request is removed.
5	After the acknowledgement, the STO and SSE functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

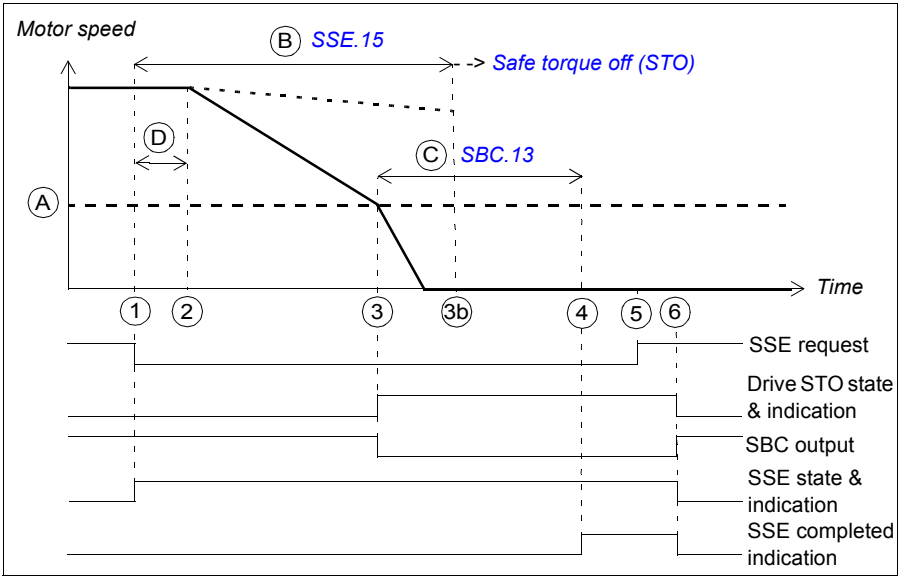
SSE with speed limit activated SBC

In these examples, the SBC and drive STO functions are activated at a user-defined speed limit.

With time monitoring

The operation of the SSE with speed limit activated SBC and time monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with speed limit activated SBC* on page *289*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates SBC (brake) and drive STO functions while ramping.

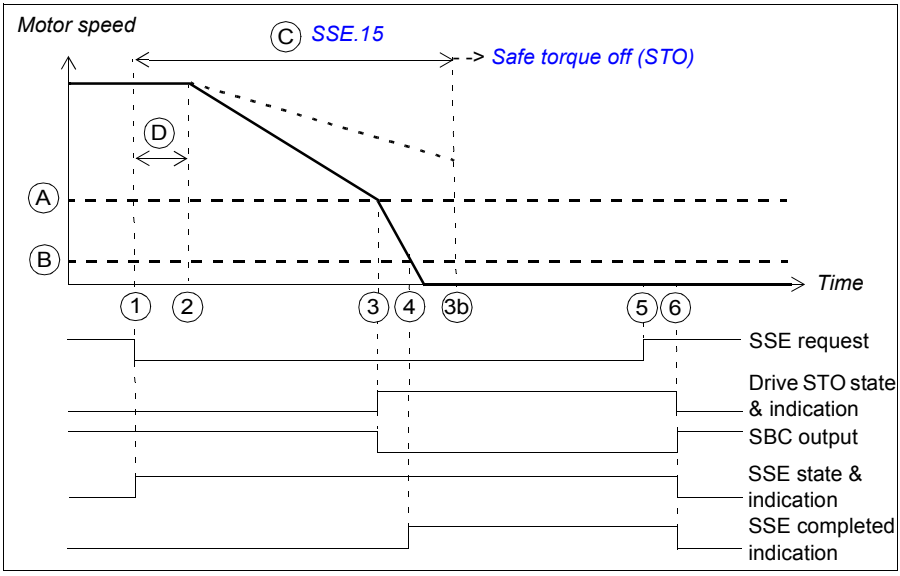
B SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the drive STO function regardless of the motor speed.

C SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

D Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time B.
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SSE with speed limit activated SBC, SBC before STO* on page *119*). The FSO starts a counter for time C. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the drive has not ramped down fast enough when time B has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO defines the motor as stopped, the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) and drive STO functions while ramping.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

C SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the STO function regardless of the motor speed.

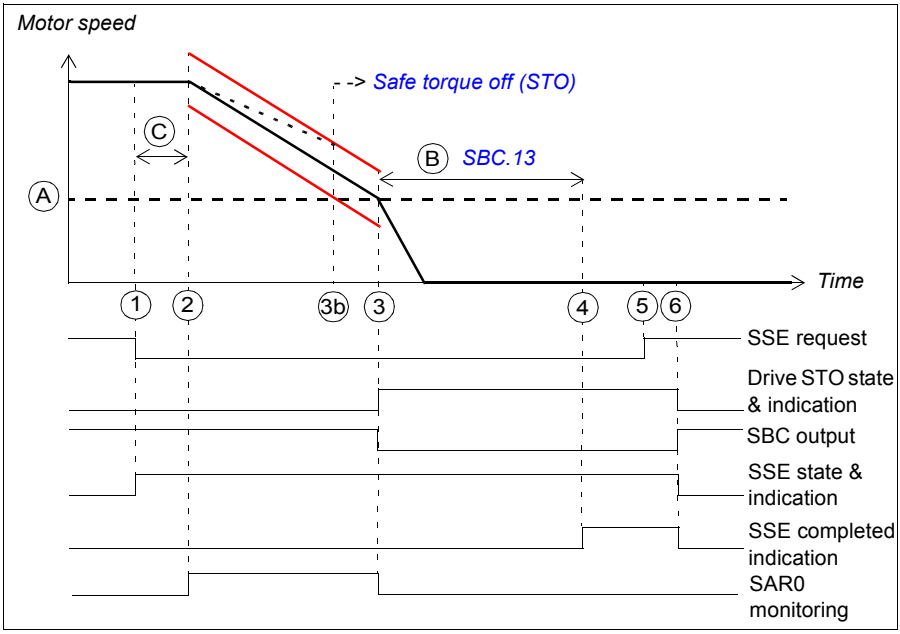
D Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time C.
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions:. • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SSE with speed limit activated SBC, SBC before STO* on page *119*). **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the drive has not ramped down fast enough when time C has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped, the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With ramp monitoring

The operation of the SSE with speed limit activated SBC and ramp monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with speed limit activated SBC* on page *289*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) and drive STO functions while ramping. The safety function is completed, the ramp monitoring is stopped and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

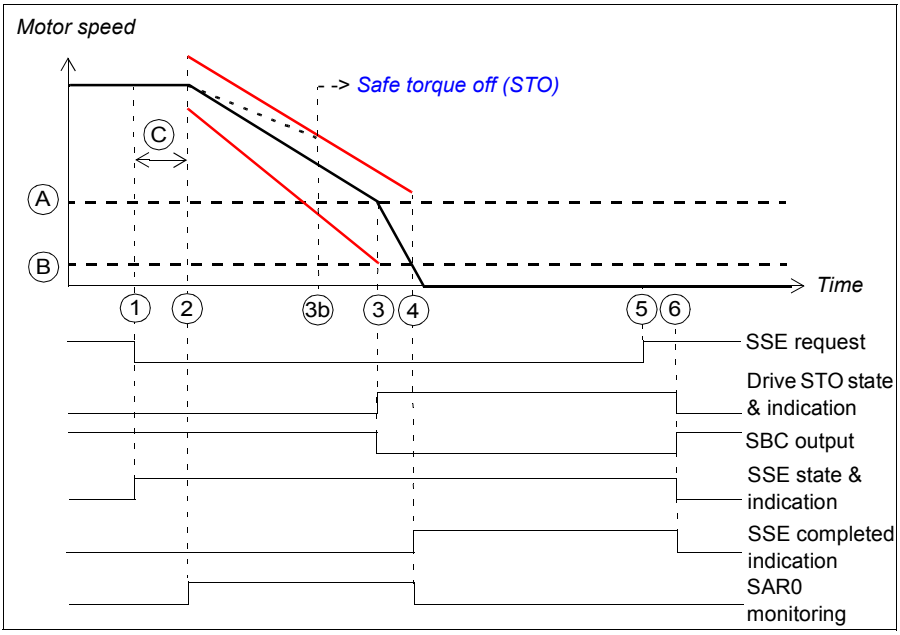
B SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

C Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
3	The motor speed goes below the SBC speed limit (A), the FSO stops the SAR1 monitoring. The FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SSE with speed limit activated SBC, SBC before STO* on page *119*.) The FSO starts a counter for time B. **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time B has elapsed, the FSO defines the motor as stopped, the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which FSO activates the SBC (brake) and drive STO functions while ramping and stops the ramp monitoring.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed, the ramp monitoring is stopped and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

C Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time C has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
3	The motor speed goes below the SBC speed limit (A). The FSO checks the value of *STO SBC delay* (parameter *SBC.12*) and activates the SBC and drive STO functions: • If the *STO SBC delay* is positive or zero, the SBC and drive STO functions are activated at the same time (this case is shown in the figure). • If the *STO SBC delay* is negative, the SBC is activated here and the drive STO after this delay (see section *SSE with speed limit activated SBC, SBC before STO* on page *119*). **Note**: You can define an extra delay (parameter *SSE.16*) before the FSO activates the SBC and drive STO functions (not shown in the figure).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped and the SSE completed indication goes on. The acknowledgement becomes allowed as soon as the SSE request has been removed (step 5). The FSO stops the SAR0 monitoring.
5	The SSE request is removed.
6	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

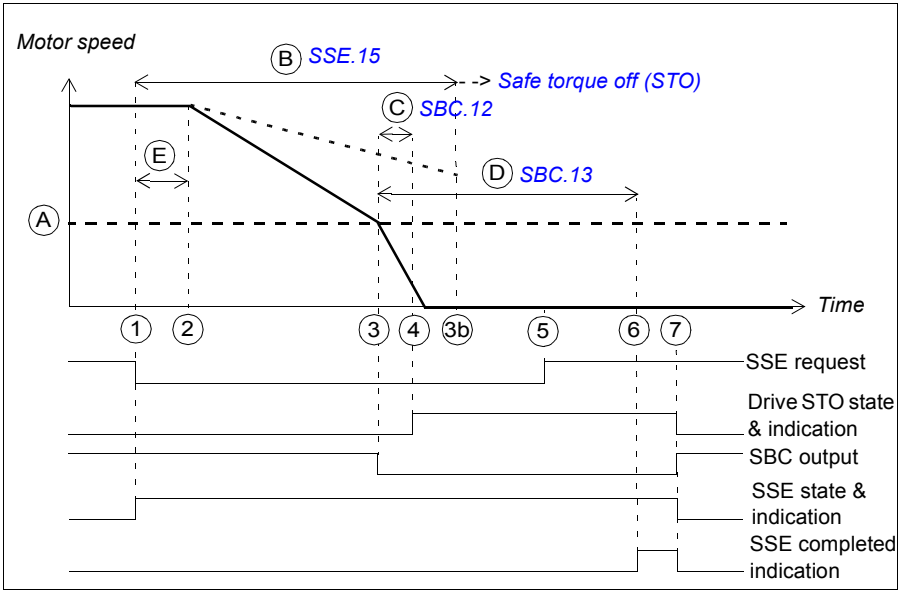
SSE with speed limit activated SBC, SBC before STO

In these examples, the SBC function is activated at a user-defined speed limit and drive STO function after a user-defined delay (negative SBC delay). The reason to use a negative SBC delay (parameter *SBC.12*) is to have the mechanical brake closed just before the drive STO circuit is opened.

With time monitoring

The operation of the SSE with speed limit activated SBC, SBC before STO and time monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with speed limit activated SBC, SBC before STO* on page *293*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC function (brake).

B SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the STO function regardless of the motor speed.

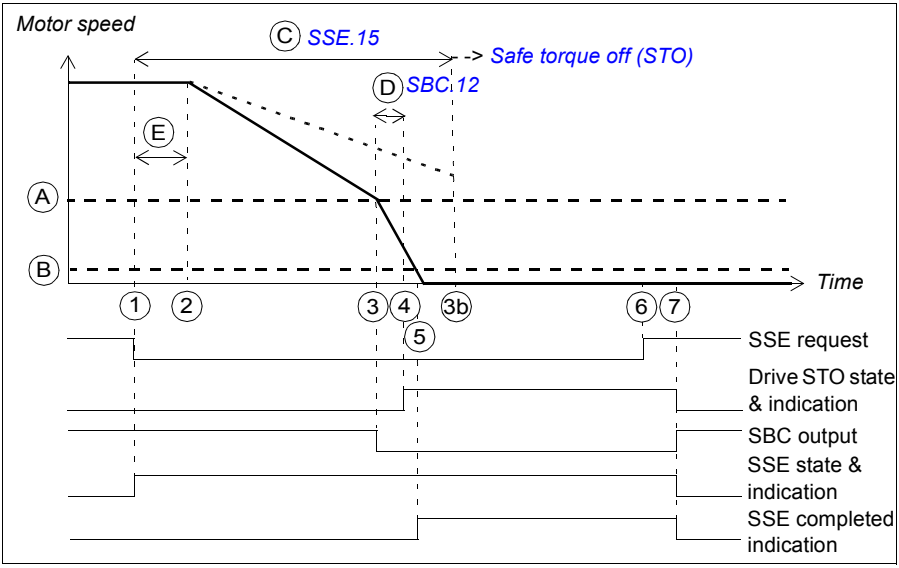
C SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

D SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

E Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time B.
2	After time E has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO activates SBC function. The FSO starts counters for times C and D. **Note**: You can define an extra delay (parameter *SSE.16*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the drive has not ramped down fast enough when time B has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO activates the drive STO function.
5	The SSE request is removed.
6	After time D has elapsed, the safety function is completed, the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
7	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC function (brake).

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

C SSE delay for STO (parameter *SSE.15*): Time after which the FSO activates the STO function regardless of the motor speed.

D SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

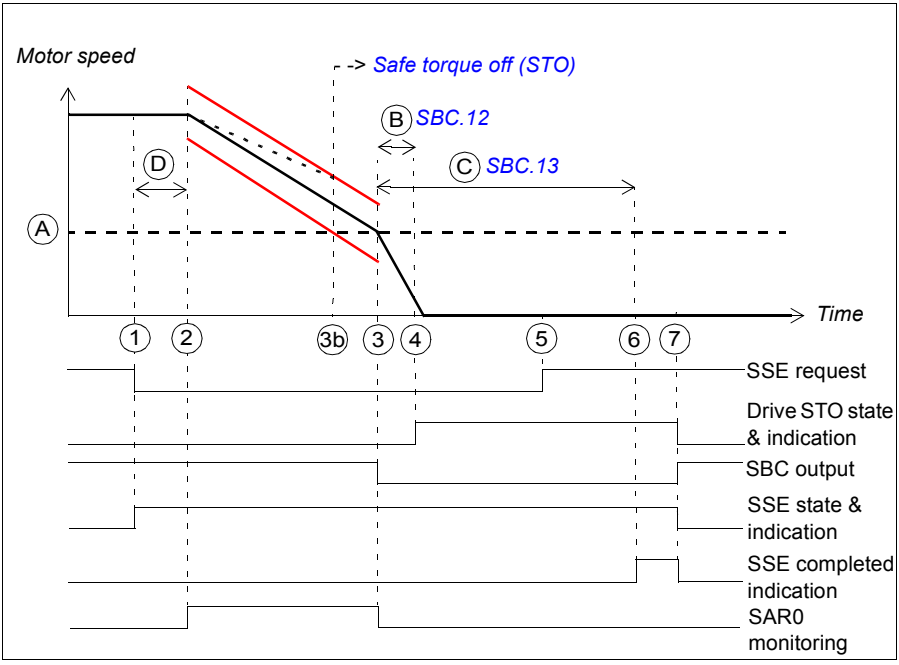
E Response time (depends on system configuration, see page *437*)

Step	Description
1	The SSE request is received (for example, from the I/O). The FSO starts a counter for time C.
2	After time E has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp.
3	The motor speed goes below the SBC speed limit (A), the FSO activates SBC function. The FSO starts counters for time D (parameter *SBC.12*). **Note**: You can define an extra delay (parameter *SSE.16*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the drive has not ramped down fast enough when time C has elapsed, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time D has elapsed, the FSO activates the drive STO function.
5	The motor speed goes below the zero speed limit (B), the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 6).
6	The SSE request is removed.
7	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With ramp monitoring

The operation of the SSE with speed limit activated SBC, SBC before STO and ramp monitoring is described in the time diagrams and tables below. For configuration, see section *How to configure SSE with speed limit activated SBC, SBC before STO* on page *293*.

Without an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which the FSO activates the SBC (brake) while ramping. The SAR0 ramp monitoring is stopped.

B SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

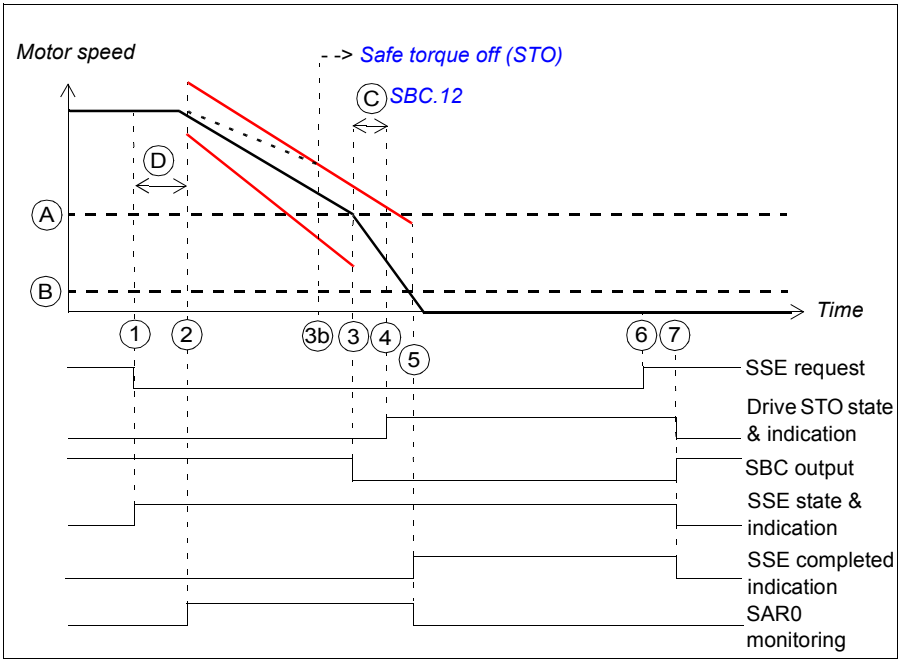
C SBC time to zero (parameter *SBC.13*): Time from the SBC activation to the moment when the safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed. You must set this to the estimated time in which the motor brakes to a stop from the maximum speed.

D Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
3	The motor speed goes below the SBC speed limit (A), the FSO stops the SAR0 monitoring and activates the SBC function. The FSO starts counters for times B and C. **Note**: You can define an extra delay (parameter *SSE.16*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time B has elapsed, the FSO activates the drive STO function.
5	The SSE request is removed.
6	After time C has elapsed, the FSO defines the motor as stopped, the SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 5).
7	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

With an encoder



A SBC speed (parameter *SBC.15*): Speed limit below which FSO activates the SBC function (brake) while ramping.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed, the SAR0 ramp monitoring is stopped and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

C SBC delay (parameter *SBC.12*): Time from the activation of the SBC function to the moment when the FSO activates the drive STO function.

D Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits

Step	Description
1	The SSE request is received (for example, from the I/O).
2	After time D has elapsed, the drive starts to ramp down the motor speed. SAR0 parameter *200.102* defines the deceleration ramp. The FSO starts the SAR0 ramp monitoring (parameters *SARx.11* and *SARx.12*).
3	The motor speed goes below the SBC speed limit (A). The FSO activates the SBC function. The FSO starts a counter for time C. **Note**: You can define an extra delay (parameter *SSE.16*, not shown in the figure) before the FSO activates the SBC function. This affects also the STO activation (step 4).
3b	If the motor speed hits a ramp monitoring limit, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
4	After time C has elapsed, the FSO activates the drive STO function.
5	The motor speed goes below the zero speed limit (B), the FSO defines the motor as stopped and stops the SAR0 monitoring. The SSE completed indication goes on and the acknowledgement becomes allowed as soon as the SSE request has been removed (step 6).
6	The SSE request is removed.
7	After the acknowledgement, the SSE, STO and SBC functions are deactivated and the control is given back to the drive, which is allowed to modulate again. The indications go off.

Safely-limited speed (SLS)

The SLS prevents the motor from exceeding user-defined speed limits. The drive limits the motor speed so that it stays between the SLS speed limits.

If the motor speed is above/below the user-defined SLS limit positive/negative when the SLS function is activated, the motor speed is first decelerated to the required speed. You can configure the SLS function to use either the time monitoring or ramp monitoring method when the motor speed is decelerated.

Time monitoring

If the motor speed does not reach the desired SLS speed limit within a given time (SLS time delay), the FSO starts to monitor the motor speed. If the motor speed is above/below the SLS trip limit positive/negative, the FSO activates the SSE function (see section *SLS with time monitoring and speed above monitored speed* on page *129*).

Ramp monitoring

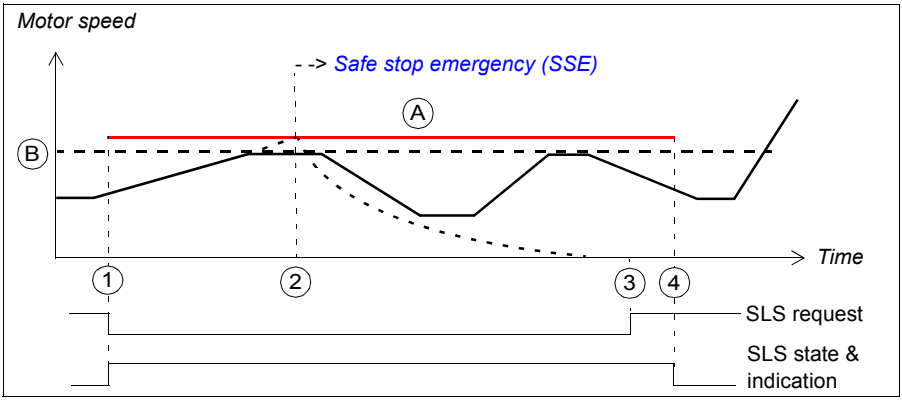
Ramp monitoring limits are given with five SAR parameters, which define a “window” within which the motor speed must stay during deceleration (see section *Ramp monitoring* on page *51*). If the motor speed reaches a ramp monitoring limit, the FSO module activates the STO function (see section *SLS with ramp monitoring and speed above monitored speed* on page *131*).

Note: If the SLS monitoring must be activated immediately after the SLS request, regardless of the current speed, time monitoring with a zero time delay (parameter *SLSx.04*) must be used instead of ramp monitoring.

When the SLS monitoring is active, the drive limits the motor speed, but if the motor speed still reaches the positive or negative SLS trip limit, the FSO module activates the SSE function (see section *SLS trip limit hits* on page *133*).

SLS with speed below monitored speed

This applies to both time and ramp monitoring.



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

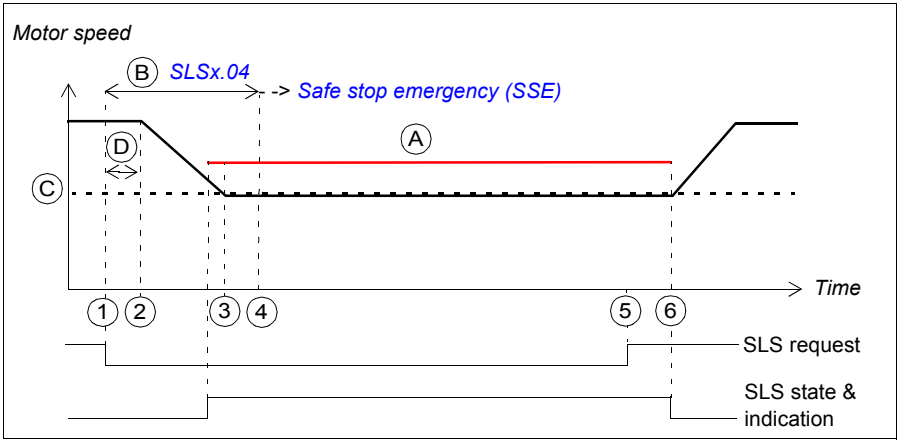
B SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

— SLS trip limit (A)

Step	Description
1	The SLS request is received. The motor speed is below the SLS limit positive (B) and the FSO starts the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on. The drive limits the motor speed so that it does not go above the SLS limit positive.
2	If the motor speed goes above the SLS trip limit positive (A), the FSO activates the SSE function and the motor coasts to a stop (in this case, the SSE function has been configured as “Immediate STO”, see section *SLS trip limit hits* on page *133*).
3	The SLS request is removed. The SLS monitoring is still on (acknowledgement method is manual or from a safety PLC). **Note**: If automatic acknowledgement is used, the SLS monitoring is also ended.
4	The SLS function is acknowledged and the FSO stops the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes off.

SLS with time monitoring and speed above monitored speed

The operation of the SLS function with time monitoring is described in the time diagram and table below. For configuration, see section *How to configure SLSn with time monitoring* on page *295*.



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

B SLS time delay (parameter *SLSx.04*): Delay for forcing to start SLS monitoring.

C SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

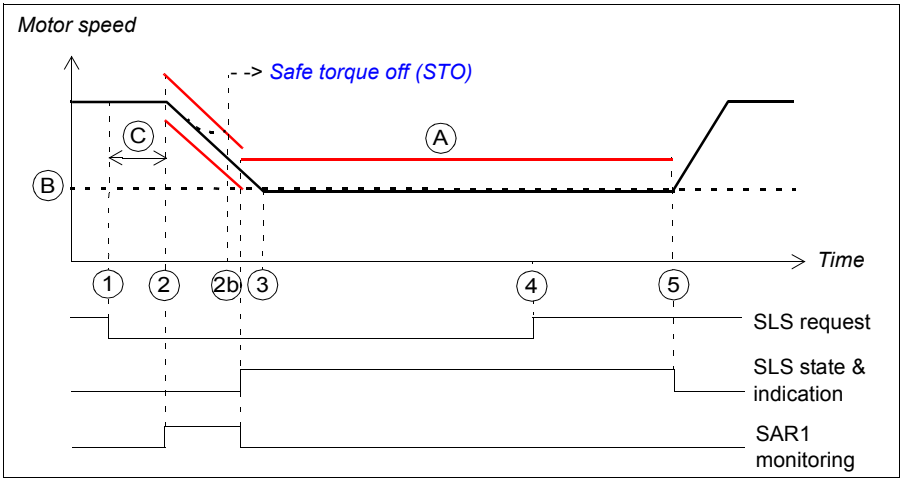
D Response time (depends on system configuration, see page *437*)

SLS trip limit (A)

Step	Description
1	The SLS request is received. The motor speed is above the SLS limit positive (C). The FSO starts to monitor the SLS time delay (B).
2	After time D has elapsed, the drive starts to ramp down the motor speed. The drive (parameter *23.13* or *23.15*) defines the deceleration ramp until the speed reaches the SLS limit positive (C). The FSO starts the SLS monitoring when the motor speed is in the middle of the SLS limit and the SLS trip limit (see also section *How to fine-tune when monitoring is started* on page *319*). The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on.
3	The motor speed reaches the SLS limit positive (C).
3-6	The drive limits the motor speed, but if the motor speed still goes above the SLS trip limit positive, the FSO activates the SSE function. See section *SLS trip limit hits* on page *133*.
4	The FSO starts the SLS monitoring at the latest here, that is, after the SLS time delay (B) has elapsed. **Note**: If the motor speed is above the SLS trip limit after the SLS time delay (B) has elapsed, the FSO module activates the SSE function. For more information, see section *SLS trip limit hits* on page *133*.
5	The SLS request is removed, but the SLS monitoring is still on (acknowledgement method is manual or from a safety PLC). **Note**: If automatic acknowledgement is used, the SLS monitoring is also ended.
6	The SLS function is acknowledged and FSO stops the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes off.

SLS with ramp monitoring and speed above monitored speed

The operation of the SLS function with ramp monitoring is described in the time diagram and table below. For configuration, see section *How to configure SLSn with ramp monitoring* on page *297*.



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

B SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

C Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits or SLS trip limit (A)

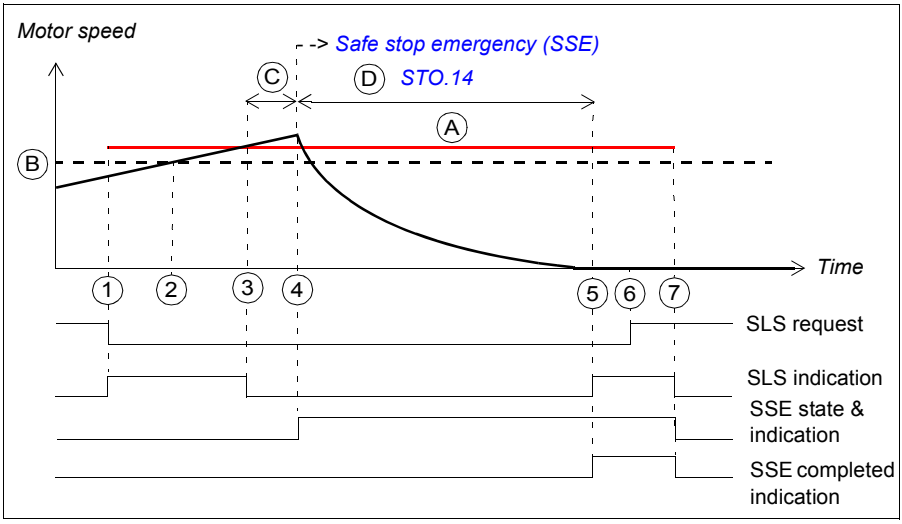
Step	Description
1	The SLS request is received. The motor speed is above the SLS limit positive (B).
2	After time C has elapsed, the drive starts to ramp down the motor speed. The SAR1 parameter *200.112* defines the deceleration ramp until the speed reaches the SLS limit positive (B). The FSO starts the SAR1 ramp monitoring (parameters *SARx.21*, *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp. The FSO starts the SLS monitoring when the motor speed is in the middle of the SLS limit and the SLS trip limit (see also section *How to fine-tune when monitoring is started* on page *319*), and stops the SAR1 monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on.
2b	If the motor speed does not follow the ramp monitoring limits, the FSO activates the STO function. See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The motor speed reaches the SLS limit positive (B).
3-5	The drive limits the motor speed, but if the motor speed still goes above the SLS trip limit positive, the FSO activates the SSE function. For more information, see section *SLS trip limit hits* on page *133*.
4	The SLS request is removed, but the SLS monitoring is still on (acknowledgement method is manual or from a safety PLC). **Note**: If automatic acknowledgement is used, the SLS monitoring is also ended.
5	The SLS function is acknowledged and the FSO stops the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes off.

SLS trip limit hits

If the motor speed goes above/below an SLS trip limit, the FSO activates the SSE function. The operation of SLS and SSE indications in SLS trip limit hit situations are described in the diagrams and tables below. For more information on the SSE function, see section *Safe stop emergency (SSE)* on page *93*.

SSE with immediate STO, without an encoder

This applies when the SSE function has been configured as “Immediate STO”.



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

B SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

C Response time (depends on system configuration, see page *437*)

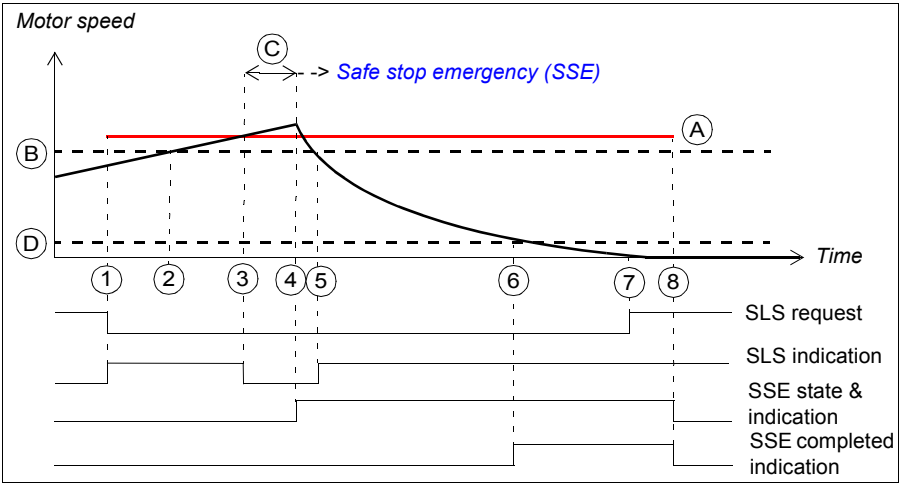
D Time to zero speed (parameter *STO.14*)

— SLS trip limit (A)

Step	Description
1	The SLS request is received, the motor speed is below the SLS limit positive (B) and the FSO starts the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on.
2	The motor speed goes above the SLS limit positive (B).
3	The motor speed reaches the SLS trip limit positive (A). The SLS indication goes off.
4	After time C has elapsed, the FSO activates the SSE function, opens the drive STO circuit and the motor coasts to a stop.
5	After time D has elapsed, the motor has stopped and the SLS indication goes on (speed is below the SLS limit positive). The SSE completed indication goes on. **Note**: If the SBC is configured in the SSE function, parameter *SBC.13* is used here instead of *STO.14*.
6	The SLS request is removed. The SLS monitoring is still on (acknowledgement method is manual or from a safety PLC).
7	The SLS function is acknowledged and the FSO stops the SLS monitoring. The SSE function is acknowledged with the same acknowledgement. The indications go off.

SSE with immediate STO, with an encoder

This applies when the SSE function has been configured as “Immediate STO” and an encoder is used.



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

B SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

C Response time (depends on system configuration, see page *437*)

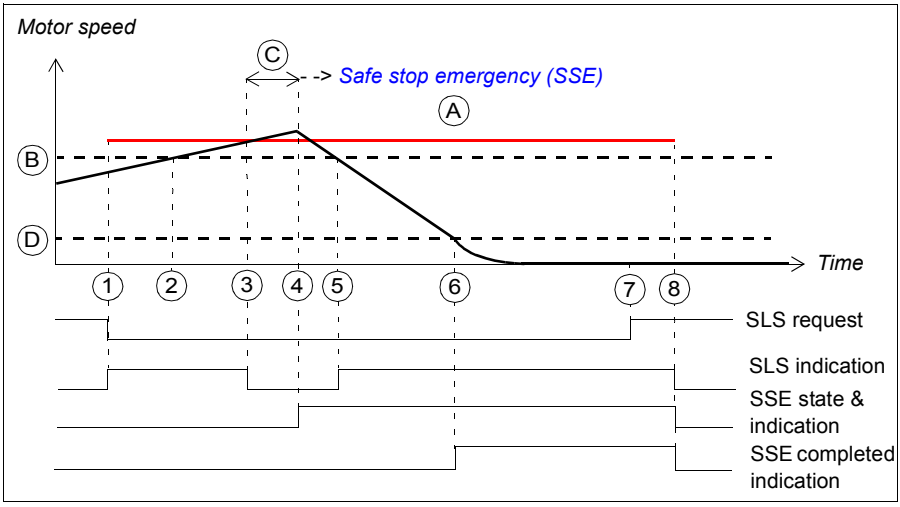
D Zero speed limit (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

SLS trip limit (A)

Step	Description
1	The SLS request is received, the motor speed is below the SLS limit positive (B) and the FSO starts the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on.
2	The motor speed goes above the SLS limit positive (B).
3	The motor speed reaches the SLS trip limit positive (A). The SLS indication goes off.
4	After time C, the FSO activates the SSE function, opens the drive STO circuit and the motor coasts to a stop.
5	The motor speed goes below the SLS limit positive (B). The SLS indication goes on.
6	The motor speed goes below the zero speed limit (D). The motor has stopped and the SSE completed indication goes on.
7	The SLS request is removed. The SLS monitoring is still on (acknowledgement method is manual or from a safety PLC).
8	The SLS function is acknowledged and the FSO stops the SLS monitoring. The SSE function is acknowledged with the same acknowledgement. The indications go off.

SSE with emergency ramp

This applies when the SSE function has been configured as “Emergency ramp” (with ramp monitoring or time monitoring).



A SLS trip limit positive (parameter *SLSx.14*, *SLSx.23*, *SLSx.33* or *SLSx.43*)

B SLS limit positive (parameter *200.23*, *200.33*, *200.43* or *200.53*)

C Response time (depends on system configuration, see page *437*)

D Zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The acknowledgment becomes allowed.

— SLS trip limit (A)

Step	Description
1	The SLS request is received, the motor speed is below the SLS limit positive (B) and the FSO starts the SLS monitoring. The SLS indication (parameter *SLSx.15*, *SLSx.24*, *SLSx.34* or *SLSx.44*) goes on.
2	The motor speed goes above the SLS limit positive (B).
3	The motor speed reaches the SLS trip limit positive (A). The SLS indication goes off.
4	After time C has elapsed, the FSO activates the SSE function and the drive starts the ramp down the motor speed. SAR0 parameter *200.102* defines the ramp.
5	The motor speed goes below the SLS limit positive (B) and the SLS indication goes on.
6	The motor speed goes below the zero speed limit (D). The motor has stopped and the FSO opens the drive STO circuit. The SSE completed indication goes on.
7	The SLS request is removed. The SLS monitoring is still on (acknowledgement method is manual or from a safety PLC).
8	The SLS function is acknowledged and the FSO stops the SLS monitoring. The SSE function is acknowledged with the same acknowledgement. The indications go off.

Variable Safely-limited speed (SLS)

This safety function requires that a safety PLC is connected to the FSO module via the PROFIsafe communication bus. For more information, see chapter *PROFIsafe*.

The SLS function prevents the motor from exceeding user-defined speed limits. With the Variable SLS function, the speed limits can be changed on the fly. The speed limits are controlled from a safety PLC via the PROFIsafe communication bus.

If the motor speed reaches the positive or negative SLS trip limit, the FSO module activates the SSE function (see section *SLS trip limit hits* on page *133*). If the motor speed reaches a ramp monitoring limit during deceleration, the FSO module activates the STO function. If the motor speed reaches a time monitoring limit during deceleration, the FSO module starts to monitor the speed and if it is above/below the SLS trip limit positive/negative, the FSO activates the SSE function.

Also a “non-variable” SLS function and the SMS function can be active at the same time with the Variable SLS function. In this case, the FSO module monitors all limits and limits the motor speed according to the lowest speed limit.

The safety PLC sends the Variable SLS request to the FSO module in a PROFIsafe message. The message includes a scaling value as a percentage (%). The scaling value is used to scale the original SLS and trip limits (SLS4 parameters) to new, scaled values. The FSO module uses these scaled values until a new scaling value is received the safety PLC.

The Variable SLS limits cannot be scaled above the SLS4 limits.

In the PROFIsafe message, the bits that are used to configure the Variable SLS function are:

- Positive_Scaling: defines whether the positive SLS limits are scaled or not.
- Negative_Scaling: defines whether the negative SLS limits are scaled or not.
- Variable_SLS_limit (MSB and LSB): defines the scaling value. For example, if the value set in Variable_SLS_limit = 5000, the scaling value is 50%.

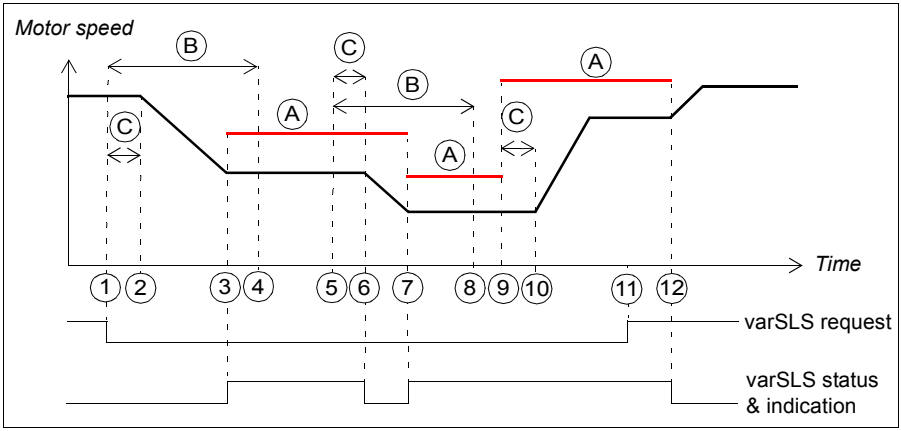
The same scaling value is applied to both the positive and the negative limits. For more information, see section *ABB_PS1 profile F-Output user data* on page *167*.

For more information on how the FSO module defines the scaled limits, see section *Defining the scaled SLS4 limit and SLS4 trip limits* on page *303*.

Variable SLS with time monitoring

In Variable SLS with time monitoring, the ramp according to which the drive decelerates the motor to different speeds is monitored using the time monitoring method. Drive parameters define the deceleration ramp. If the motor speed is accelerated, drive parameters define the acceleration ramp and it is not monitored.

For configuration, see section *How to configure Variable SLS with time monitoring* on page *299*.



A Variable SLS trip limits (parameter *SLSx.43* and the scaling values set in the safety PLC)

B SLS time delay (parameter *SLSx.04*): Delay for forcing to start SLS monitoring.

C Response time (depends on system configuration, see page *437*)

— Variable SLS trip limit (A)

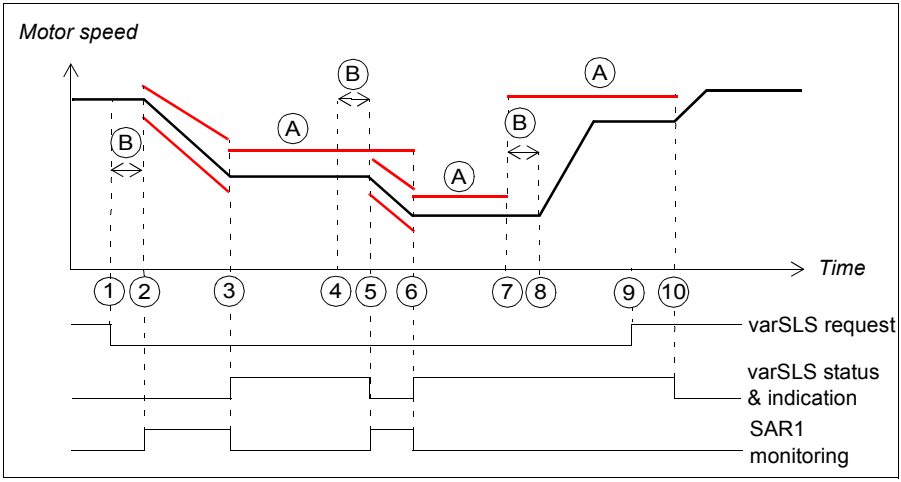
Step	Description
1	The Variable SLS request is received from the safety PLC (for example, 70%). The FSO sends a request to the drive to ramp down the motor speed to the new SLS speed limit. The FSO start a counter for the SLS time delay (B).
2	After time C has elapsed, the drive starts to ramp down the motor speed. The drive (parameter *23.13* or *23.15*) defines the deceleration ramp. The FSO starts the SLS monitoring when the motor speed is in the middle of the new SLS limit and the SLS trip limit (see also section *How to fine-tune when monitoring is started* on page *319*).
3	The new motor speed has been reached. The Variable SLS indication (parameter *SLSx.51*) goes on.
4	The FSO starts the SLS monitoring at the latest here, that is, after the SLS time delay (B) has elapsed. **Note**: If the motor speed is above the SLS trip limit after the SLS time delay (B) has elapsed, the FSO module activates the SSE function. For more information, see section *SLS with time monitoring and speed above monitored speed* on page *129*.

Step	Description
5	The Variable SLS request is received again from the safety PLC (for example, 50%). The FSO sends a request to the drive to ramp down the motor speed to the new speed limit. The FSO starts a counter for the SLS time delay (B). **Note**: The FSO continues to monitor the existing Variable SLS limits until the new speed limit has been reached.
6	After time C has elapsed, the drive starts to ramp down the motor speed. Drive parameters define the deceleration ramp. The Variable SLS indication goes off (see also section *How to fine-tune limit hit situations* on page *314*). The FSO starts the SLS monitoring when the motor speed is in the middle of the new SLS limit and the SLS trip limit (see also section *How to fine-tune when monitoring is started* on page *319*).
7	The new motor speed has been reached. The SLS indication goes on.
8	The FSO starts the SLS monitoring with the new SLS limits at the latest here, that is, after the SLS time delay (B) has elapsed.
9	The Variable SLS request is received again from the safety PLC (100%). The FSO sends a request to the drive to accelerate the motor speed to the new speed limit. The FSO starts to monitor the motor speed according to the new SLS limits when the motor speed is in the middle of the SLS limit and SLS trip limit.
10	After time C has elapsed and if the motor speed is lower than the new speed limit, the drive accelerates the motor speed to the requested speed.
11	The Variable SLS request is removed from the safety PLC (acknowledgement method is manual or from a safety PLC). **Note**: If automatic acknowledgement is used, the Variable SLS monitoring is also ended.
12	The Variable SLS is acknowledged, the FSO stops the SLS monitoring and the drive continues with the speed reference set by the user. The Variable SLS indication (parameter *SLSx.51*) goes off.

Variable SLS with ramp monitoring

In Variable SLS with ramp monitoring, the ramp according to which the drive decelerates the motor to different speeds is monitored using the ramp monitoring method (SAR1 parameters of the FSO module). Drive or SAR1 parameters define the deceleration ramp. If the motor speed is accelerated, drive parameters define the acceleration ramp and it is not monitored.

For configuration, see section *How to configure Variable SLS with ramp monitoring* on page *299*.



A Variable SLS trip limits (parameter *SLSx.43* and the scaling values set in the safety PLC)

B Response time (depends on system configuration, see page *437*)

— Ramp monitoring limits or Variable SLS trip limit (A)

Step	Description
1	The Variable SLS request is received from the safety PLC (for example, 70%). The FSO sends a request to the drive to ramp down the motor speed to the new speed limit.
2-3	After time B has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts to monitor the ramp according to SAR1 parameters (*SARx.21*, *SARx.22*). **Note:** If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp. **Note**: If the motor speed does not follow the ramp, the FSO activates the STO function. The FSO starts the SLS monitoring when the motor speed is in the middle of the new SLS limit and the SLS trip limit (see also section *How to fine-tune when monitoring is started* on page *319*).
3	The new motor speed has been reached. The Variable SLS indication (parameter *SLSx.51*) goes on.

Step	Description
4	The Variable SLS request is received again from the safety PLC (for example, 50%). The FSO sends a request to the drive to ramp down the motor speed to the new speed limit.
5	After time B has elapsed, the drive starts to ramp down the motor speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO starts to monitor the ramp with SAR1 parameters (*SARx.21*, *SARx.22*). The Variable SLS indication goes off (see also section *How to fine-tune limit hit situations* on page *314*). **Note**: The FSO continues to monitor the existing Variable SLS limits until the new speed limit has been reached.
6	The new motor speed has been reached and the FSO starts to monitor the motor speed according to the new SLS limits. The Variable SLS indication goes on.
7	The Variable SLS request is received again from the safety PLC (100%). The FSO sends a request to the drive. The FSO starts to monitor the motor speed according to the new SLS limits.
8	After time B has elapsed and if the motor speed is lower than the new speed limit, the drive accelerates the motor speed to the requested speed.
9	The Variable SLS request is removed from the safety PLC (acknowledgement method is manual or from a safety PLC). **Note**: If automatic acknowledgement is used, the Variable SLS monitoring is also ended.
10	The Variable SLS is acknowledged and the FSO stops the SLS monitoring. The drive continues with the speed reference set by the user. The Variable SLS indication (parameter *SLSx.51*) goes off.

Safe maximum speed (SMS)

The SMS function is used to protect the machine from too high speeds/frequencies. You can configure it to be permanently on or off. There are two different versions of the SMS function:

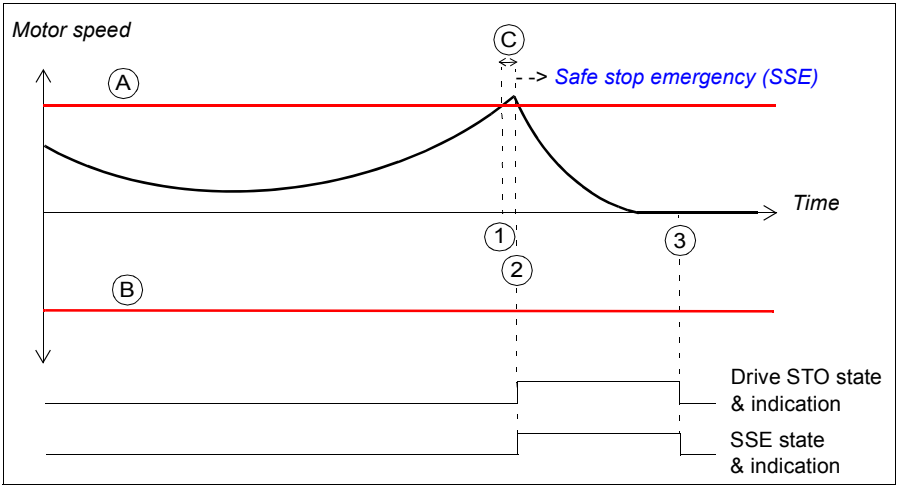
1. **Version 1**: If the motor speed reaches the minimum or the maximum SMS trip limit, the FSO module activates the SSE function.
2. **Version 2**: The minimum and maximum SMS limits limit the motor speed. This version of the SMS function is similar to the SLS function except that it can only be permanently on or off.

The required SMS function is selected with an FSO parameter at the start-up.

You can configure the minimum and maximum SMS and SMS trip limits separately.

SMS function, version 1

The operation of the SMS function, version 1 is described in the time diagram and table below. For configuration, see section *How to configure SMS, version 1* on page *306*.



A SMS trip limit positive (parameter *SMS.14*)

B SMS trip limit negative (parameter *SMS.13*)

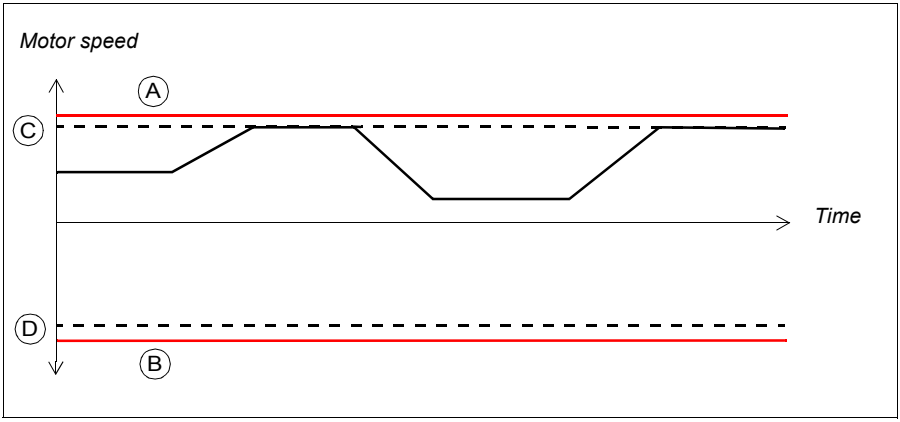
C Response time (depends on system configuration, see page *437*)

— SMS trip limits (A and B)

Step	Description
1	The motor speed reaches the SMS trip limit positive (A).
2	After time C has elapsed, the FSO activates the SSE function. In this case, the SSE function has been configured as “Immediate STO” (parameter *SSE.13*). This opens the drive STO circuit immediately and the motor coasts to a stop. The STO and SSE indications go on. **Note**: If SBC is used, it is also activated (see the note on page *42*). See section *Safe stop emergency (SSE)* on page *93* for more information on how to configure the SSE function.
3	After the SSE function has been completed, the FSO acknowledges the SSE function (in this case, automatic acknowledgement is used) and deactivates the SSE and drive STO functions. The indications go off.

SMS function, version 2

The operation of the SMS function, version 2 is described in the time diagram and table below. For configuration, see section *How to configure SMS, version 2* on page *307*.



A	SMS trip limit positive (parameter *SMS.14*)
B	SMS trip limit negative (parameter *SMS.13*)
C	SMS limit positive (parameter *200.73*)
D	SMS limit negative (parameter *200.72*)
—	SMS trip limits (A and B)

The drive limits the motor speed so that it stays between the SMS limit positive and negative. If the motor speed stills hits the SMS trip limit positive or negative, the FSO module activates the SSE function (see section *Safe stop emergency (SSE)* on page *93* for more information on how to configure the SSE function).

Note: If you use the SMS function, version 2 and you have to remove the FSO module from the drive, do these steps:

1. Re-configure the FSO module so that the SMS function, version 2 is deactivated (set parameter *200.71 SMS activity and version* to *Disabled*). For more information, see chapter *Configuration*.
2. Remove the FSO module from the drive.

This removes the SMS limits from the drive. Unnecessary limits can affect the normal operation of the drive.

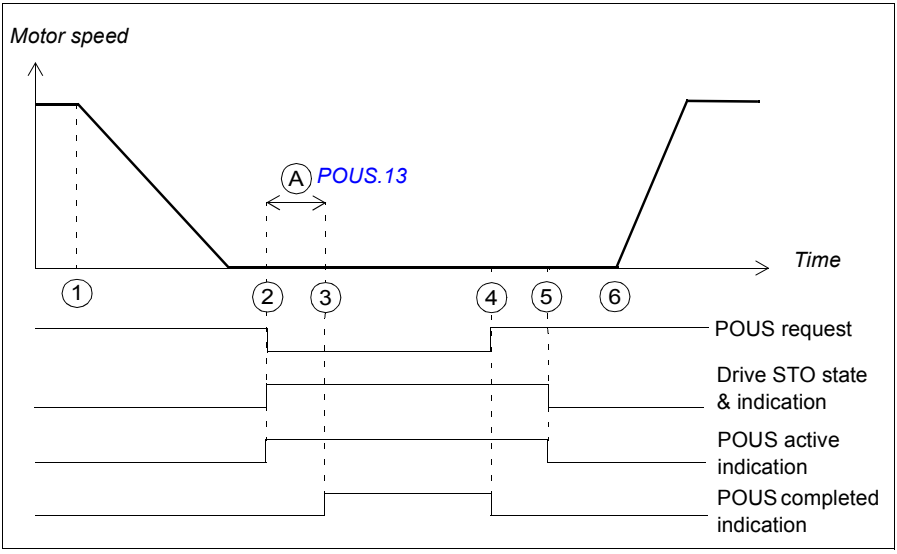
Prevention of unexpected start-up (POUS)

The POUS function prevents the machine from starting unexpectedly. The POUS function activates the Safe torque off (STO) function in the drive.

WARNING! The situations in which you can use the POUS function must always be based on a risk assessment (see IEC 60204-1:2016).

For more information on the STO function in the ACS880 drives, see the drive hardware manual.

The operation of the POUS function is described in the time diagram and table below. For configuration, see section *Configuring POUS* on page *308*.



A POUS delay for completion (parameter *POUS.13*): An additional security delay. The POUS completed indication (parameter *POUS.22*) goes on after this delay.

Step	Description
1	The user stops the motor.
2	The user activates the POUS function. The FSO activates the drive STO function and starts a counter for time A. The POUS active indication (parameter *POUS.21*) and the STO output indication (parameter *STO.21*) become active. **Note**: If the user activates the POUS function when the motor is running, the FSO activates the drive STO function, generates a fault (7A97) and the motor coasts to a stop.
3	After time A has elapsed, the POUS completed indication becomes active (parameter *POUS.22*). **Note**: Connect the POUS indication lamp to this indication signal.
4	The user removes the POUS request. The POUS completed indication is deactivated. The acknowledgement becomes allowed. **Note**: If the user activates the POUS request again before the POUS function has been acknowledged, the counter for time A is restarted and the POUS completed indication is activated after this delay.
5	The user acknowledges the POUS function. The POUS active indication goes off. The FSO deactivates the drive STO function and the user can restart the motor. **Note**: If automatic acknowledgement is used, this happens already when the POUS request is removed (step 4).
6	The user starts the motor.

Safe speed monitor (SSM)

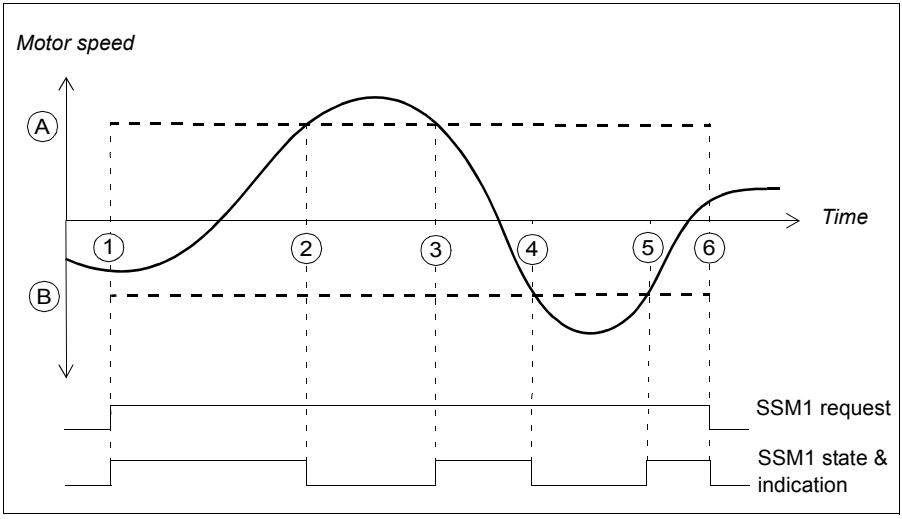
The SSM function provides a safe output signal to indicate whether the motor speed is between user-defined limits. There are four separate SSM functions (SSM1...SSM4) with separate monitoring limits and indications. Several SSM functions can be active at the same time.

You can configure the SSM function to be permanently on or off, or to be activated externally from the FSO module I/O or from a safety PLC.

You can use the SSM function with or without an encoder. With an encoder, the FSO module is always aware of the exact motor speed. Without an encoder, the speed information is valid only when the drive is modulating (see section *SSM without an encoder* on page *149*).

Note: If there is a fault in the speed data and the SSM function is the only active safety function, this does not trip the drive. This only removes the SSM indication and generates a warning to the drive.

The operation of the SSM function is described in the time diagrams and tables below. The SSM1 function is used as an example. For configuration, see section *Configuring SSM* on page *309*.



A SSM1 limit positive (parameter *SSMx.13*)

B SSM1 limit negative (parameter *SSMx.12*)

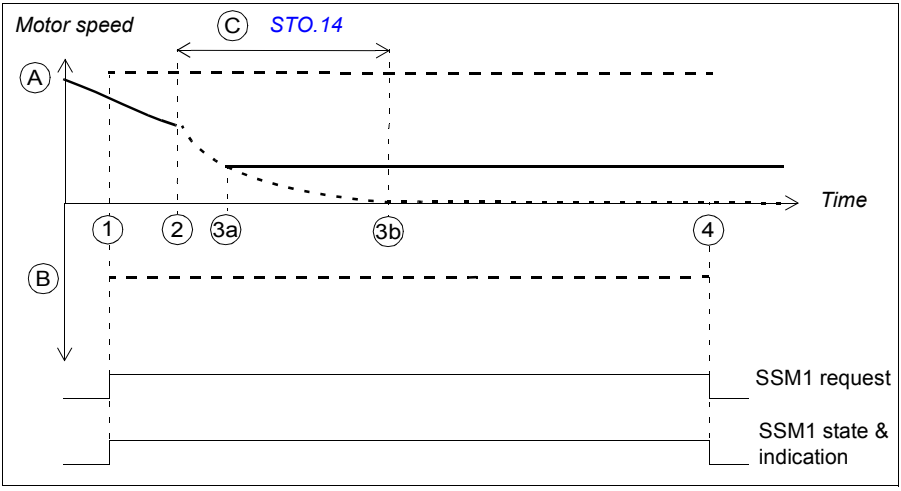
▪▪▪ SSM limits (A and B)

Step	Description
1	The SSM1 request is received (for example, from the I/O) and the FSO starts the SSM1 monitoring. The motor speed is between the SSM1 limit positive (A) and SSM1 limit positive (B). The SSM1 indication goes on.
2	The motor speed goes above the SSM1 limit positive (A), the SSM1 indication goes off.
3	The motor speed goes below the SSM1 limit positive (A), the SSM1 indication goes on.
4	The motor speed goes below the SSM1 limit negative (B), the SSM1 indication goes off.
5	The motor speed goes above the SSM1 limit negative (B), the SSM1 indication goes on.
6	The SSM1 request is removed and the FSO stops the SSM1 monitoring. The SSM1 indication goes off.

SSM without an encoder

This section describes situations when an encoder is not used and the drive stops modulating when the SSM monitoring is on.

Case A: This applies when the drive stops modulating after the SSM monitoring limit has been reached.



A SSM1 limit positive (parameter *SSMx.13*)

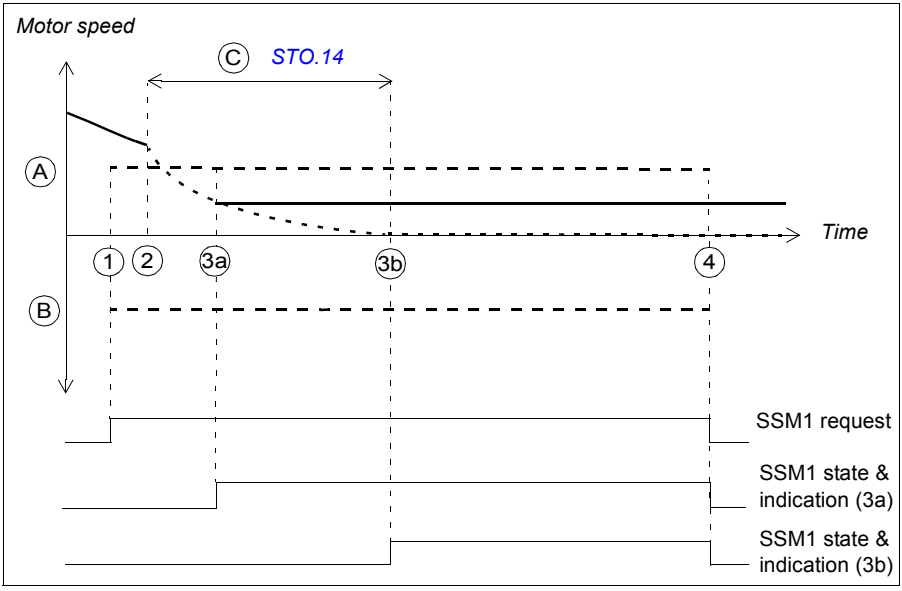
B SSM1 limit negative (parameter *SSMx.12*)

C Time to zero speed (parameter *STO.14*): When the drive stops modulating, the state of the SSM1 indication becomes valid after this delay.

▪ ▪ ▪ SSM limits (A and B)

Step	Description
1	The SSM1 request is received (for example, from the I/O) and the FSO starts the SSM1 monitoring. The motor speed is between the SSM1 limit positive (A) and SSM1 limit positive (B). The SSM1 indication goes on.
2	The drive stops modulating and the FSO starts a counter for time C. The motor speed starts to decelerate. While the drive is not modulating, the state of the FSO outputs is based on the latest speed information from modulation.
3a	The drive starts to modulate again and the FSO sees the actual motor speed again. The motor speed is between the SSM1 limit positive (A) and SSM1 limit positive (B), and the SSM1 indication stays on.
3b	Time C has elapsed, but the drive is still not modulating. The FSO assumes that the motor has stopped. The motor speed is still between the SSM1 limit positive (A) and SSM1 limit positive (B), and the SSM1 indication stays on.
4	SSM1 request is removed and the FSO stops the SSM1 monitoring. The SSM1 indication goes off.

Case B: This applies when the drive stops modulating before the SSM monitoring limit has been reached.



A SSM1 limit positive (parameter *SSMx.13*)

B SSM1 limit negative (parameter *SSMx.12*)

C Time to zero speed (parameter *STO.14*): When the drive stops modulating, the state of the SSM1 indication becomes valid after this delay.

▪ ▬ ▪ SSM limits (A and B)

Step	Description
1	The SSM1 request is received (for example, from the I/O) and the FSO starts the SSM1 monitoring. The motor speed is not between the SSM1 limit positive (A) and SSM1 limit positive (B). The SSM1 indication is off.
2	The drive stops modulating and the FSO starts a counter for time C. The motor speed starts to decelerate. While the drive is not modulating, the state of the FSO outputs is based on the latest speed information from modulation.
3a	The drive starts to modulate again and the FSO sees the actual motor speed again. The motor speed is between the SSM1 limit positive (A) and SSM1 limit positive (B), and the SSM1 indication goes on.
3b	Time C has elapsed, but the drive is still not modulating. The FSO assumes that the motor has stopped. The motor speed is still between the SSM1 limit positive (A) and SSM1 limit positive (B) and the SSM1 indication goes on.
4	The SSM1 request is removed and the FSO stops the SSM1 monitoring. The SSM1 indication goes off.

Safe direction (SDI)

This safety function requires that you use an encoder in the safety application.

The SDI function monitors that the motor rotates into the correct direction. There are separate functions to monitor the positive and negative directions. You can activate them separately.

The SDI functions can be configured to be always on or off, or to be activated externally from the FSO module I/O or from a safety PLC.

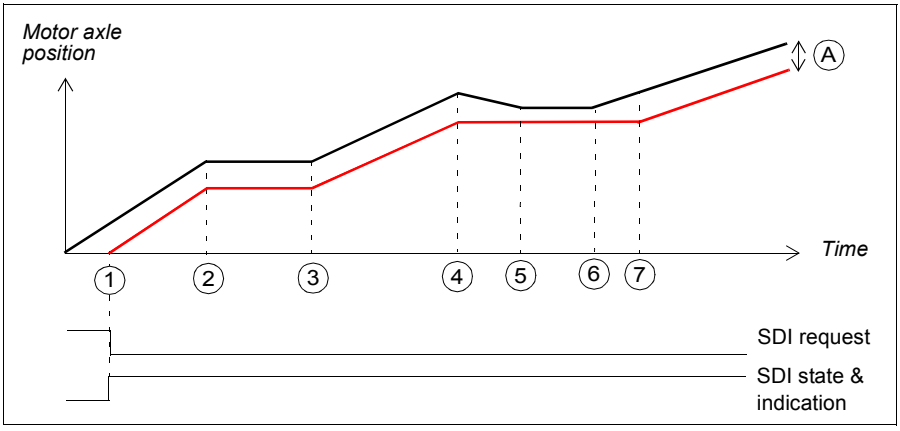
When the SDI function is active, the drive limits the speed reference so that the user cannot set it to the forbidden direction. If the motor rotates into the forbidden direction more than the user-defined SDI tolerance limit allows, the FSO module activates the SSE function and the motor stops.

If the motor does not rotate in the correct direction when the SDI function is activated, the motor speed is first decelerated to zero speed. You can configure the SDI function to use either the time monitoring or ramp monitoring method when the motor speed is decelerated. After the user has given a new speed reference, the motor starts to rotate to the correct direction.

SDI with correct rotation direction

This applies when the motor rotates into the correct direction when the SDI function is activated. The SDI positive function is used as an example.

Note: This diagram shows the position of the motor axle (not the motor speed).



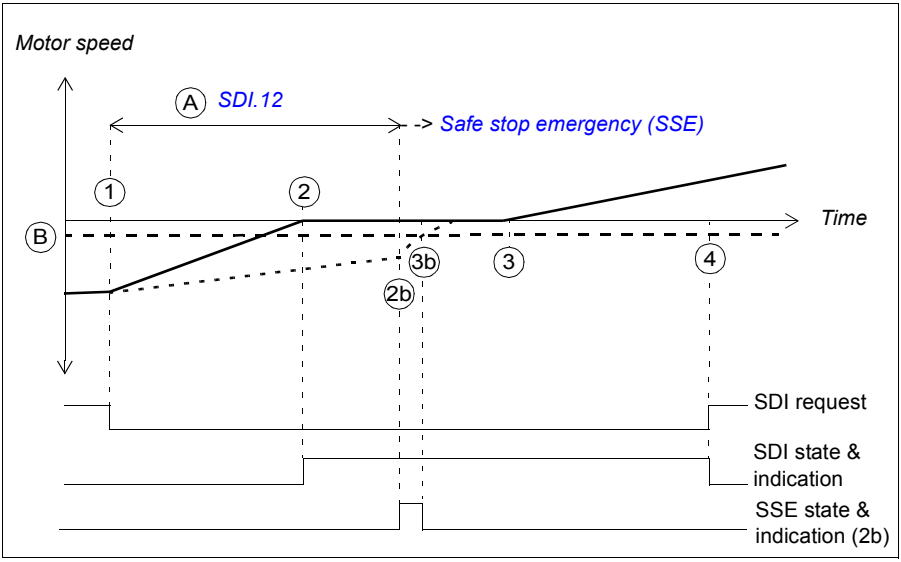
A SDI tolerance limit degree (parameter *SDI.14*): The motor axle cannot move to the forbidden direction more than defined with this parameter.

SDI monitoring limit

Step	Description
1	The SDI positive request is received (for example, from the I/O) and the FSO starts the SDI monitoring. The SDI indication goes on. The motor rotates to the correct direction (in this case, positive).
2	The motor stops.
3	The motor starts to rotate again (into the positive direction).
4	The rotation direction of the motor changes to the forbidden (negative) direction. The FSO locks the SDI tolerance limit degree (A) into its current position.
5	The motor stops before the SDI tolerance limit (A) is reached.
6	The motor starts to rotate again (into the positive direction).
7	The motor continues to rotate to the correct direction and the SDI tolerance limit degree (A) is update to its original value.

SDI with time monitoring

This applies when the motor rotates into the forbidden direction when the SDI function is activated and the time monitoring method is used. The SDI positive function is used as an example.



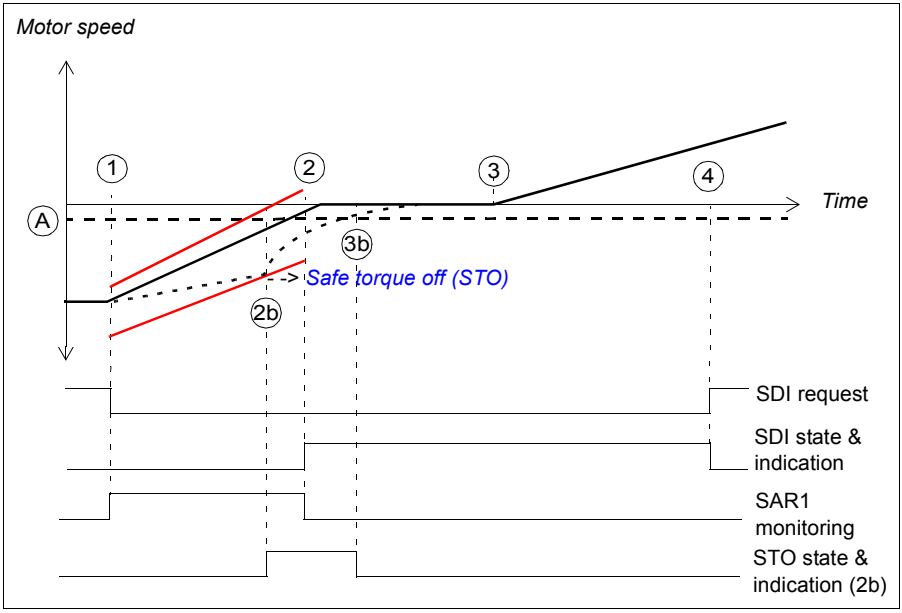
A SDI delay (parameter *SDI.12*): Delay for forcing to start the SDI monitoring.

B Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the SSE completed indication (parameter *SSE.22*) goes on. The STO acknowledgment becomes allowed.

Step	Description
1	The SDI positive request is received (for example, from the I/O). The motor rotates into the forbidden direction (in this case, negative). The drive starts to ramp down the motor speed to zero speed. The drive (parameter *23.13* or *23.15*) defines the deceleration ramp. The FSO module starts a counter for time A. The SDI indication is off.
2	The motor speed reaches zero and the motor stops. The FSO starts the SDI monitoring according to the SDI tolerance limit degree (not shown in this figure, see section *SDI with correct rotation direction* on page *151*). The SDI indication goes on.
2b	The FSO starts the SDI monitoring at the latest here, that is, after the SDI delay (A) has elapsed. **Note**: If the rotation direction of the motor is not correct after the SDI delay (A) has elapsed, the FSO module activates the SDI monitoring. If the motor rotates to the forbidden direction more that the SDI tolerance limit degree (parameter *SDI.14*, not shown in this figure) allows, the FSO activates the SSE function and the motor coasts to a stop (in this case the SSE function has been configured as “Immediate STO”). See section *SDI trip limit hits* on page *157*.
3	The user gives a new speed reference. The motor starts to rotate into the correct (positive) direction.
3b	Zero speed limit (B) reached. If the SSE function was activated at 2b, the STO acknowledgement becomes allowed and the FSO starts the SDI monitoring.
4	The SDI request is removed and the FSO stops the SDI monitoring. The SDI function is acknowledged (automatic SDI acknowledgement) and the SDI indication goes off.

SDI with ramp monitoring

This applies when the motor rotates into the forbidden direction when the SDI is activated and the ramp monitoring method is used. The SDI positive function is used as an example.



A Zero speed with encoder (parameter *FSOGEN.52*): Speed limit to define the motor as stopped. The safety function is completed and the STO completed indication (parameter *STO.22*) goes on. The STO acknowledgment becomes allowed.

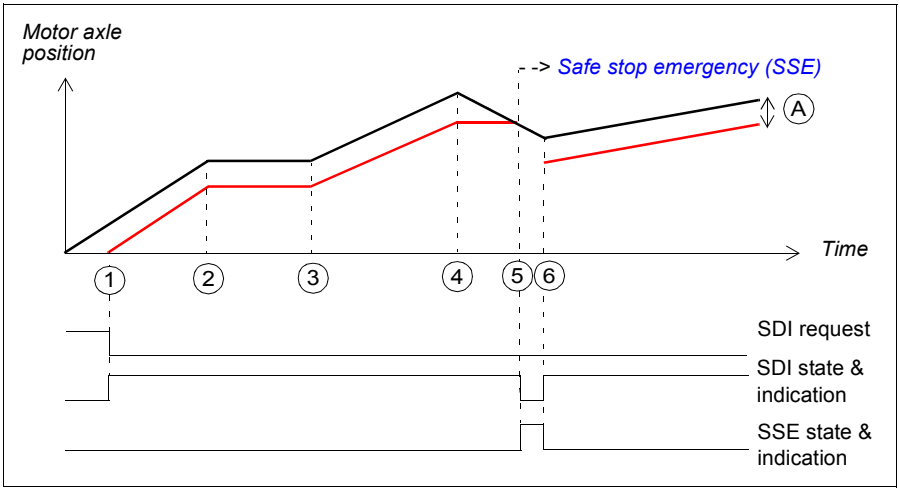
Ramp monitoring limits

Step	Description
1	The SDI positive request is received (for example, from the I/O). The motor rotates into the forbidden direction (in this case, negative). The drive starts to ramp down the motor speed to zero speed. SAR1 parameter *200.112* defines the deceleration ramp. The FSO module starts the ramp monitoring (SAR1 parameters *SARx.21*, *SARx.22*). The SDI indication is off. **Note**: If parameter *200.112* has value *0*, the drive (parameter *23.23*) defines the ramp.
2	The motor speed reaches zero and the motor stops. The FSO stops the ramp monitoring and starts the SDI monitoring according to the SDI tolerance limit degree (not shown in this figure, see section *SDI with correct rotation direction* on page *151*). The SDI indication goes on.
2b	If the deceleration of the motor does not follow the ramp monitoring limits, the FSO module activates the STO function and the motor coasts to a stop. The STO indication goes on (parameter *STO.21*). See section *Safe torque off (STO)* on page *57* for more information on how to configure the STO function.
3	The user gives a new speed reference. The motor starts to rotate into the correct (positive) direction.
3b	Zero speed limit (A) reached. If the STO function was activated at 2b, the STO acknowledgement becomes allowed and the FSO starts the SDI monitoring.
4	The SDI request is removed and the FSO stops the SDI monitoring. The SDI function is acknowledged (automatic SDI acknowledgement) and the SDI indication goes off.

SDI trip limit hits

This applies to SDI trip limit hit situations, that is, when the motor rotates too much to the forbidden direction while the SDI monitoring is on. The SDI positive function is used as an example.

Note: This diagram shows the position of the motor axle (not the motor speed).



A SDI tolerance limit degree (parameter *SDI.14*): The motor axle cannot move to the forbidden direction more than defined with this parameter.

— SDI monitoring limit

Step	Description
1	The SDI positive request is received (for example, from the I/O) and the FSO starts the SDI monitoring. The SDI indication goes on. The motor rotates to the correct direction (in this case, positive).
2	The motor stops.
3	The motor starts to rotate again (into the positive direction).
4	The rotation direction of the motor changes to the forbidden (negative) direction. The FSO locks the SDI tolerance limit (A) into its current position.
5	The SDI tolerance limit (A) is reached. The FSO stops the SDI monitoring and activates the SSE function and the motor coasts to a stop. The SDI indication goes off. The SSE indication goes on. See section *Safe stop emergency (SSE)* on page *93* for more information on how to configure the SSE function.
6	The motor has stopped. The SSE function is completed and the FSO starts the SDI monitoring. The SDI indication goes on and the SSE indication goes off. When the motor starts to rotate again (into the correct direction), the SDI monitoring continues with the original SDI tolerance limit (A).

Priorities between safety functions

When several safety functions are active at the same time, these priorities apply:

1. the STO function overrides the SSE and SS1 functions
2. the SSE function overrides the SS1 function.

The POUS function is independent of other safety functions. If you activate the POUS function when another safety function is active (for example, during a deceleration ramp), it can disturb the performance of the other safety function. We recommend that you do not activate the POUS function when the motor is running.

Example: The SS1 function uses SAR1 parameters to define the stop ramp. In some situations (for example, in internal fault situations or due to another safety function), the FSO module can activate the Safe stop emergency (SSE) function. When the SSE function has been configured as “Emergency ramp”, it uses SAR0 parameters to define the stop ramp. If the FSO module activates the SSE function while the SS1 function is active, the SSE function overrides the SS1 function. Therefore, SAR0 parameters are used instead of SAR1 parameters to define the stop ramp.

When a safety function overrides another safety function, this does not remove the request of the overridden safety function. Therefore, the overridden safety function restarts after the other safety function has been completed and acknowledged.

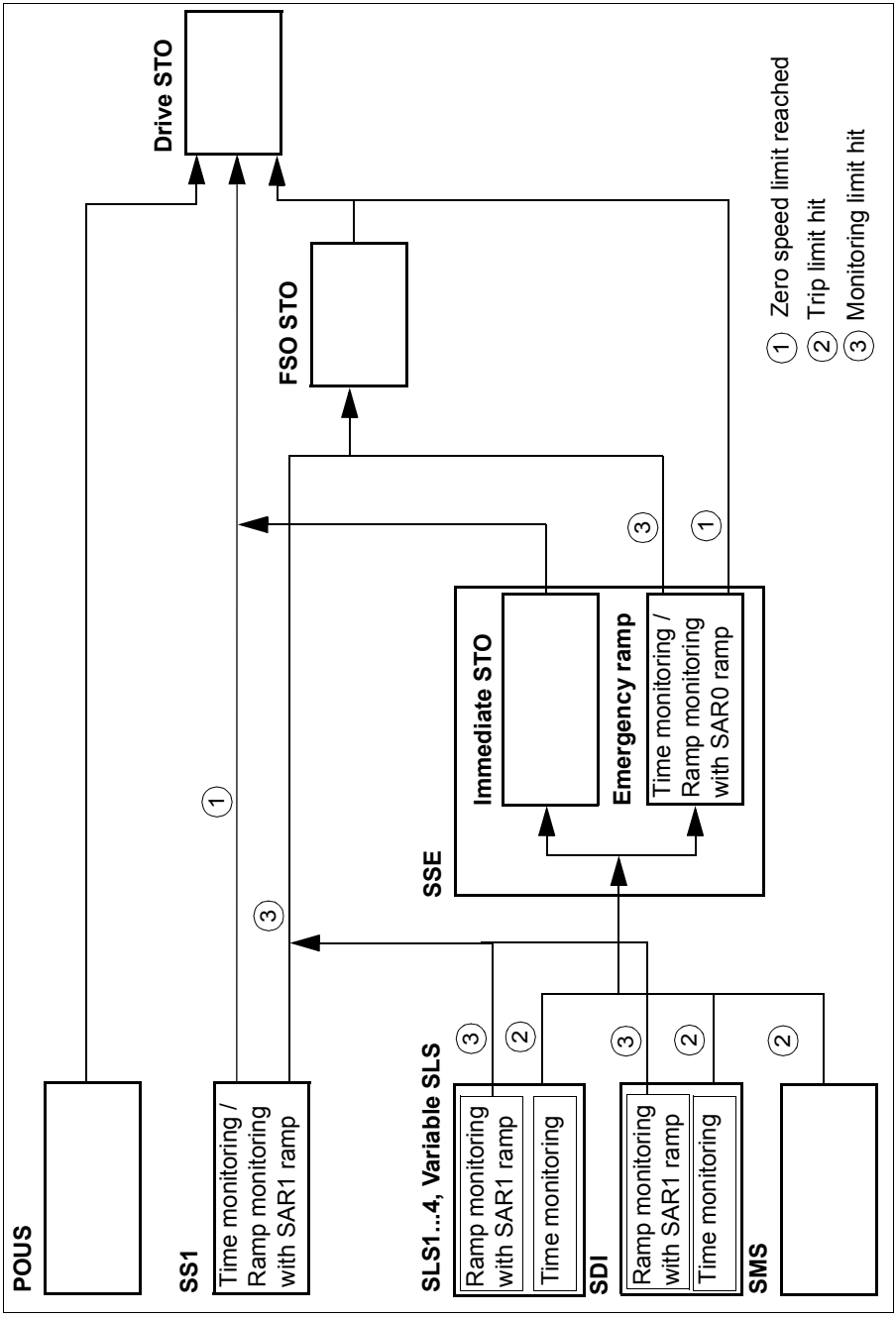
Dependencies between safety functions

The figure below shows how different safety functions of the FSO module are related to each other and the drive STO function.

1. Zero speed limit reached: The SS1 and SSE (with emergency ramp) functions activate the drive STO function (that is, open the drive STO circuit) when the motor speed reaches the user-defined zero speed limit.
2. Trip limit hit: The SMS and SLS functions activate the SSE function when the motor speed reaches a user-defined trip limit. The SDI function activates the SSE function when motor rotation reaches the user-defined SDI tolerance limit.
3. Monitoring limit hit: The SS1, SSE (with emergency ramp), SLS and SDI functions (with ramp monitoring) activate the STO function of the FSO module when the motor speed reaches a monitoring limit.

The STO, SSE with immediate STO and POUS functions activate the drive STO function, that is, open the drive STO circuit.

The POUS function is independent of other safety functions of the FSO module.


Drive STO
FSO STO
POUS
SS1
Time monitoring / Ramp monitoring with SAR1 ramp
SLS1...4, Variable SLS
Ramp monitoring with SAR1 ramp
Time monitoring
SDI
Ramp monitoring with SAR1 ramp
Time monitoring
SMS
SSE
Immediate STO
Emergency ramp
Time monitoring / Ramp monitoring with SAR0 ramp
1 Zero speed limit reached
2 Trip limit hit
3 Monitoring limit hit

6

PROFIsafe

Contents of this chapter

This chapter describes the safety system when the FSO module is connected to a safety PLC through the FENA Ethernet adapter module using the PROFIsafe profile of PROFINET. It describes the FSO module states and transitions and the contents of the PROFIsafe messages. The chapter also includes installation instructions, configuration instructions for the ABB AC500-S Safety PLC and Siemens SIMATIC Fail-safe S7 PLC and fault tracing tips.

Introduction

When the drive is controlled from a safety PLC, the reliability of the fieldbus communication must be secured. This can be done with the PROFIsafe technology. The PROFIsafe technology includes several safety measures to minimize the effect of various transmission errors that can occur when messages are transferred in a complex network.

PROFIsafe is an application layer (protocol) that describes the safety communication between fail-safe devices. It is an additional layer on top of the standard PROFIBUS and PROFINET protocols.

There are two versions of the PROFIsafe protocol:

- V1 can only be used with PROFIBUS
- V2 can be used with PROFIBUS and PROFINET.

The FSO module supports version V2.4 with PROFINET.

The PROFIsafe protocol can be used for safety applications up to SIL 3 according to IEC 61508 / IEC 62061, Category 4 according to EN 954-1 or PL e according to ISO 13849-1.

For more information on PROFIsafe and PROFINET, see www.profibus.com/.

System description

Required components

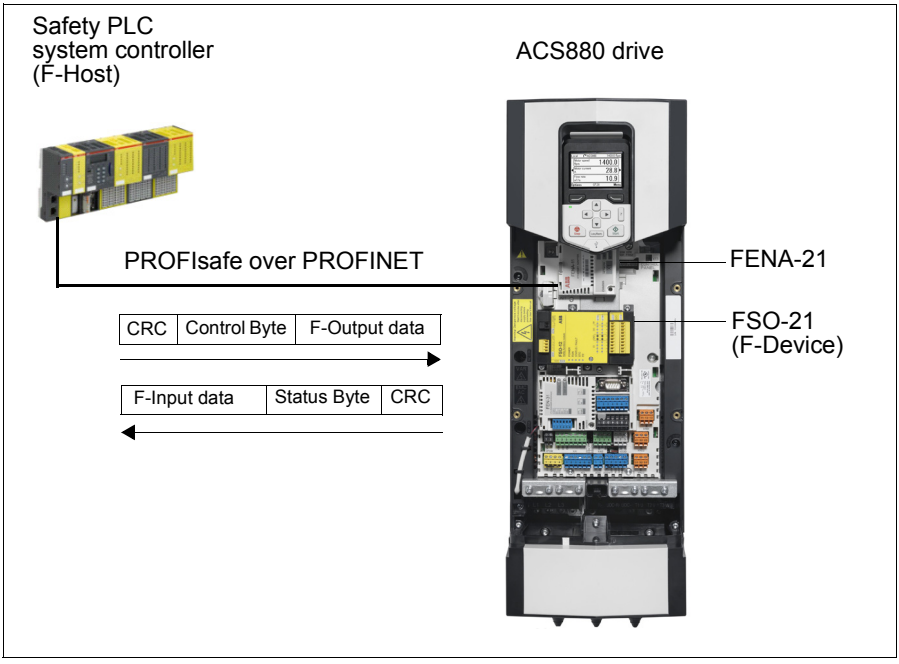
- FSO-21 safety functions module
- ACS880 Primary control program: version 2.12 or later
- FENA-21 Ethernet adapter module: version 3.05 or later
- compatible safety PLC system, for example, ABB AC500-S Safety PLC or Siemens SIMATIC Fail-safe S7 PLC

Tools

- Drive composer pro: version 1.7 or later
- For ABB PLCs: Automation builder: 1.0 or later (includes PS501 Control Builder Plus version 2.3.0), safety license PS501-S
- For Siemens PLCs: SIMATIC Step 7 V5.5 + S7 Distributed Safety V5.4 and SIMATIC Step 7 V 11 (TIA Portal) + Step 7 Safety Advanced V 13

System overview

This figure shows an overview of a safety PLC that is connected to the ACS880 drive via the PROFIsafe communication bus.



The FSO-21 safety functions module and the FENA-21 Ethernet adapter module are installed on the ACS880 drive. The safety PLC is connected to the FENA module, which communicates with the FSO module. The safety PLC activates safety functions via the PROFIsafe communication bus. The user can also activate safety functions from an I/O device (for example, an emergency stop button) which is connected to the FSO module.

The PROFIsafe protocol secures the whole path from the location where a safety signal originates to the location where it is processed and vice versa.

The safety PLC sends PROFIsafe messages (frames) to the FSO module through the FENA module which extracts the frame from the PROFINET communication. The FSO module reads and interprets the PROFIsafe messages and performs the required actions. The FSO module sends PROFIsafe messages back to the FENA module which transmits them to the safety PLC.

The term PROFIsafe F-Output data refers to the application-specific user data in the frames that are transmitted to the FSO module (F-Device) from the safety PLC (F-Host). The term PROFIsafe F-Input data refers to the application-specific user data in the frames that are transmitted from the FSO module to the safety PLC. For a detailed description of the PROFIsafe message format, see section *PROFIsafe message format* on page *165*.

F-Parameters are PROFIsafe parameters that all PROFIsafe devices support. F-Parameters are sent from the F-Host (safety PLC) to the F-Device (FSO module) when the PROFIsafe connection is created. They contain the PROFIsafe addresses and the watchdog time for the PROFIsafe connection.

Note: We recommend that you use only PROFINET compatible Ethernet switches and cables in the PROFIsafe communication bus.

Remote I/O control

You can control the FSO module outputs and read input information also from the safety PLC. A request to activate or deactivate an output is sent from the safety PLC (PROFIsafe controller) to the FSO module in a PROFIsafe message. See section *FSO PROFIsafe profiles* on page *166*.

Only FSO outputs that are not configured for any control use (for example, to control an indication lamp or a brake) can be activated from the safety PLC. If the safety PLC tries to activate an FSO output that is configured for control use, the FSO module rejects the request, activates the SSE function and goes into the Fail-safe mode (see section *FSO module modes and states* on page *177*). To exit the Fail-safe mode, remove the power from the FSO or reboot the FSO with drive parameter *96.09 FSO reboot*.

FSO module passivation

If the FSO module or the safety PLC detects an error in the fieldbus communication, the FSO module is passivated. The status of the FSO outputs that are not configured for any control use (for example, to control an indication lamp or a brake) are set to “low”. The FSO module activates the SSE function, goes into the Safe state and generates an event. The user can select the event type (warning, fault or event) with parameter *SBUSGEN.10 STO indication passivation*.

After the cause of the passivation has been detected, the SSE function must be acknowledged before the communication continues. The status of the safety functions and FSO outputs are set according to the PROFIsafe message that was received before the passivation.

PROFIsafe description

PROFIsafe message format

The FSO module supports only the PROFIsafe short frame format. The short frame supports a maximum of 12 octets of user data. The frame also includes a CRC (3 octets) and one Status/Control Byte octet. Therefore, the maximum frame size of the message is 16 octets.

Data	F-Input / F-Output user data	Status / Control Byte	CRC2
Size (octets)	Max. 12	1	3

Control Byte and CRC2 bit order

PROFIsafe messages sent from the safety PLC to the FSO module include the F-Output user data, the Control Byte and CRC2.

This table shows the bit order of the Control Byte and CRC2.
N_O is the length of F-Output user data.

Octet	Bit	Name	Description
Control Byte			
N_O	7	Reserved	The value is ignored.
	6	Reserved	The value is ignored.
	5	Toggle_h	Toggle bit
	4	Activate_FV	Fail-safe values (FV) to be activated
	3	Use_TO2	Use F_WD_Time_2 (secondary watchdog). Not in use. The value is ignored.
	2	R_cons_nr	Reset Vconsnr_d
	1	OA_Req	Operator acknowledgement requested
	0	iPar_EN	Parameter assignment deblocked. Not in use. The value is ignored.
CRC2			
N_O+1	7	CRC bit 23	Octet 3 (MSB) of 24 bit CRC
	…		
	0	CRC bit 16	
N_O+2	7	CRC bit 15	Octet 2 of 24 bit CRC
	…		
	0	CRC bit 8	
N_O+3	7	CRC bit 7	Octet 1 (LSB) of 24 bit CRC
	…		
	0	CRC Bit 0	

Status Byte and CRC2 bit order

PROFIsafe messages sent from the FSO module to the safety PLC include the F-Input user data, the Status Byte and CRC2.

This table shows the bit order of the Status Byte and CRC2.
N_i is the length of F-Input user data.

Octet	Bit	Name	Description
Status Byte			
N_i	7	Reserved	The value is always 0. Must be ignored by the F-Host.
	6	cons_nr_R	Vconsnr_d has been reset.
	5	Toggle_d	Toggle bit
	4	FV_activated	Fail-safe values (FV) activated.
	3	WD_timeout	Communication fault: Watchdog timeout
	2	CE_CRC	Communication fault: CRC error
	1	Device_Fault	Failure exists in the F-Device.
	0	iPar_OK	F-Device has new iParameter values assigned. Not in use. The value is always 0.
CRC2			
N_i+1	7	CRC bit 23	Octet 3 (MSB) of 24 bit CRC
	…		
	0	CRC bit 16	
N_i+2	7	CRC bit 15	Octet 2 of 24 bit CRC
	…		
	0	CRC bit 8	
Ni+3	7	CRC bit 7	Octet 1 (LSB) of 24 bit CRC
	…		
	0	CRC bit 0	

FSO PROFIsafe profiles

The content of the F-Input and F-Output user data is configured with FSO specific PROFIsafe profiles. The FSO-21 module supports the ABB_PS1 and ABB_PS2 profiles.

The ABB_PS1 profile provides the functionality to control and monitor the safety functions, the SLS limits, the safe speed value and the states of the FSO I/O. In addition to the functionality in the ABB_PS1 profile, the ABB_PS2 profile includes the safe position value. The ABB_PS2 profile requires that an encoder is used in the safety system.

ABB_PS1 profile F-Output user data

This table shows the bit order of the F-Output data, which is included in the PROFIsafe message sent to the FSO module from the safety PLC. For all the bits in the F-Output data, one (1) means active and zero (0) non-active.

Octet	Bit	Name	Description
0	0	SLS2_request	SLS2 (Safely-limited speed) activation requested by the controller.
	1	SLS1_request	SLS1 (Safely-limited speed) activation requested by the controller.
	2	Reserved*)	Must not be used (must be 0).
	3	Reserved*)	Must not be used (must be 0).
	4	SS1_request	SS1 (Safe stop 1) activation requested by the controller.
	5	SSE_request	SSE (Safe stop emergency) activation requested by the controller.
	6	POUS_request	POUS (Prevention of unexpected start-up) activation request by the controller.
	7	STO_request	STO (Safe torque off) activation requested by the controller.
1	0	SDI_N_ activate	SDI_N (Safe direction) activation requested by the controller.
	1	SDI_P_ activate	SDI_P (Safe direction) activation requested by the controller.
	2	Reserved*)	Must not be used (must be 0).
	3	Reserved*)	Must not be used (must be 0).
	4	Reserved*)	Must not be used (must be 0).
	5	Reserved*)	Must not be used (must be 0).
	6	SLS4_request	SLS4 (Safely-limited speed) activation requested by the controller.
	7	SLS3_request	SLS3 (Safely-limited speed) activation requested by the controller.
2	0	Variable_SLS_request	Variable SLS (Safely-limited speed) activation requested by the controller and the Variable SLS limit is valid.
	1	Reserved*)	Must not be used (must be 0).
	2	SF_end_ack	Safety function ending acknowledgement = 1, no acknowledgement = 0.
	3	Reserved*)	Must not be used (must be 0).
	4	SSM4_activate	SSM4 (Safe speed monitor) activation requested by the controller.
	5	SSM3_activate	SSM3 (Safe speed monitor) activation requested by the controller.
	6	SSM2_activate	SSM2 (Safe speed monitor) activation requested by the controller.
	7	SSM1_activate	SSM1 (Safe speed monitor) activation requested by the controller.

Octet	Bit	Name	Description
3	0	Safe_output_X114_9_ctrl	State of the safe output X114:9 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	1	Safe_output_X114_8_ctrl	State of the safe output X114:8 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	2	Safe_output_X114_7_ctrl	State of the safe output X114:7 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	3	Safe_output_X113_9_ctrl	State of the safe output X113:9 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	4	Safe_output_X113_8_ctrl	State of the safe output X113:8 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	5	Safe_output_x113_7_ctrl	State of the safe output X113:7 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	6	Negative_Scaling	Selects whether Variable SLS limit is scaled for negative direction. 0 = Limit scaled, 1 = Limit not scaled (100%).
	7	Positive_Scaling	Selects whether Variable SLS limit is scaled for positive direction. 0 = Limit scaled, 1 = Limit not scaled (100%).
4		Variable_SLS_limit_MSB	Safely-limited speed relative limit (MSB) [0.01%]
5		Variable_SLS_limit_LSB	Safely-limited speed relative limit (LSB) [0.01%]

*) If the PROFIsafe message includes a safety function request which is not supported or if the safety function has not been configured, the FSO module activates the SSE function and generates an FSO configuration fault (see chapter *Fault tracing*).

ABB_PS1 profile F-Input user data

This table shows the bit order of the F-Input user data, which is included in the PROFIsafe message sent from the FSO module to the safety PLC. For all the bits in the F-Input data, one (1) means active and zero (0) non-active.

Note: In the Fail-safe and Configuration states, all the bits in the PROFIsafe message are set to “0”. In these cases, you can read the FSO state from:

- Siemens PLC: bits QBAD and PASS_OUT in the PROFIsafe data block
- ABB PLC: bit Device_Fault in the PROFIsafe data structure.

See also section *FSO module modes and states* on page *177*.

Octet	Bit	Name	Description
0	0	SLS2_active	SLS2 (Safely-limited speed) is active. Active when the SLS2 function is active and the motor speed is below the SLS1 limit (that is, when the SLS2 monitoring is on).
	1	SLS1_active	SLS1 (Safely-limited speed) is active. Active when the SLS1 function is active and the motor speed is below the SLS1 limit (that is, when the SLS1 monitoring is on).
	2	Reserved*)	The value is 0. Must be ignored by the F-Host.
	3	Reserved*)	The value is 0. Must be ignored by the F-Host.
	4	SS1_active	SS1 (Safe stop 1) is function active.
	5	SSE_active	SSE (Safe stop emergency) function is active.
	6	SBC_active	SBC (Safe brake control) function is active.
	7	STO_active	STO (Safe torque off) function is active.
1	0	Reserved*)	The value is 0. Must be ignored by the F-Host.
	1	Reserved*)	The value is 0. Must be ignored by the F-Host.
	2	Reserved*)	The value is 0. Must be ignored by the F-Host.
	3	Reserved*)	The value is 0. Must be ignored by the F-Host.
	4	SAR1_active	SAR1 (Safe acceleration range) is active.
	5	SAR0_active	SAR0 (Safe acceleration range) is active.
	6	SLS4_active	SLS4 (Safely-limited speed) is active. Active when the SLS4 function is active and the motor speed is below the SLS4 limit (that is, when the SLS4 monitoring is on).
	7	SLS3_active	SLS3 (Safely-limited speed) is active. Active when the SLS3 function is active and the motor speed is below the SLS3 limit (that is, when the SLS3 monitoring is on).

Octet	Bit	Name	Description
2	0	Speed_feedback_type	Active speed feedback 0=Estimate is active 1=Encoder is active
	1	SMS_active	SMS (Safe maximum speed) function is active.
	2	SSM4_active	SSM4 (Safe speed monitor) function is active and the motor speed is within the SSM4 limits.
	3	SSM3_active	SSM3 (Safe speed monitor) function is active and the motor speed is within the SSM3 limits.
	4	SSM2_active	SSM2 (Safe speed monitor) function is active and the motor speed is within the SSM2 limits.
	5	SSM1_active	SSM1 (Safe speed monitor) function is active and the motor speed is within the SSM1 limits.
	6	SDI_N_active	SDI_N (Safe direction) is active.
	7	SDI_P_active	SDI_P (Safe direction) is active.
3	0	Safe_input_X114_4	State of the safe input X114:4.
	1	Safe_input_X114_3	State of the safe input X114:3.
	2	Safe_input_X114_2	State of the safe input X114:2.
	3	Safe_input_X114_1	State of the safe input X114:1.
	4	Safe_input_X113_4	State of the safe input X113:4.
	5	Safe_input_X113_3	State of the safe input X113:3.
	6	Safe_input_X113_2	State of the safe input X113:2.
	7	Safe_input_X113_1	State of the safe input X113:1.
4	0	Variable_SLS_active	Variable SLS (Safely-limited speed) is active. Active when the Variable SLS function is active and the motor speed is below the Variable SLS limit (that is, when the Variable SLS monitoring is on).
	1	POUS_active	POUS (Prevention of unexpected start-up) function is active.
	2	Safe_output_X114_9	State of the safe output X114:9.
	3	Safe_output_X114_8	State of the safe output X114:8.
	4	Safe_output_X114_7	State of the safe output X114:7.
	5	Safe_output_X113_9	State of the safe output X113:9.
	6	Safe_output_X113_8	State of the safe output X113:8.
	7	Safe_output_X113_7	State of the safe output X113:7.

<table>
<tr><th>Octet</th><th>Bit</th><th>Name</th><th>Description</th></tr>
<tr><td rowspan="8">5</td><td>0</td><td>SF_end_ack_req</td><td>Safety function ending acknowledgement requested = 1, no acknowledgement requested = 0.
Acknowledgement can be done via PROFIsafe.</td></tr>
<tr><td>1</td><td>SF_end_ack_req_local</td><td>Local safety function ending acknowledgement requested = 1, no acknowledgement requested = 0.
Acknowledgement can only be done locally via the FSO I/O if SF_end_ack_req is 0.</td></tr>
<tr><td>2</td><td>STO_control_active</td><td>The drive STO circuit is open.
Note: The motor may still be rotating.</td></tr>
<tr><td>3</td><td>Speed_value_valid</td><td>Is the speed value valid (= 1) or not (= 0).
The speed value is defined in octets 6 and 7.</td></tr>
<tr><td>4</td><td>FSO_state</td><td>Safe state = 1
Operational state = 0</td></tr>
<tr><td>5</td><td>FSO_mode.0</td><td rowspan="2"></td></tr>
<tr><td>6</td><td>FSO_mode.1</td></tr>
<tr><td>7</td><td>Modulating</td><td>The drive is modulating = 1
The drive is not modulating = 0</td></tr>
<tr><td>6</td><td></td><td>Safe_speed_MSB</td><td>The current motor speed value from FSO (LSB).</td></tr>
<tr><td>7</td><td></td><td>Safe_speed_LSB</td><td>The current motor speed value from FSO (MSB).</td></tr>
</table>

FSO operating mode	FSO_mode.1	FSO_mode.0
Start-up	0	0
Running	0	1
Fail-safe	1	0
Configuration	1	1

*) The safety PLC must ignore the value of the reserved bits. This ensures the compatibility with future versions of the PROFIsafe profile where the reserved bits may be used.

Note: The states of all FSO inputs and outputs are shown in the PROFIsafe message. These states also show the states of SBC outputs and feedback inputs.

ABB_PS2 profile F-Output user data

This table shows the bit order of the F-Output data, which is included in the PROFIsafe message sent to the FSO module from the safety PLC. For all the bits in the F-Output data, one (1) means active and zero (0) non-active.

Octet	Bit	Name	Description
0	0	SLS2_request	SLS2 (Safely-limited speed) activation requested by the controller.
	1	SLS1_request	SLS1 (Safely-limited speed) activation requested by the controller.
	2	Reserved*)	Must not be used (must be 0).
	3	Reserved*)	Must not be used (must be 0).
	4	SS1_request	SS1 (Safe stop 1) activation requested by the controller.
	5	SSE_request	SSE (Safe stop emergency) activation requested by the controller.
	6	POUS_request	POUS (Prevention of unexpected start-up) activation request by the controller.
	7	STO_request	STO (Safe torque off) activation requested by the controller.
1	0	SDI_N_ activate	SDI_N (Safe direction) activation requested by the controller.
	1	SDI_P_ activate	SDI_P (Safe direction) activation requested by the controller.
	2	Reserved*)	Must not be used (must be 0).
	3	Reserved*)	Must not be used (must be 0).
	4	Reserved*)	Must not be used (must be 0).
	5	Reserved*)	Must not be used (must be 0).
	6	SLS4_request	SLS4 (Safely-limited speed) activation requested by the controller.
	7	SLS3_request	SLS3 (Safely-limited speed) activation requested by the controller.
2	0	Variable_SLS_request	Variable SLS (Safely-limited speed) activation requested by the controller and Variable SLS limit is valid.
	1	Reserved*)	Must not be used (must be 0).
	2	SF_end_ack	Safety function ending acknowledgement = 1, no acknowledgement = 0.
	3	Reserved*)	Must not be used (must be 0).
	4	SSM4_activate	SSM4 (Safe speed monitor) activation requested by the controller.
	5	SSM3_activate	SSM3 (Safe speed monitor) activation requested by the controller.
	6	SSM2_activate	SSM2 (Safe speed monitor) activation requested by the controller.
	7	SSM1_activate	SSM1 (Safe speed monitor) activation requested by the controller.

Octet	Bit	Name	Description
3	0	Safe_output_X114 _9_ctrl	State of the safe output X114:9 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	1	Safe_output_X114 _8_ctrl	State of the safe output X114:8 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	2	Safe_output_X114 _7_ctrl	State of the safe output X114:7 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	3	Safe_output_X113 _9_ctrl	State of the safe output X113:9 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	4	Safe_output_X113 _8_ctrl	State of the safe output X113:8 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	5	Safe_output_x113 _7_ctrl	State of the safe output X113:7 (see section *Remote I/O control* on page *164*). 1 = 24 V, 0 = 0 V.
	6	Negative_Scaling	Selects whether Variable SLS limit is scaled for negative direction. 0 = Limit scaled, 1 = Limit not scaled (100%).
	7	Positive_Scaling	Selects whether Variable SLS limit is scaled for positive direction. 0 = Limit scaled, 1 = Limit not scaled (100%).
4		Variable_SLS_limit _MSB	Safely-limited speed relative limit (MSB) [0.01%]
5		Variable_SLS_limit _LSB	Safely-limited speed relative limit (LSB) [0.01%]

*) If the PROFIsafe message includes a safety function request which is not supported or if the safety function has not been configured, the FSO module activates the SSE function and generates an FSO configuration fault (see chapter *Fault tracing*).

ABB_PS2 profile F-Input user data

This table shows the bit order of the F-Input user data, which is included in the PROFIsafe message sent from the FSO module to the safety PLC. For all the bits in the F-Input data, one (1) means active and zero (0) non-active.

Note: In the Fail-safe and Configuration states, all the bits in the PROFIsafe message are set to “0”. In these cases, you can read the FSO state from:

- Siemens PLC: bits QBAD and PASS_OUT in the PROFIsafe data block
- ABB PLC: bit Device_Fault in the PROFIsafe data structure.

See also section *FSO module modes and states* on page *177*.

Octet	Bit	Name	Description
0	0	SLS2_active	SLS2 (Safely-limited speed) is active. Active when the SLS2 function is active and the motor speed is below the SLS1 limit (that is, when the SLS2 monitoring is on).
	1	SLS1_active	SLS1 (Safely-limited speed) is active. Active when the SLS1 function is active and the motor speed is below the SLS1 limit (that is, when the SLS1 monitoring is on).
	2	Reserved*)	The value is 0. Must be ignored by the F-Host.
	3	Reserved*)	The value is 0. Must be ignored by the F-Host.
	4	SS1_active	SS1 (Safe stop 1) function is active.
	5	SSE_active	SSE (Safe stop emergency) function is active.
	6	SBC_active	SBC (Safe brake control) function is active.
	7	STO_active	STO (Safe torque off) function is active.
1	0	Reserved*)	The value is 0. Must be ignored by the F-Host.
	1	Reserved*)	The value is 0. Must be ignored by the F-Host.
	2	Reserved*)	The value is 0. Must be ignored by the F-Host.
	3	Reserved*)	The value is 0. Must be ignored by the F-Host.
	4	SAR1_active	SAR1 (Safe acceleration range) is active.
	5	SAR0_active	SAR0 (Safe acceleration range) is active.
	6	SLS4_active	SLS4 (Safely-limited speed) is active. Active when the SLS4 function is active and the motor speed is below the SLS4 limit (that is, when the SLS4 monitoring is on).
	7	SLS3_active	SLS3 (Safely-limited speed) is active. Active when the SLS3 function is active and the motor speed is below the SLS3 limit (that is, when the SLS3 monitoring is on).

Octet	Bit	Name	Description
2	0	Speed_feedback_type	Active speed feedback 0=Estimate is active 1=Encoder is active
	1	SMS_active	SMS (Safe maximum speed) function is active.
	2	SSM4_active	SSM4 (Safe speed monitor) function is active and the motor speed is within the SSM4 limits.
	3	SSM3_active	SSM3 (Safe speed monitor) function is active and the motor speed is within the SSM3 limits.
	4	SSM2_active	SSM2 (Safe speed monitor) function is active and the motor speed is within the SSM2 limits.
	5	SSM1_active	SSM1 (Safe speed monitor) function is active and the motor speed is within the SSM1 limits.
	6	SDI_N_active	SDI_N (Safe direction) is active.
	7	SDI_P_active	SDI_P (Safe direction) is active.
3	0	Safe_input_X114_4	State of the safe input X114:4.
	1	Safe_input_X114_3	State of the safe input X114:3.
	2	Safe_input_X114_2	State of the safe input X114:2.
	3	Safe_input_X114_1	State of the safe input X114:1.
	4	Safe_input_X113_4	State of the safe input X113:4.
	5	Safe_input_X113_3	State of the safe input X113:3.
	6	Safe_input_X113_2	State of the safe input X113:2.
	7	Safe_input_X113_1	State of the safe input X113:1.
4	0	Variable_SLS_active	Variable SLS (Safely-limited speed) is active. Active when the Variable SLS function is active and the motor speed is below the Variable SLS limit (that is, when the Variable SLS monitoring is on).
	1	POUS_active	POUS (Prevention of unexpected start-up) function is active.
	2	Safe_output_X114_9	State of the safe output X114:9.
	3	Safe_output_X114_8	State of the safe output X114:8.
	4	Safe_output_X114_7	State of the safe output X114:7.
	5	Safe_output_X113_9	State of the safe output X113:9.
	6	Safe_output_X113_8	State of the safe output X113:8.
	7	Safe_output_X113_7	State of the safe output X113:7.

Octet	Bit	Name	Description
5	0	SF_end_ack_req	Safety function ending acknowledgement requested = 1, no acknowledgement requested = 0. Acknowledgement can be done via PROFIsafe.
	1	SF_end_ack_req_local	Local safety function ending acknowledgement requested = 1, no acknowledgement requested = 0. Acknowledgement can only be done locally via the FSO I/O if SF_end_ack_req is 0.
	2	STO_control_active	The drive STO circuit is open. The motor may still be running.
	3	Speed_Pos_value_valid	Are the speed and position values valid (= 1) or not (= 0). The speed value is defined in octets 6 and 7. The position value is defined in octets 8 and 9.
	4	FSO_state	Safe state = 1 Operational state = 0
	5	FSO_mode.0	
	6	FSO_mode.1	
	7	Modulating	The drive is modulating = 1 The drive is not modulating = 0
6		Safe_speed_MSB	The current motor speed value from the FSO (LSB).
7		Safe_speed_LSB	The current motor speed value from the FSO (MSB).
8		Safe_position_MSB	Safe position value (MSB).
9		Safe_position_LSB	Safe position value (LSB).

FSO operating mode	FSO_mode.1	FSO_mode.0
Start-up	0	0
Running	0	1
Fail-safe	1	0
Configuration	1	1

*) The safety PLC must ignore the value of the reserved bits. This ensures the compatibility with future versions of the PROFIsafe profile where the reserved bits may be used.

Note: The states of all FSO inputs and outputs are shown in the PROFIsafe message. These states show also the states of SBC outputs and feedback inputs.

FSO module modes and states

When the FSO module is connected to a safety PLC via the PROFIsafe communications bus, the FSO module can be in the following modes and states:

- Start-up mode
- Configuration mode
- Fail-safe mode
- RUN states:
  - Operational
  - Safe (User acknowledgement request)
  - Safe (Module passivation)
  - Safe (Module passivation & reintegration)
  - Safe (Module passivation with a command).

The FSO module modes and states are described in the following two figures and tables.

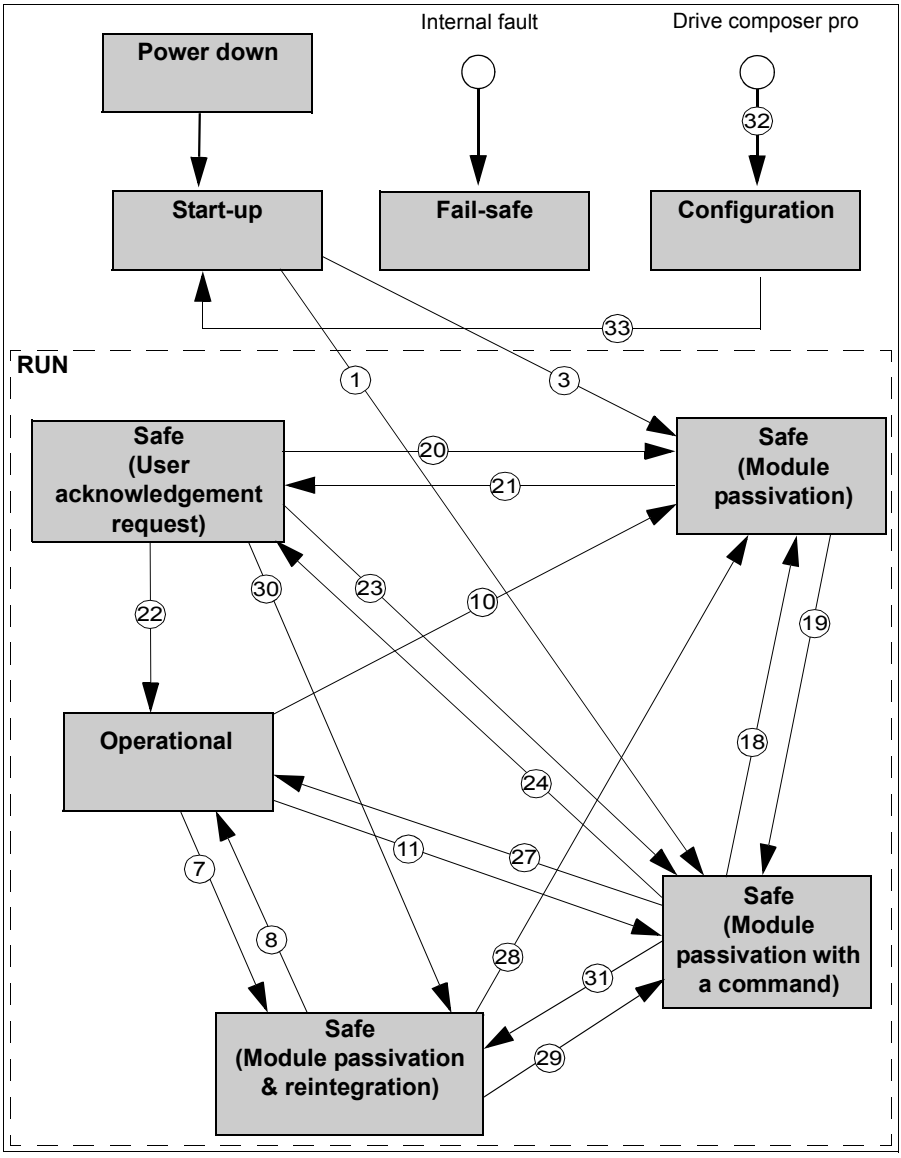
The first figure shows the modes, states and transitions during normal operation. The second figure shows the modes, states and transitions when fatal errors in the FSO module occur or when cycling power of the FSO module.

Note: If PROFIsafe is not configured, see the FSO states described in section *FSO states* on page *53* in chapter *Safety functions*.

Note: If PROFIsafe is configured, the FSO module stays in the Start-up mode until it has received valid F-Parameters from the safety PLC.

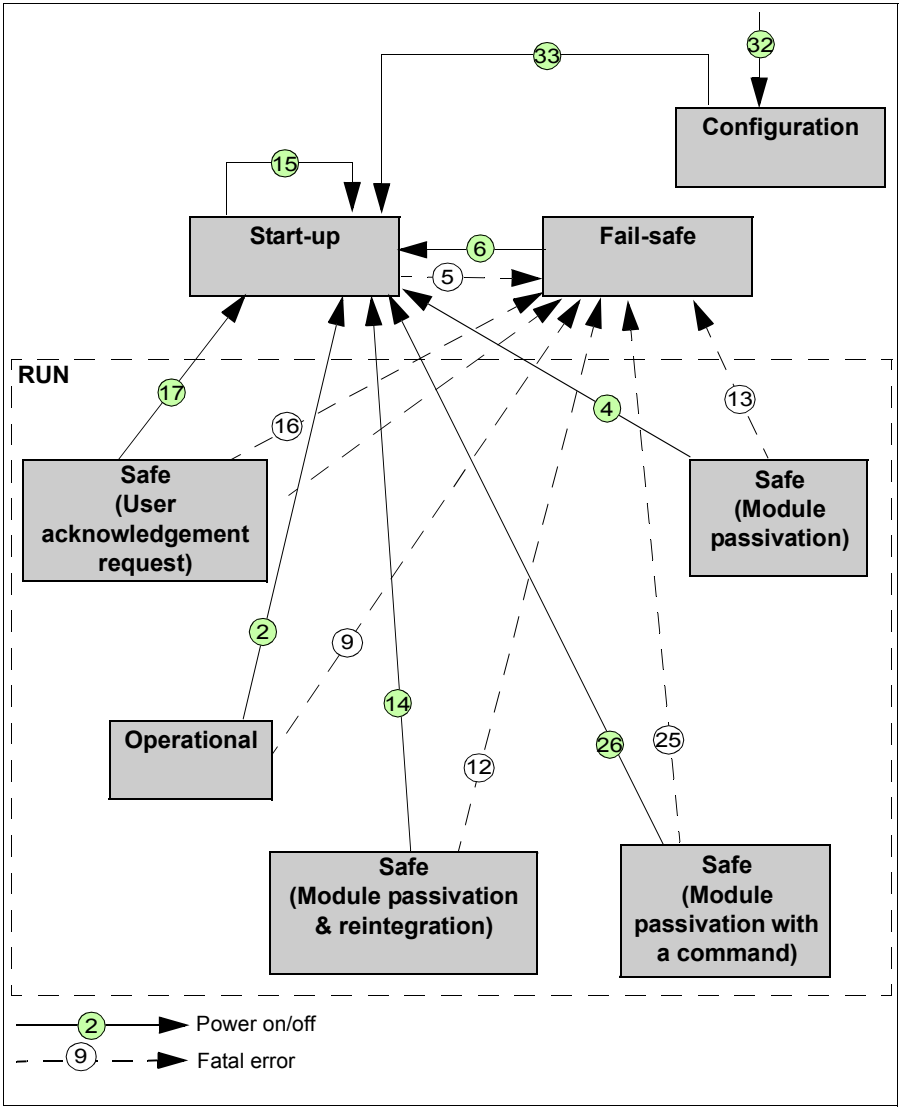
State diagrams

Overview of states and transitions in the FSO module during normal operation.



Note: It is possible to go to the Configuration mode from any other state when the drive is not modulating. From the Configuration mode, it is possible to go only to the Start-up mode.

Overview of states and transitions in the FSO module when fatal errors in the FSO module occur or when cycling power of the FSO module.



Description of states

This table describes the FSO module states and how the states are shown in the PROFIsafe messages. The Status Byte and the profiles are described in detail in sections *Status Byte and CRC2 bit order* on page *166* and *FSO PROFIsafe profiles* on page *166*.

The table refers to several variables that are available to the programmer of an F-Host program (for example, an AC500-S program in CoDeSys):

OA_Req_S	This variable indicates that the FSO is in the “Safe (User acknowledgement request)” state ready for acknowledgement.
FV_Activated_S	This variable indicates that the FSO is in the Safe state. Fail-safe values (“0”) are set to the I/O channels.
OA_C	This variable indicates that PROFIsafe is running successfully after PROFIsafe communication error(s) have been solved. The FSO is in the “Safe (User acknowledgement request)” state and variable OA_Req_S is set to “1”. Setting OA_C variable to “1” acknowledges that the PROFIsafe communication errors have been solved and it is possible to go to the Operational state.
Device_Fault	This variable is the Device_Fault bit of the PROFIsafe Status Byte. When the value is 1, the FSO is in the Fail-safe mode.

State	Description
Start-up	The FSO module hardware is initialized and internal start-up tests are executed. After a successful parameterization, the PROFIsafe communication is expected to be initiated by the PROFIsafe F-Host. The FSO module remains in this state: • if the parameterization failed or is pending • if the PROFIsafe communication is pending. PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 1 • Device_Fault = 0 ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 0 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 1

State	Description
Operational	PROFIsafe communication is up and running. The safety application is running without any detected errors. PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 0 • Device_Fault = 0 ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 1 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 0

State	Description
Safe (Module passivation & reintegration)	PROFIsafe communication is up and running. The FSO application is running with detected errors. At least one of the active safety functions has encountered an error. For example, the SLS1 function is active and its speed limits are violated. The drive is stopped using the configured method. In the end, the drive STO is activated. As soon as the STO function has been completed and no errors are detected, reintegration of the FSO module is possible. It depends on the FSO configuration from where the reintegration can be done. All tripped safety functions must be acknowledged to complete the reintegration. SF_end_ack_req_local is set if any of the safety functions can be acknowledged locally via FSO inputs. SF_end_ack_req is set if any of the safety functions can be acknowledged via PROFIsafe frame bit SF_end_ack. A positive edge from “0” to “1” is required to acknowledge the module reintegration. If automatic acknowledgement is configured for the error condition, neither of the status bits is set. The acknowledgement is done automatically. As soon as all errors have been solved and they have been acknowledged, the Operational state is reached. PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 0 • Device_Fault = 0 ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 1 • SF_end_ack_req_local = 1, if it is possible to acknowledge any of the tripped safety functions locally via the FSO inputs. SF_end_ack_req_local = 0, otherwise. • SF_end_ack_req = 1, if it is possible to acknowledge any of the tripped safety functions via PROFIsafe. SF_end_ack_req = 0, otherwise. • FSO_state =1

State	Description
Safe (Module passivation)	The FSO application is running and there has been an error in the PROFIsafe communication. The FSO module and, as a result, all its I/O channels are passivated. Possible reasons for module passivation are: 1. PROFIsafe communication failure (CRC error) 2. PROFIsafe watchdog timeout exceeded. The drive is stopped using the configured method. In the end, the drive STO is activated. The fail-safe value “0” is set to all I/O channels. If the connection to the PROFIsafe F-Host is possible, the fail-safe value “0” is transferred to the safety PLC for all I/O channels. If the PROFIsafe communication is broken, the safety application continuously attempts to establish a communication to the safety PLC. A state transition to another RUN state is possible only if the detected error has been solved. PROFIsafe Status Byte bits in the F-Host for the FSO module (if communication is possible): • OA_Req_S = 0 • FV_activated_S = 1 • Device_Fault = 0 • CE_CRC = 1, in case of a communication error, CE_CRC = 0, otherwise • WD_timeout = 1, in case of a watchdog timeout, WD_timeout = 0, otherwise ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 1 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 1

State	Description
Safe (Module passivation with a command)	PROFIsafe communication is up and running. The FSO application is running without any detected errors. The FSO module and all its I/O channels are passivated because the safety application on the safety PLC requested a module passivation (activate_FV_C = 1 was set). The drive is stopped using the configured method. In the end, the drive STO is activated and the FSO module is in the Safe state. The fail-safe value “0” is set to all I/O channels. The fail-safe value “0” is transferred to the safety PLC for all I/O channels. PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 1 • Device_Fault = 0 ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 1 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 1
Safe (User acknowledgement request)	PROFIsafe communication is up and running. The FSO application is running without any errors but waits for the acknowledgment of a module reintegration (module error has been solved). The FSO module is in the Safe state. The fail-safe value “0” is still transferred to the safety PLC for all input channels. All output channels have a state of “0”. The OA_Req_S bit is reported as “1”. As soon as the safety application in the safety PLC sets OA_C (positive edge), the FSO module goes to the Operational state if no further errors are detected. The OA_C must be “1” until OA_Req_S starts to deliver “0”. PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 1 • FV_activated_S = 1 • Device_Fault = 0 ABB_PS1 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 0 • FSO_mode.0 = 1 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 1

State	Description
Fail-safe	The FSO application keeps the system in the Fail-safe mode. PROFIsafe communication is up and running. This state is reached if a fatal error (for example, CPU test, RAM test, I/O channel test etc. failed) takes place. The drive is stopped using the configured method. In the end, the drive STO is activated. The fail-safe value “0” is set to all I/O channels. The fail-safe value “0” is transferred to the safety PLC for all I/O channels. This state can be left only to the Start-up mode by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual). PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 1 • Device_Fault = 1 ABB_PS1 or ABB_PS2 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 1 • FSO_mode.0 = 0 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state =1 See also the Note on page *169*.
Configuration	The FSO module is in the Safe state. Upon transferring to the Configuration mode, the FSO answers to one PROFIsafe frame. The fail-safe value “0” is transferred to the safety PLC for all I/O channels. After that PROFIsafe communication is not possible. The fail-safe value “0” is set to all I/O channels. This state can only be entered from the Fail-safe mode or from any other state when the drive is not modulating. This state can be left only to the Start-up mode by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual). PROFIsafe Status Byte bits in the F-Host for the FSO module: • OA_Req_S = 0 • FV_activated_S = 1 • Device_Fault = 0 ABB_PS1 profile bits in the F-Host for the FSO module: • FSO_mode.1 = 1 • FSO_mode.0 = 1 • SF_end_ack_req_local = 0 • SF_end_ack_req = 0 • FSO_state = 1 See also the Note on page *169*.

Transitions between states

This table describes the transitions between the FSO module states. The numbering of the transitions refer to the transitions shown in the state diagrams on page *178*.

ID	From	To	Description
1	Start-up	Safe (Module passivation with a command)	The FSO module goes to this state directly after Start-up during a normal start-up.
2	Operational	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
3	Start-up	Safe (Module passivation)	PROFIsafe watchdog time or PROFIsafe communication error was detected directly after Start-up.
4	Safe (Module passivation)	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
5	Start-up	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
6	Fail-safe	Start-up	The FSO module goes to the Start-up mode by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
7	Operational	Safe (Module passivation & reintegration)	Execution of at least one safety function encountered a problem. The system reaches the Safe state. As soon as at least one of the errors can be acknowledged, it can be done locally, via PROFIsafe, or automatically depending on the FSO configuration.
8	Safe (Module passivation & reintegration)	Operational	All the related errors have been solved and acknowledged.
9	Operational	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
10	Operational	Safe (Module passivation)	PROFIsafe watchdog time or PROFIsafe communication error was detected.
11	Operational	Safe (Module passivation with a command)	Command “activate_FV_C = 1” was sent from the safety PLC.

ID	From	To	Description
12	Safe (Module passivation & reintegration)	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
13	Safe (Module passivation)	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
14	Safe (Module passivation & reintegration)	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
15	Start-up	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
16	Safe (User acknowledgement request)	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
17	Safe (User acknowledgement request)	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
18	Safe (Module passivation with a command)	Safe (Module passivation)	PROFIsafe watchdog time or PROFIsafe communication error was detected.
19	Safe (Module passivation)	Safe (Module passivation with a command)	Module error (watchdog time or communication error (CRC)) has been solved and command “activate_FV_C = 1” is received.
20	Safe (User acknowledgement request)	Safe (Module passivation)	PROFIsafe watchdog time or PROFIsafe communication error was detected.
21	Safe (Module passivation)	Safe (User acknowledgement request)	Module error (watchdog time or communication error (CRC)) has been solved and • command “activate_FV_C = 0” then • the FSO module sets OA_Req_S = 1.
22	Safe (User acknowledgement request)	Operational	OA_C (positive edge) was set by the PROFIsafe F-Host for the FSO module.
23	Safe (User acknowledgement request)	Safe (Module passivation with a command)	Command “activate_FV_C = 1” was sent from the PROFIsafe F-Host.

ID	From	To	Description
24	Safe (Module passivation with a command)	Safe (User acknowledgement request)	Command “activate_FV_C = 0” has been received and “OA_Req_S = 1”.
25	Safe (Module passivation with a command)	Fail-safe	Fatal error(s) (CPU test, RAM test, etc. failed) detected.
26	Safe (Module passivation with a command)	Start-up	The FSO module goes to this state by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).
27	Safe (Module passivation with a command)	Operational	No module error and “activate_FV_C = 0”.
28	Safe (Module passivation & reintegration)	Safe (Module passivation)	PROFIsafe watchdog or PROFIsafe communication error was detected.
29	Safe (Module passivation & reintegration)	Safe (Module passivation with a command)	Command “activate_FV_C = 1” was sent from the safety PLC.
30	Safe (User acknowledgement request)	Safe (Module passivation & reintegration)	OA_C (positive edge) was set by the PROFIsafe F-Host, but there are existing errors in the active safety functions or there are errors that need to be acknowledged.
31	Safe (Module passivation with a command)	Safe (Module passivation & reintegration)	Command “activate_FV_C = 0” was set by the PROFIsafe F-Host but there are existing errors in the active safety functions or there are errors that need to be acknowledged.
32	Any state when the motor is not running	Configuration	Drive composer pro connects to the FSO module and as a result the FSO goes to the Configuration sate.
33	Configuration	Start-up	From the Configuration mode, it is possible to go only to the Start-up mode by cycling power of the FSO module or by giving the reset command via the drive (parameter *96.09 FSO reboot*, see the drive firmware manual).

PROFIsafe response time

The safety function response time (SFRT) is the time within which the safety system must react after an error has occurred in the system.

SFRT is also the maximum time within which the safety system must respond to a change in the input signals.

According to *PROFIsafe System Description, Version November 2010,* SFRT for PROFIsafe devices can be defined as:

SFRT = TWCDT + Longest ∆T_WD

where

- TWCDT (total worst case delay time) is the maximum time for input signal transfer in the safety system until the output reaction under worst-case conditions (all components require the maximum time)
- Longest ∆T_WD is the longest time difference between the watchdog time for a given entity and the worst case delay time.

In safety systems, to define SFRT you must take into account a potential single fault in one of the components during the signal transfer. It is enough to consider a single fault only (see *PROFIsafe System Description, Version November 2010)*.

The worst case delay time (WCDT) and watchdog (WD) values for the FSO and FENA modules are listed in the table below.

Device	WCDT	Device WD
FSO	50 ms	50 ms
FENA-21	3 ms	-

The documentation of the safety PLC defines how you can calculate the processing time and transmission time of the PROFIsafe connection.

For example, *AC500-S Safety User Manual* (3ADR025091M0202 [English]) proposes that SFRT is calculated using the following formula:

SFRT = Device_WD1 + 0.5 x F_WD_Time1 + F_Host_WD + 0.5 x F_WD_Time2 + Device_WD2 + Longest ∆T_WD

where

- Device_WD1 is an internal input device watchdog time
- F_WD_Time1 is the watchdog time for receipt of the new valid telegram (from the input device to the safety PLC)
- F_Host_WD is the watchdog time of the safety PLC
- F_WD_Time2 is the watchdog time for receipt of the new valid telegram (from the safety PLC to the output)
- Device_WD2 is an internal output device watchdog time.

Instead of WCDT values, the calculation uses watchdog times. See *AC500-S Safety User Manual* (3ADR025091M0202 [English]) for details.

For example, when using the ABB AI581-S as the input device, the SM560-S safety PLC and the FSO module as the output device, SFRT can be calculated as follows:

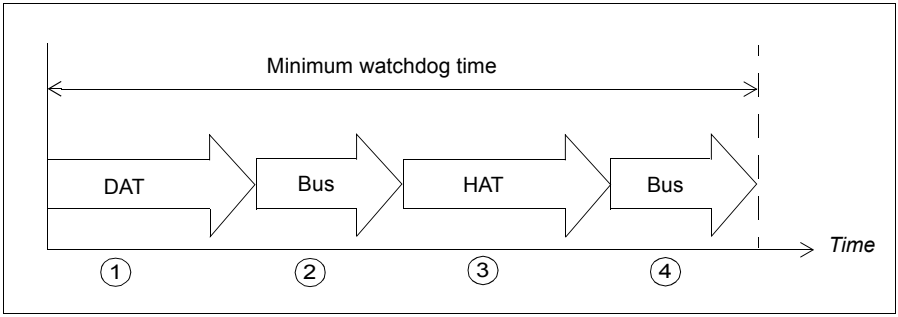
$$\begin{aligned} SFRT &= Device_WD1 + 0.5 \times F_WD_Time1 + F_Host_WD + 0.5 \times F_WD_Time2 \\ &\quad + Device_WD2 + Longest\ \Delta T_WD \\ &= 76.5 + 15 + 6 + 45.5 + 50 + 45.5 = 238.5\ ms \end{aligned}$$

where

- Device_WD1 = 76.5 ms
- F_WD_Time1 = 30 ms
- F_Host_WD = 6 ms
- F_WD_Time2 = 91 ms
- Device_WD2 = 50 ms
- Longest ΔT_WD = Max (0.5 x F_WD_Time1; 0.5 x F_WD_Time2) = 45.5 ms (all other used WCDT values are equal to their corresponding watchdog times).

PROFIsafe watchdog time

F-Parameter F_WD_Time determines the watchdog time for the PROFIsafe connection. The minimum watchdog time is composed of four timing sections as shown in this figure.



1. Device acknowledgement time (DAT) is the time it takes for the F-Device (such as the FSO module) to process an incoming PROFIsafe frame. DAT starts when the F-Device receives the PROFIsafe frame and ends when the F-Device has prepared a new PROFIsafe frame using the currently available process values.
2. Bus time is the time it takes when the PROFIsafe frame is transmitted from the F-Device (FSO module) to the F-Host (such as the ABB SM560-S safety controller station) through the "black channel".
3. Host acknowledgement time (HAT) is the time it takes for the F-Host to process an incoming PROFIsafe frame.
4. Another Bus time elapses when the new PROFIsafe frame is transmitted from the F-Host back to the F-Device.

F_WD_Time assigned to the FSO module must be higher than the minimum watchdog time. The worst case delay time of the FSO module also depends on the safety functions that are used simultaneously and on the PROFIsafe cycle time. The longest worst case delay time of the FSO module is 50 ms which is based on its internal watchdog.

Calculating the watchdog time

It is not always easy to calculate the worst case delay time of “black channel” components. See *AC500-S Safety User Manual* (3ADR025091M0202 [English]) for a proposed method of tracing the actual PROFIsafe cycle times in a real system.

You must then set F_WD_Time about 30% higher than the worst case value in variable tResponseTimeMS (in the AC500-S safety program) for the given safety device.

If you use this approach for the FSO module, you can set the PROFIsafe cycle time and the corresponding watchdog time F_WD_Time as short as possible for the given system.

If the longest recorded PROFIsafe cycle time (minimum F_WD_Time) is, for example, 40 ms, a suitable value for F_WD_Time is:

F_WD_Time = 40 ms x 1.3 = 52 ms.

If you can calculate F_WD_Time instead, use the values given in the table on page *189*. DAT time for the FSO module is 50 ms and the FENA-21 module adds 3 ms to both Bus times.

For example, if HAT is 6 ms and Bus times are 4 ms until FENA, F_WD_Time is:

F_WD_Time = (50 ms + (3 ms + 4 ms) + 6 ms + (4 ms + 3 ms)) x 1.3 = 91 ms.

Installation

Installation procedure:

1. Install the FSO safety functions module to the drive, see chapters *Planning for installation* and *Installation* and the drive hardware manual.
2. Install the FENA-21 Ethernet adapter module to the drive. See *FENA-01/-11/-21 Ethernet adapter module user's manual* (3AUA0000093568 [English]).
3. Connect the FENA-21 adapter module to the safety PLC through a PROFINET network. See *FENA-01/-11/-21 Ethernet adapter module user's manual* (3AUA0000093568 [English]) and the user's manual of the safety PLC.

Configuration

Configuring the FENA adapter module

You can use either the drive control panel or the Drive composer pro PC tool to modify the settings of the FENA adapter module.

Note: This section describes only the most important configuration steps. For more detailed information, see *FENA-01/-11/-21 Ethernet adapter module user's manual* (3AUA0000093568 [English]) and the drive firmware manual.

Parameters for the PROFINET communication

1. Depending on the drive, you can configure the FENA module as fieldbus channel A or B. Enable the communication between the drive and the FENA module for the option slot in which the FENA module is installed into (parameter *50.01 FBA A enable* or *50.31 FBA B enable*).
2. Set the FENA parameters that correspond to the selected fieldbus channel. Parameter groups 51, 52 and 53 include the settings for FBA A and groups 54, 55 and 56 for FBA B.

   Groups 52, 53, 55 and 56 configure the contents of the normal PROFINET cyclic communication by mapping the words in the PROFINET frame to the desired drive parameters.

   Groups 51 and 54 configure the PROFINET connection.

Index	Name/Value	Description	Example value
50.01	FBA A enable	Enables/disables communication between the drive and fieldbus adapter A and specifies the slot the adapter is installed into.	
	Option slot 1	Communication between drive and fieldbus adapter A enabled. The adapter is in slot 1.	1
50.31	FBA B enable	Enables/disables communication between the drive and fieldbus adapter B, and specifies the slot the adapter is installed into.	
	Disable	Communication between drive and fieldbus adapter B disabled.	0
51/54.01	FBA A/B type	Shows the type of the connected fieldbus adapter module A/B. This parameter is read-only.	Ethernet
51/54.02	FBA A/B PAR2 (PROTOCOL/ PROFILE)	Selects one of the PNIO profiles.	
	PNIO ABB Pro	Profile PNIO ABB Pro is selected	11
51/54.03	FBA A/B PAR2 (COMMRATE)	Sets the Ethernet communication rate.	

Index	Name/Value	Description	Example value
	Auto	Ethernet communication rate is negotiated automatically by the device.	0
51/54.04…13	IP CONFIGURATION	The user can set the IP configuration for the network in these parameters or in the PLC project.	Static IP 0
51/54.20	Telegram type	Shows the telegram type for the selected I/O communication. This parameter is read-only.	
	PPO4	PPO Type 4	4
51/54.21	Alarm disable	Enables/disables the sending of diagnostic messages to the PROFINET network.	
	Enabled	Diagnostic messages are sent.	0
51/54.27	FBA A/B PAR REFRESH	Validates any changed FENA module configuration settings and reboots the FENA module taking all the changes to the drive parameters in use. After refreshing, the value reverts automatically to Done (0). **Note**: This parameter cannot be changed while the drive is running.	
	REFRESH	Refreshing.	1

Note: When the FENA module is installed to the drive for the first time, you must set the value of parameter *51/54.02* to one of the PROFINET profiles (value *11* if a drop-down list is unavailable) and reboot the FENA module with parameter *51/54.27*. Only after this, the rest of the parameters in group 51/54 get the correct texts and options. If required, you must reconnect Drive composer pro to the drive to get the parameters show up correctly (select **Refresh** from the **New** menu).

See the FENA user's manual and the drive firmware manual for all necessary parameter settings and detailed instructions on how to control the drive and motor using the normal PROFINET cyclic communication.

Configuring the FSO module

Set the FSO module parameters as described in section *Configuring the safety fieldbus communication* on page *254*.

Configuring the safety PLC

After the drive has initialized the FENA adapter module, you must prepare the safety PLC for communication with the adapter module. Examples of ABB AC500-S Safety PLC and Siemens SIMATIC Fail-safe S7 PLC are given below. The examples include the minimum required steps for starting the PROFINET and PROFIsafe communication with the FENA and FSO modules. For detailed information, see the documentation of your safety PLC.

The examples apply to all drive types that are compatible with the FENA and FSO modules.

Downloading the GSD file

To configure the controller station, you need a type definition (GSD) file. In PROFINET IO, the GSD file is written in an XML-based language called GSDML.

Download the FENA GSD file from the ABB Document library (www.abb.com/drives/documents). The file name format is: **GSDML-Vx.x-ABB-FENA-yyyymmdd.xml.**

The GSD file describes the vendor-specific, PROFIdrive-specific and PROFIsafe-specific features of the adapter module. You can use the vendor-specific features, for example, in the ABB Drives communication profile. The PROFIdrive profile supports a set of services described in the PROFIdrive specification.

The actual PROFIsafe messages are processed in the FSO module. The GSD file and the instructions in this chapter refer to the FENA adapter module which is the device that is connected to PROFINET.

Configuring the ABB AC500-S Safety PLC

This example shows how to configure the communication between the ABB AC500-S Safety PLC and the FENA-21 adapter module using PS501 Control Builder Plus (software version 2.3.0).

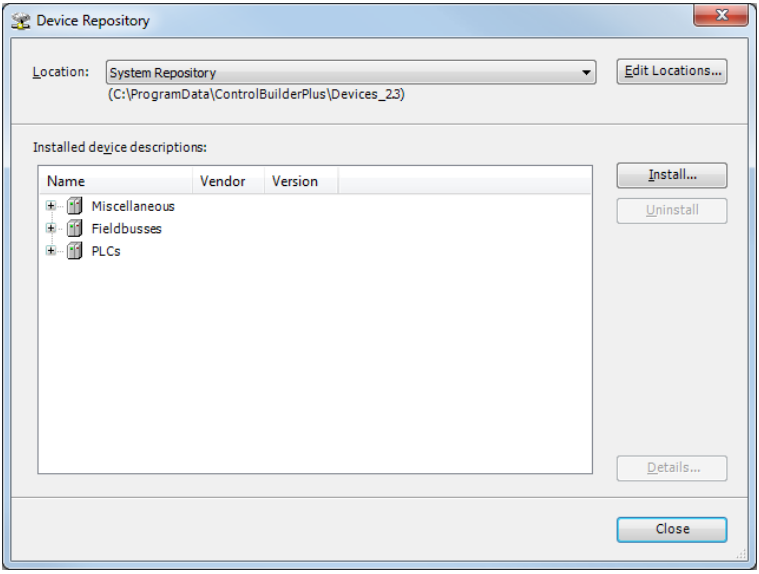
Before you use the safety configuration and programming tools in PS501 Control Builder Plus, you must study the AC500-S Safety PLC user manual (*AC500-S Safety User Manual* (3ADR025091M0202 [English]). Only qualified persons are allowed to work with the AC500-S Safety PLC.

You need a password to configure the safety parts of a Control Builder Plus project. In all new PS501 Control Builder Plus projects, there is a default user "Owner" with an empty password. This is a project administrator who can, for example, access the safety controller station. For detailed information on the passwords and access permissions in Control Builder Plus, see the AC500-S Safety PLC user manual.

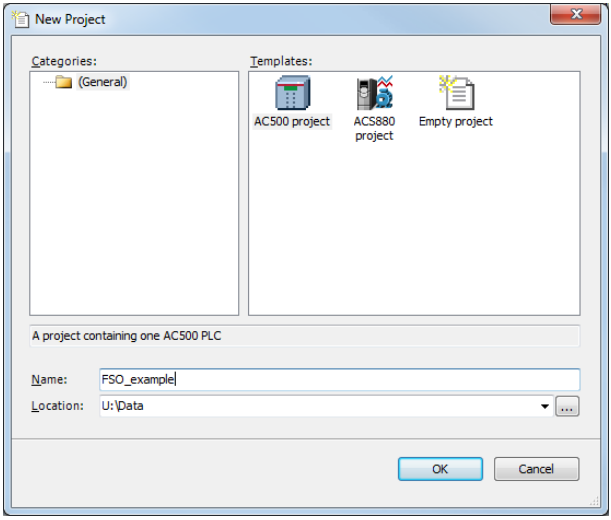
You can find the complete documentation of ABB PLCs and the PS501 Control Builder Plus application in www.abb.com/PLC.

Before you start, make sure that you have downloaded the FENA GSD file from the ABB Document library. See section *Downloading the GSD file* on page *196*.

1. Start the ABB Control Builder application.
2. On the **Tools** menu, select **Device Repository**.
3. In the window that opens, click **Install...** and browse for the GSD file.



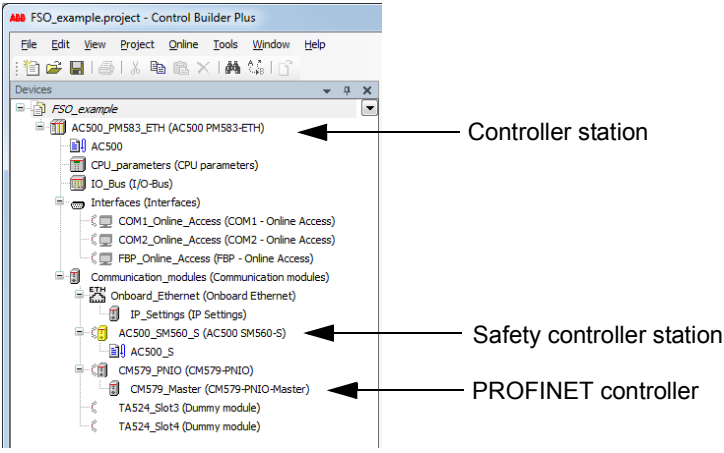
4. Open or create the PLC project that is used to control the drive.



5. Add the necessary controller devices to the PLC project.

   In the project below, these controller stations have been added:

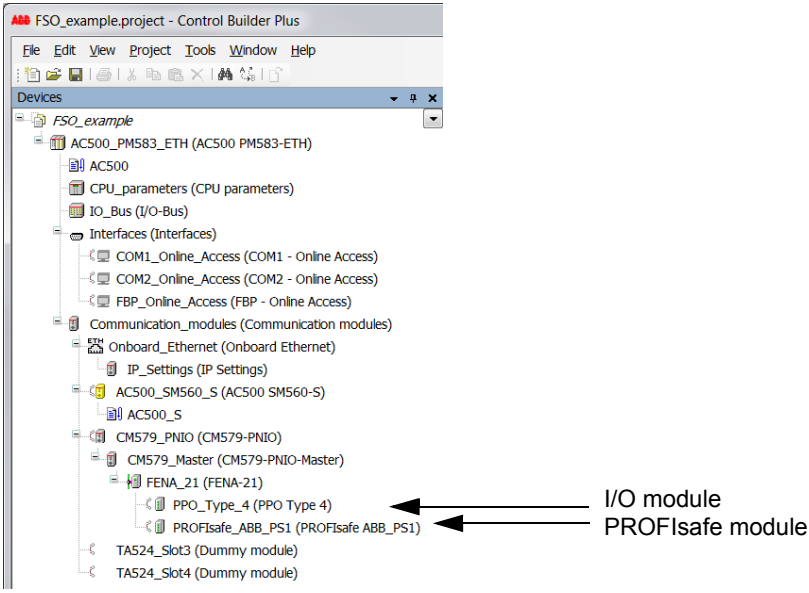
   - controller station AC500 PM583-ETH,
   - safety controller station AC500 SM560-S and
   - PROFINET controller CM579-PNIO.



Note: Make sure that the “Enable debug” setting is On for the safety controller station, if you want to view or debug the PLC program after the download.

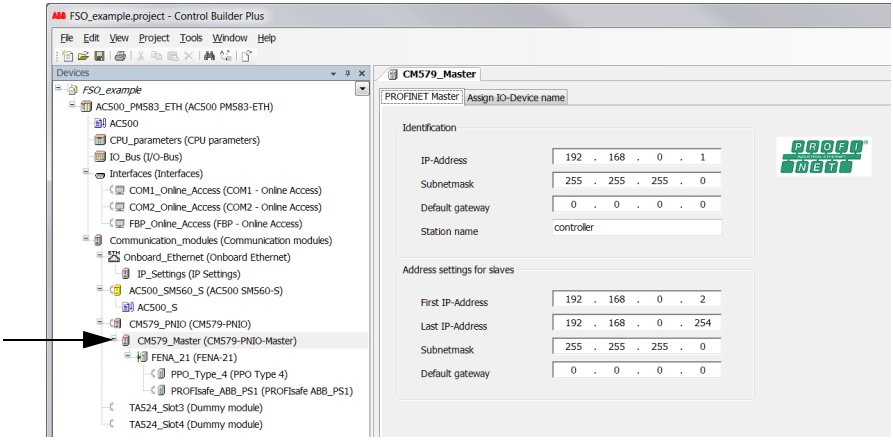
6. Right-click on the PROFINET controller **CM579-PNIO-Master** and add the FENA module to the PROFINET IO network.

7. Add the desired I/O module, for example, “PPO Type 4” to the first slot of the FENA module to define cyclic communication between the module and the PLC.
8. Add the PROFIsafe module “PROFIsafe ABB_PS1” to the second slot of the FENA module to define cyclic communication between the module and the PLC.

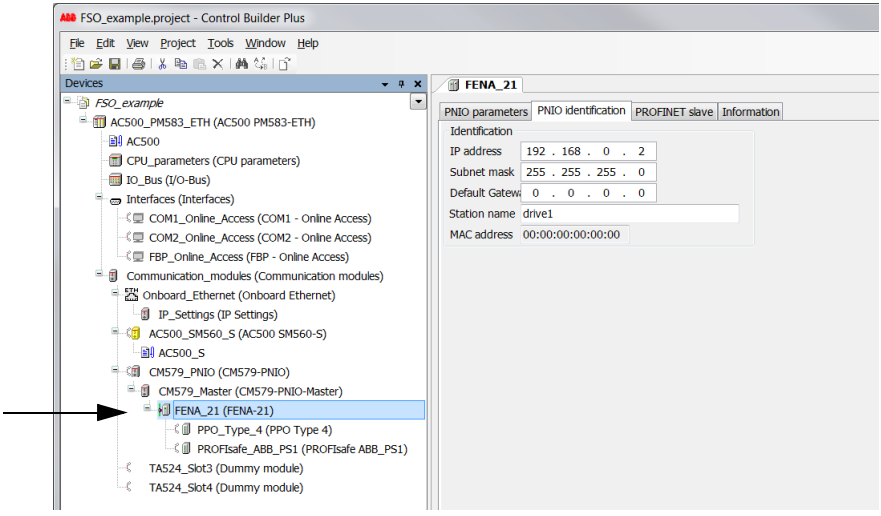


9. Download the safety and “non-safety” PLC programs.

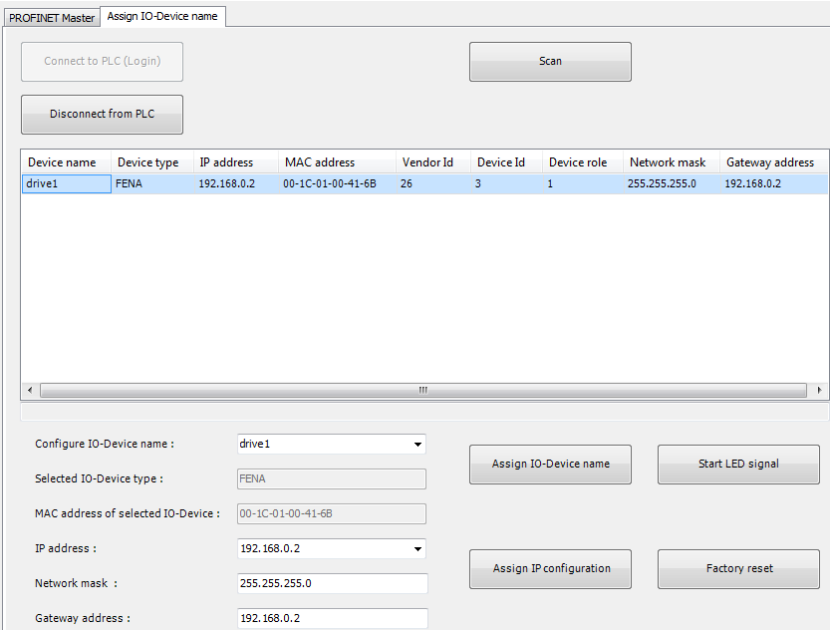
10. Define the PROFINET controller (CM579-PNIO) properties, such as the IP address and IP address settings for devices:
    - Select CM579_Master.
    - On the PROFINET Master tab, define the necessary IP addresses.



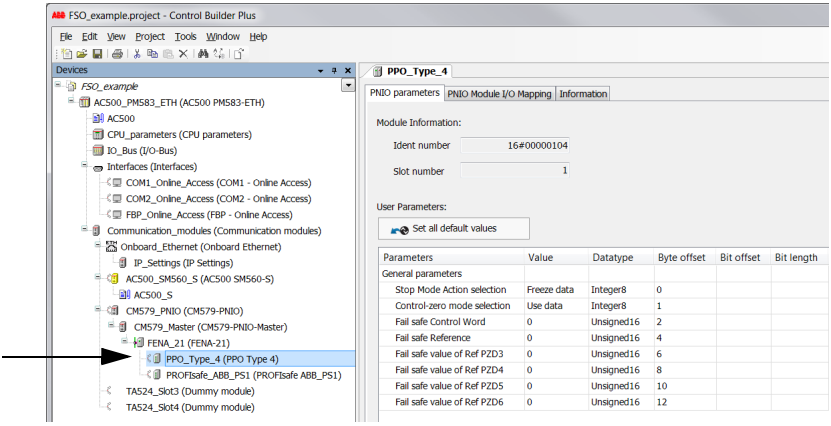
11. Define the FENA properties:
    - Select **FENA_21**.
    - On the **PNIO identification** tab, define the IP address and Subnet mask, and type the Station name (in this example, drive1).
      Note: Use only lower case letters for the Station name.



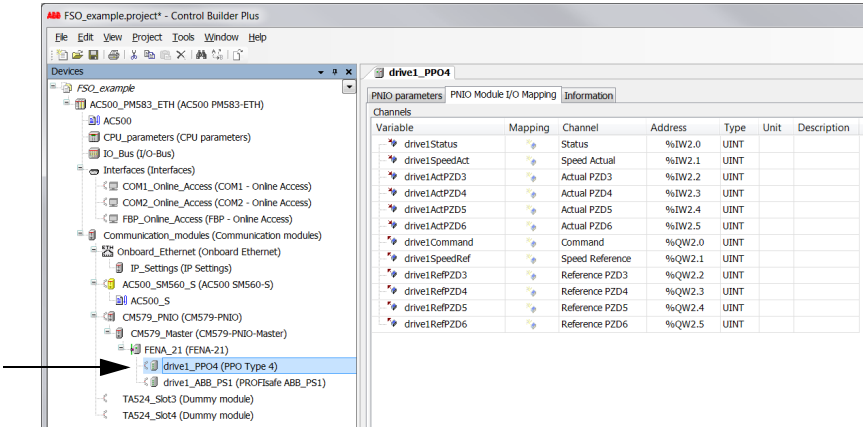
12. Return to the PROFINET controller (CM579-PNIO) properties. On the **Assign I/O Device Name** tab:
    - Click **Connect to PLC (Login)** and select the communication link used between Control Builder and the PLC.
    - Click **Scan** to find all PROFINET devices connected to the network.
    - In the **Configure station name** box, select the station name defined for the module in step 10 (in this example, drive1), and click **Assign I/O Device name**.
    - In the **IP address** and **Network mask** boxes, type the IP address and subnet mask defined in step 11, and click **Assign IP configuration**.



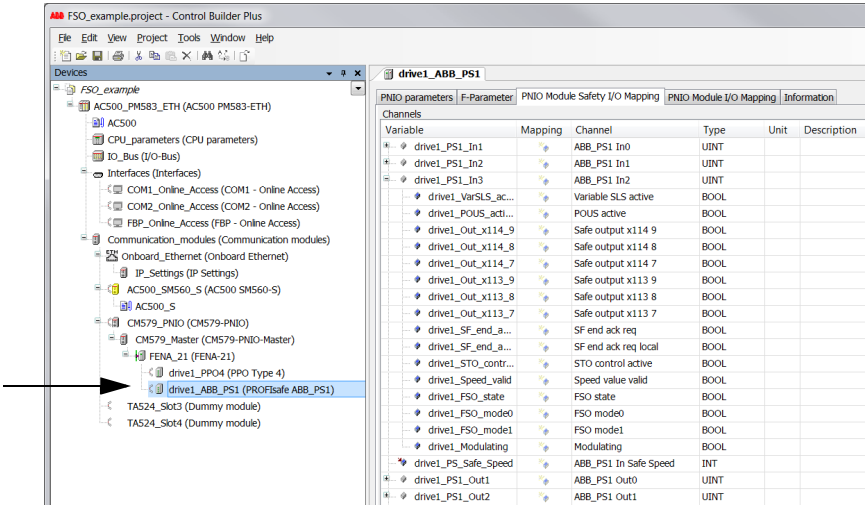
13. Define the I/O module properties:
    - Select the I/O module **PPO_Type_4**.
    - On the **PNIO parameters** tab, configure the Stop Mode Action and Control-zero mode functions, and define Fail safe values for the PLC output process data (PZDs).



    - Rename the I/O modules, for example, drive1_PPO4 and drive1_ABB_PS1.
    - On the **PNIO Module I/O Mapping** tab, type names for the variables that refer to the drive's signals in the PLC program. (See section *ABB_PS1 profile F-Output user data* on page *167*.)



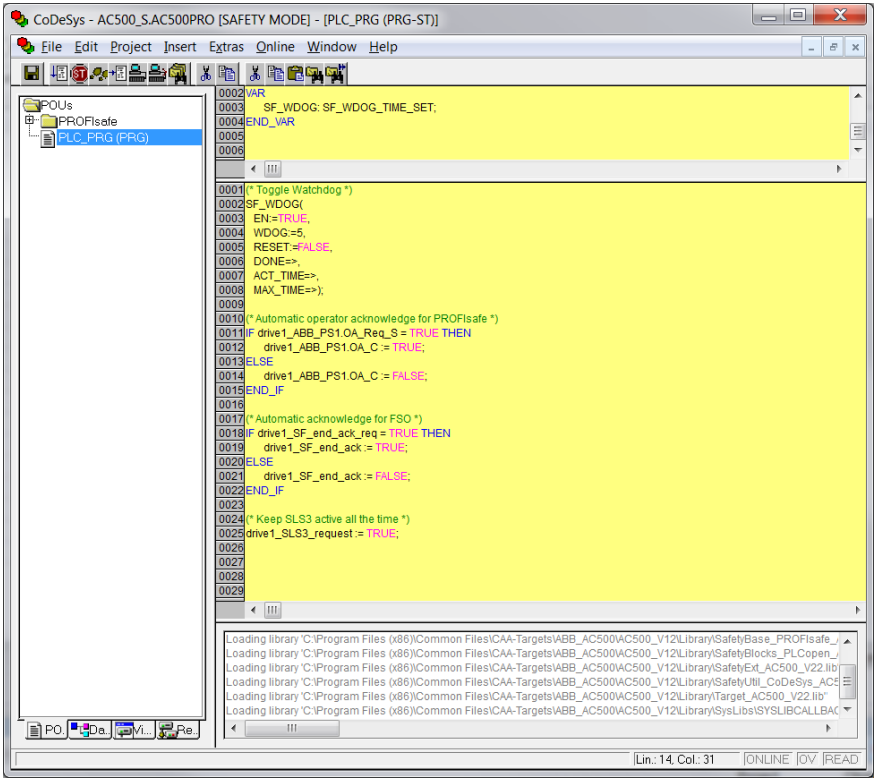
14. Define the PROFIsafe module properties:
    - Select the PROFIsafe module **PROFIsafe_ABB_PS1**.
    - On the **F-Parameter** tab, modify the PROFIsafe safety parameters. Three of the listed parameters can be modified for FENA:
        - F_Source_Add is the address of the safety controller station (in this example, AC500 SM560-S).
        - F_Dest_Add is the address of the FENA module. This is defined by FSO parameter *PROFIsafe. 11*, see section *Configuring the safety fieldbus communication* on page *254*.
          These two define the codename for the PROFIsafe relationship of this particular FENA module and the safety controller station.
        - F_WD_Time is the PROFIsafe watchdog time. See section *Calculating the watchdog time* on page *192* for instructions on how to calculate the correct watchdog time.
    - On the **PNIO Module Safety I/O Mapping** tab, type names for the variables that refer to the PROFIsafe message data in the safety PLC program. (See section *ABB_PS1 profile F-Output user data* on page *167*.)



15. Create the configuration data for the controller station:
    - Right-click on the **AC500** and select **Create Configuration Data**.
16. Create the safety configuration data for the controller station:
    - Right-click on the **AC500_S** and select **Create Safety Configuration Data**.
17. Create a program that controls the drive:
    - Double-click the **AC500.** This opens the PLC program in the CoDeSys programming tool.
18. Create a safety program that controls the FSO via PROFIsafe:
    - Double-click the **AC500_S.** This opens the safety PLC program in the CoDeSys programming tool.

    Note: If you do not have an existing safety program, you must at least implement watchdog toggling.

WARNING! Do not use this safety program in real safety applications. This safety program is shown only as an example and can only be used for trial purposes.

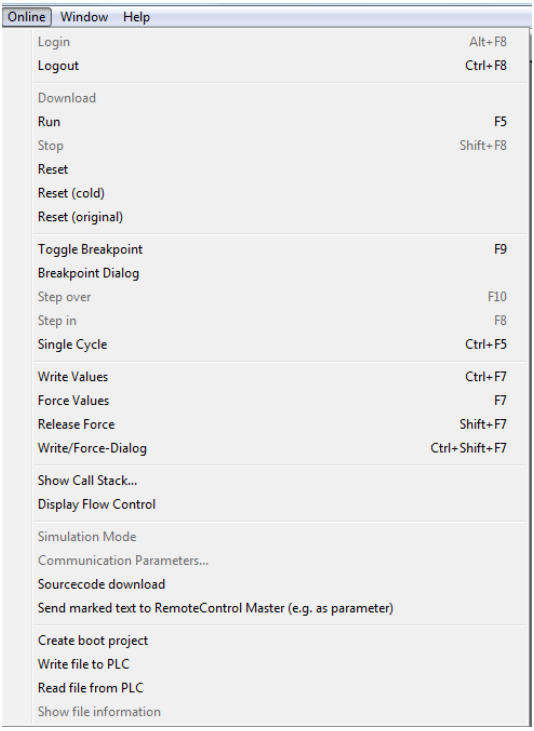


Note: This example program also keeps the SLS3 function active all the time.

19. For the “non-safety” program:
    - In the **Project** menu, select **Build**.
    - In the **Online** menu, select **Login.**

    Note: If there are communication problems at this point, select **Communication parameters...** from the **Online** menu.

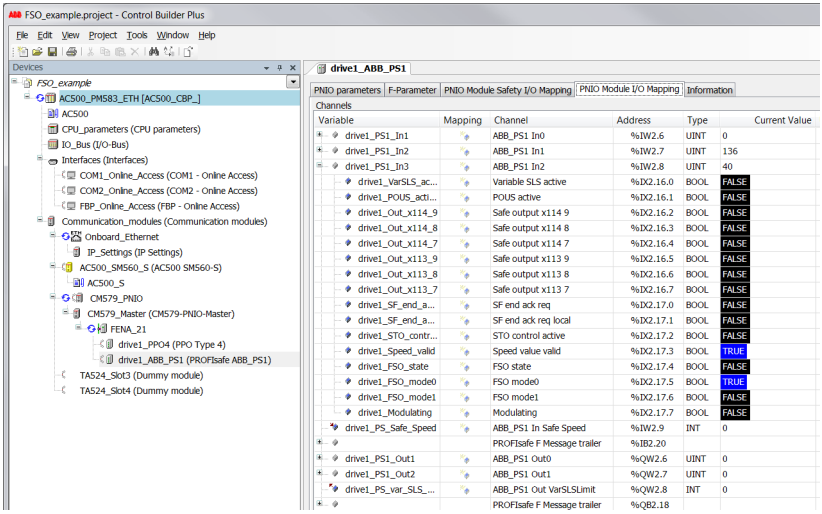
    Note: To make sure that the program is downloaded to the PLC (even when no changes have been made), select **Clean all** from the **Project** menu.
    - In the window that opens, click **Yes**. This downloads the program to the PLC.
    - In the **Online** menu, select **Create boot project**. This saves the program permanently to the PLC.
    - In the **Online** menu, select **Logout.**
20. Repeat step 19 for the safety program.
21. Switch the power of both PLCs off and on.
22. For the “non-safety” program:
    - In the **Online** menu, select **Login.**
23. In the **Online** menu of the “non-safety program”, select **Run.** This starts both programs.



Monitoring the PROFIsafe message

It is possible to monitor the contents of the PROFIsafe message. For example:

1. Check the variable values in the **Current Value** column on the **PNIO Module I/O Mapping** tab.



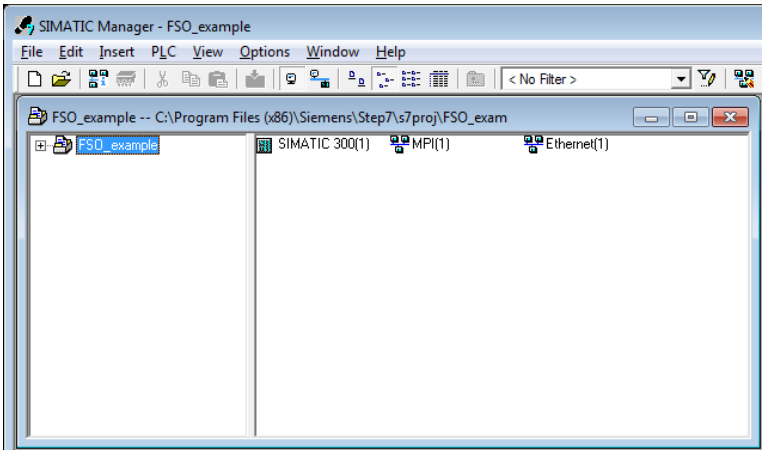
Configuring the Siemens SIMATIC Fail-safe S7 PLC

This example shows how to configure the communication between the Siemens SIMATIC Fail-safe S7 PLC and the FENA-21 adapter module using SIMATIC Manager Step 7 (version V5.5+SP2) and S7 Distributed Safety Programming (version V5.4+SP5).

For detailed configuration instructions, see the documentation of the safety PLC (*S7 Distributed Safety - configuring and programming, Programming and Operating Manual, 07/2013, A5E00109537-05*).

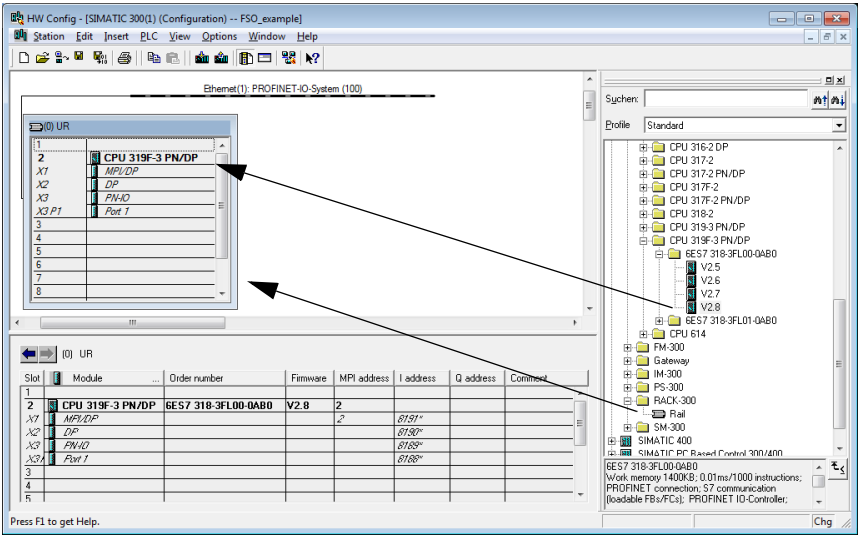
Before you start, make sure that you have downloaded the FENA GSD file from the ABB Document library. See section *Downloading the GSD file* on page *196*.

1. Start SIMATIC Manager and open/create a SIMATIC project.
2. Add the necessary objects to the project.
   In this example, a SIMATIC 300 Station and an Industrial Ethernet object have been added.

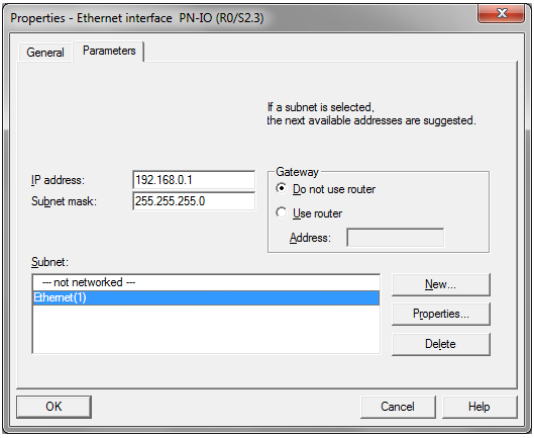


3. Open the hardware configuration of the project.

4. Select the controller station and rail from the catalog and drag them to the project. This example project uses a CPU 319F-3 controller station (V2.8) that is installed in a RACK-300 Rail.

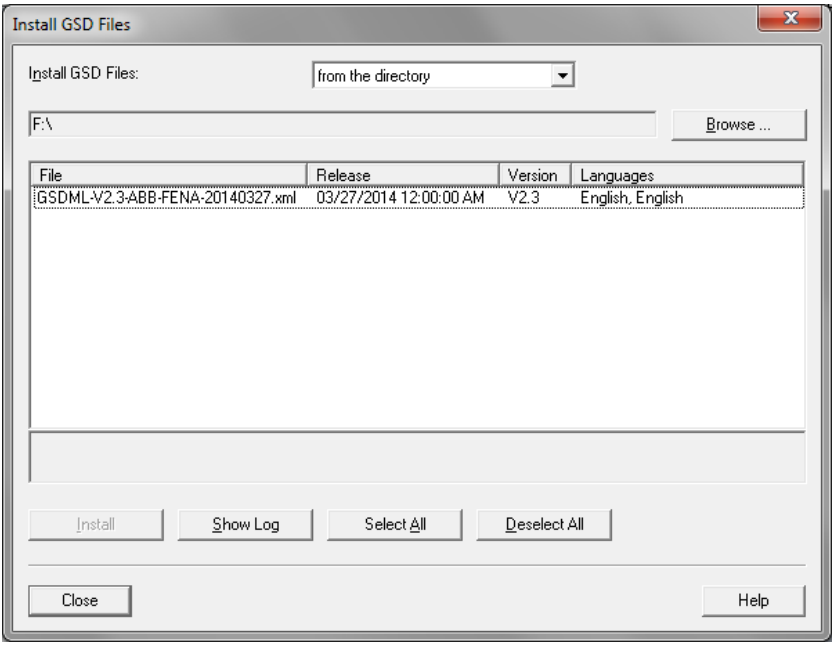


5. When you install the controller station to the rail, select Industrial Ethernet as the subnet for the controller station.



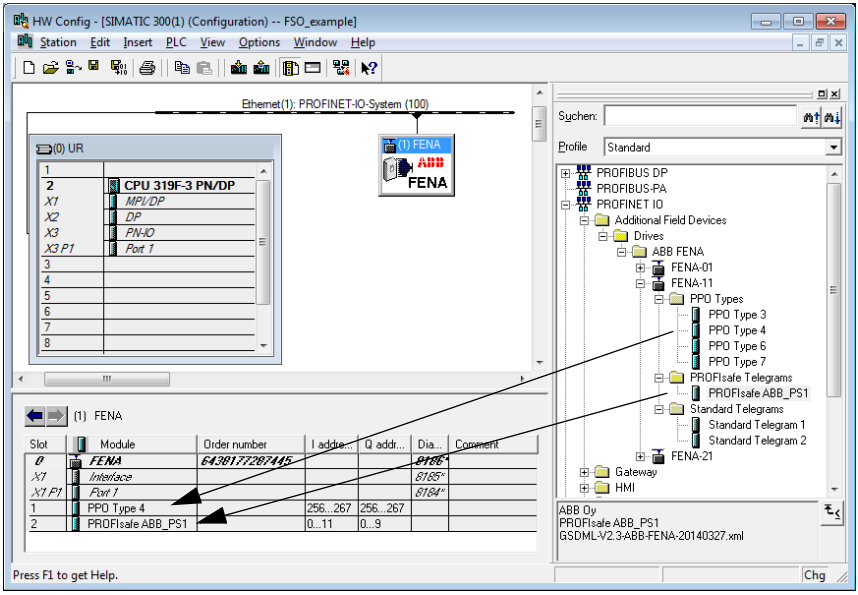
6. Install the FENA GSD file:
   - In the **Options** menu, select **Install GSD Files**.
   - Browse for the GSD file that you downloaded from the ABB Document library.
   - Click **Install**.

Note: In some versions of the SIMATIC environment, you have to close the whole SIMATIC program and open it again to make the new GSD file visible in the object catalogue.



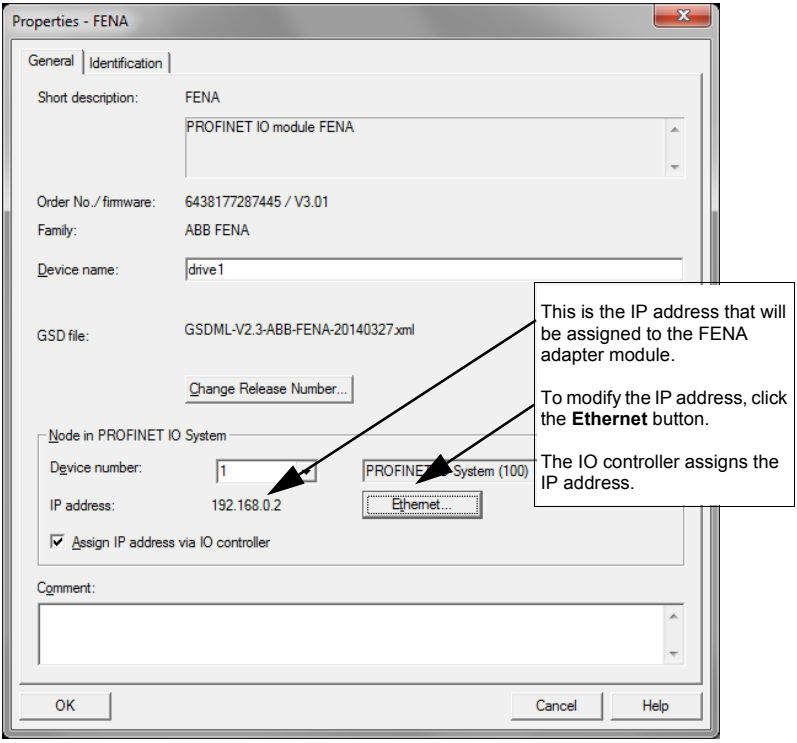
7. Click and drag the FENA object from the device catalog to the Ethernet (1): PROFINET-IO-System.

8. Click and drag the desired I/O object, for example PPO Type 4, to the first slot of the FENA module to define cyclic standard communication between the module and the PLC.
9. Click and drag the PROFIsafe object PROFIsafe ABB_PS1 to the second slot of the FENA module to define cyclic safety communication between the module and the PLC.



10. Double-click **FENA** to open the **Properties** window.

11. On the **General** tab, type the Device name for the adapter module (in this example, drive1).

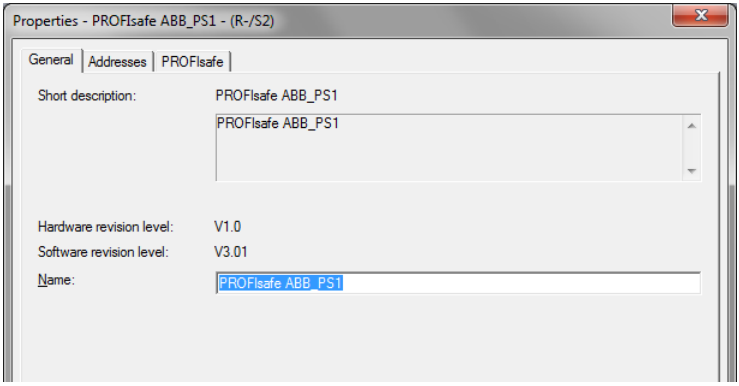


Note: Do not change the IP address assigned here. Use the same IP address for the FENA adapter module also in other tools (eg, the Drive composer pro PC tool) which you use to connect to the drive.

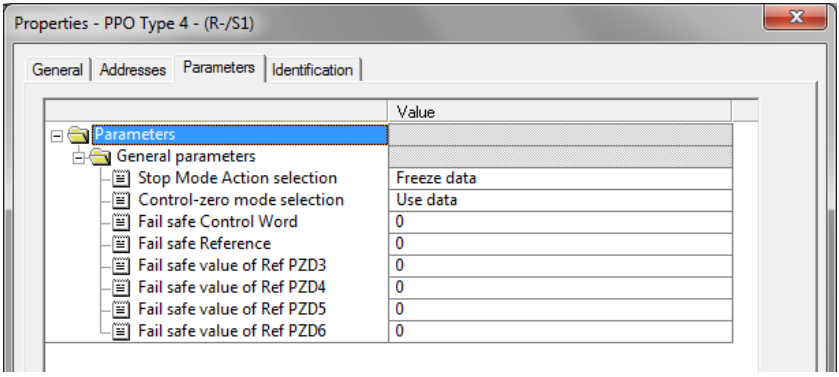
12. Click **OK**.

13. In the hardware configuration, double-click the I/O object (PPO Type 4) in Slot 1 to open the **Properties** window.

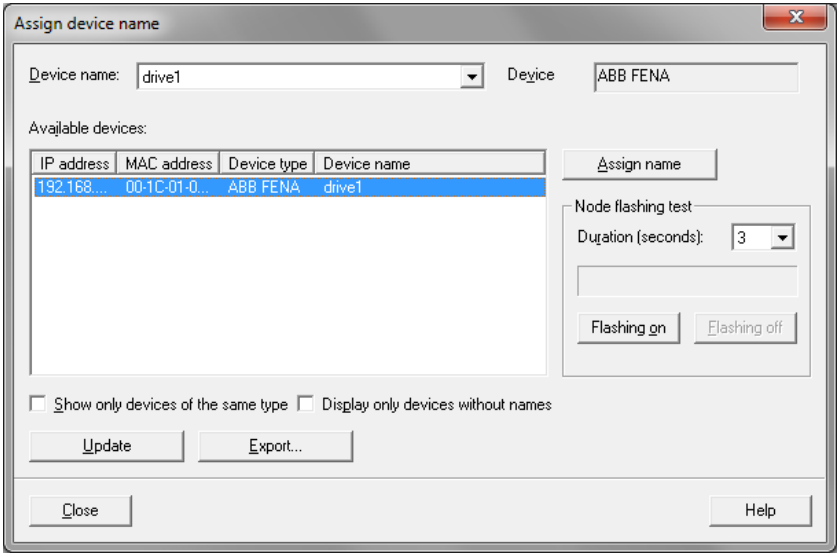
14. Type a name for the I/O object (in this example, PROFIsafe ABB_PS1).



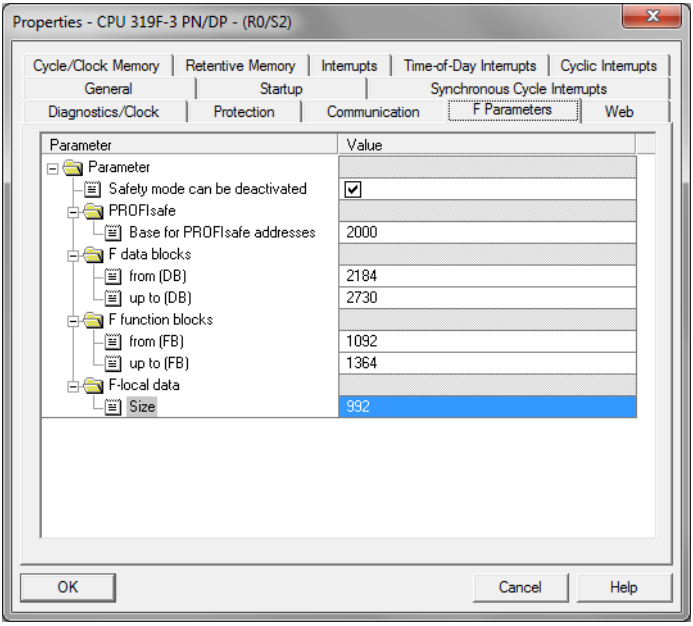
15. On the **Parameters** tab, configure the Stop mode and Control-zero mode functions, and define Fail safe values for the PLC output process data (PZDs).



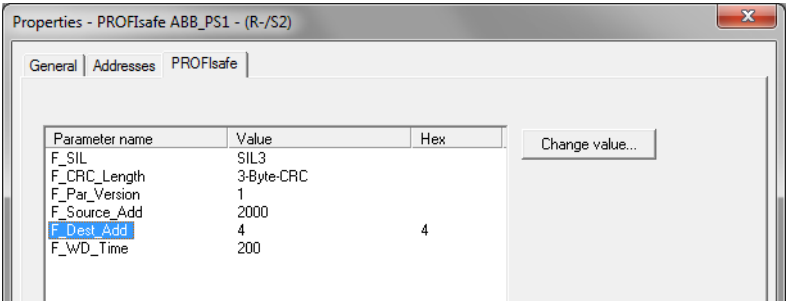
16. Assign the device name (defined in step 11) to the adapter module:
    - In the hardware configuration, click **FENA**.
    - In the **PLC** menu, select **Ethernet**, and select **Assign Device Name**.
    - Click the **Update** button.
    - Click the available device with the correct MAC address to which the device name will be assigned.
    - Click **Assign name**. This assigns the name to the FENA module.
    - Click **Close**.



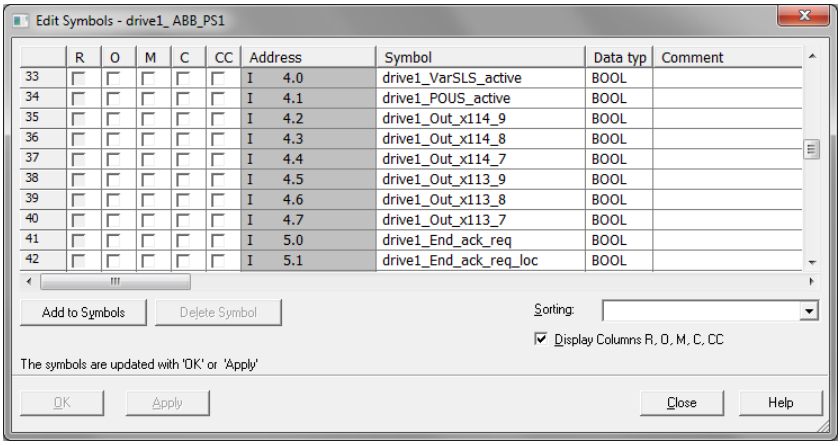
17. Check F-Parameters for the controller:
    - In the hardware configuration, double-click the controller station (for example, CPU 319F-3).
    - Select the **F Parameters** tab.
    - When prompted, give the password for the Safety Program. See the documentation of the SIMATIC system for details.
    - Make the necessary changes and click **OK**.



18. Set F-Parameters of the FENA module:
    - In the hardware configuration, double-click **PROFIsafe ABB_PS1** to open the **Properties** window.
    - On the **PROFIsafe** tab, modify the F_Dest_Add and F_WD_Time values as needed.
        - F_Source_Add is the address of the safety controller station. You can modify this in the **host** F Parameters tab.
        - F_Dest_Add is the address of the FENA module. This is defined by FSO parameter *PROFIsafe. 11*, see section *Configuring the safety fieldbus communication* on page *254*.
          These two define the codename for the PROFIsafe relationship of this particular FENA module and the safety controller station.
        - F_WD_Time is the PROFIsafe watchdog time. See section *Calculating the watchdog time* on page *192* for instructions on how to calculate the correct watchdog time.



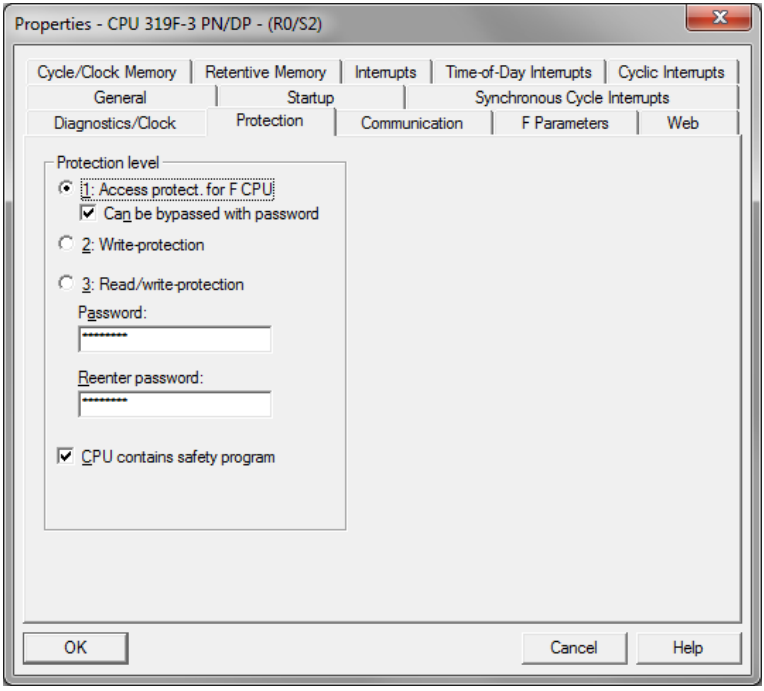
19. If necessary, you can give proper symbol names to the cyclic data:
    - Right-click the I/O object (PPO Type 4) in Slot 1 and select **Edit Symbols…**
    - Add names for the symbols.
    - Repeat the same for the PROFIsafe object (PROFIsafe ABB_PS1) in Slot 2.



	R	O	M	C	CC	Address	Symbol	Data typ	Comment
33						I 4.0	drive1_VarSLS_active	BOOL	
34						I 4.1	drive1_POUS_active	BOOL	
35						I 4.2	drive1_Out_x114_9	BOOL	
36						I 4.3	drive1_Out_x114_8	BOOL	
37						I 4.4	drive1_Out_x114_7	BOOL	
38						I 4.5	drive1_Out_x113_9	BOOL	
39						I 4.6	drive1_Out_x113_8	BOOL	
40						I 4.7	drive1_Out_x113_7	BOOL	
41						I 5.0	drive1_End_ack_req	BOOL	
42						I 5.1	drive1_End_ack_req_loc	BOOL	

Note: In PROFINET communication, the bits of each octet are sent the most significant bit first. Therefore, the bits of every octet in the PROFINET message are in reversed order compared to the bits shown in the figure. For example, the first bit that is sent in the PROFINET message is the 7th bit of the first octet (I 0.7).

20. Check the protection of the controller station:
    - In the hardware configuration, double-click the controller station (for example, CPU 319F-3).
    - Select **Protection** tab.
    - Select **1: Access protect. for F CPU**.
    - Check **Can be bypassed with password**.
    - Enter the password twice to the edit boxes.
    - Check **CPU contains safety program.**



21. Save, compile and download the hardware configuration to the PLC.

The PLC is now ready for communication with the FENA adapter module.

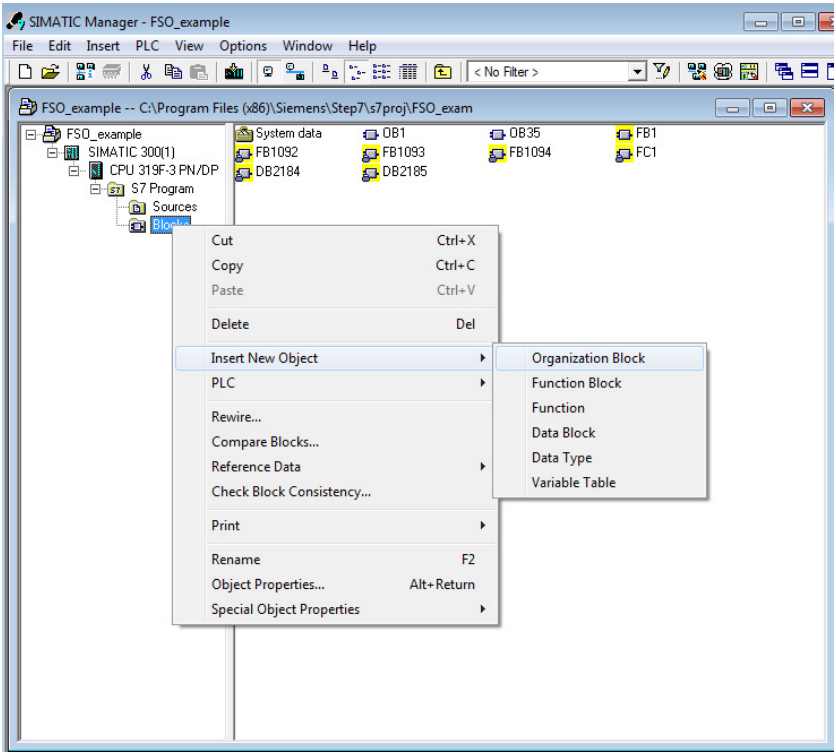
Configuring the communication when there is no safety program

If there is no safety program in the project, these instructions can help you to get the communication working.

⚠ **WARNING!** Do not use this safety program in real safety applications. This safety program is only an example which you can use only for trial purposes to get the system up and running.

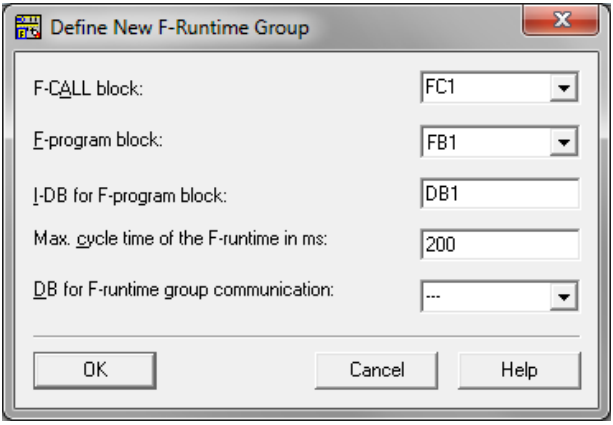
---

1. In SIMATIC Manager, right-click on the **Blocks** folder of the S7 Program of the project.
2. Select **Insert New Object**, and add the following blocks to the program:
   - Organization Block OB35 to call the safety program cyclically.
   - Function Block FB1 using F-FBD language.
   - Function FC1 using F-CALL language.

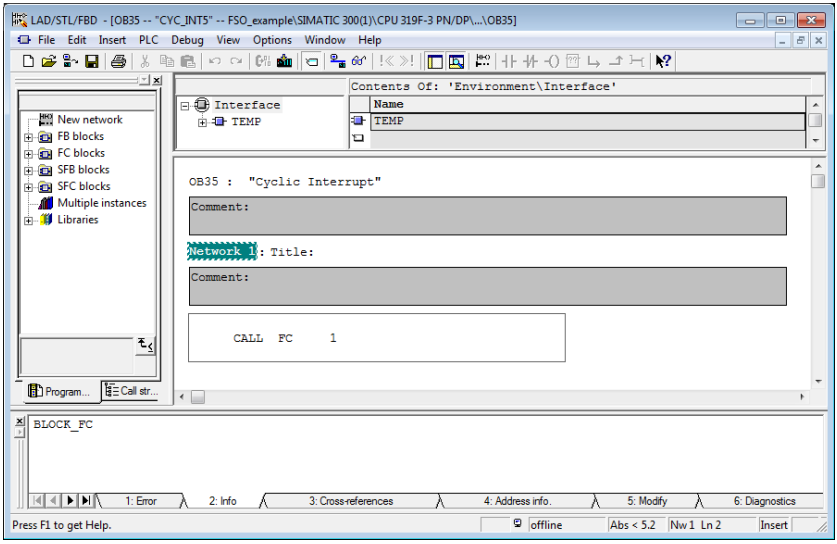


3. Double-click on the **FC1** block.

4. Set DB1 as the I-DB for the F-program block and FB1 as the F-program block.
5. Click **OK** and close the dialog windows.

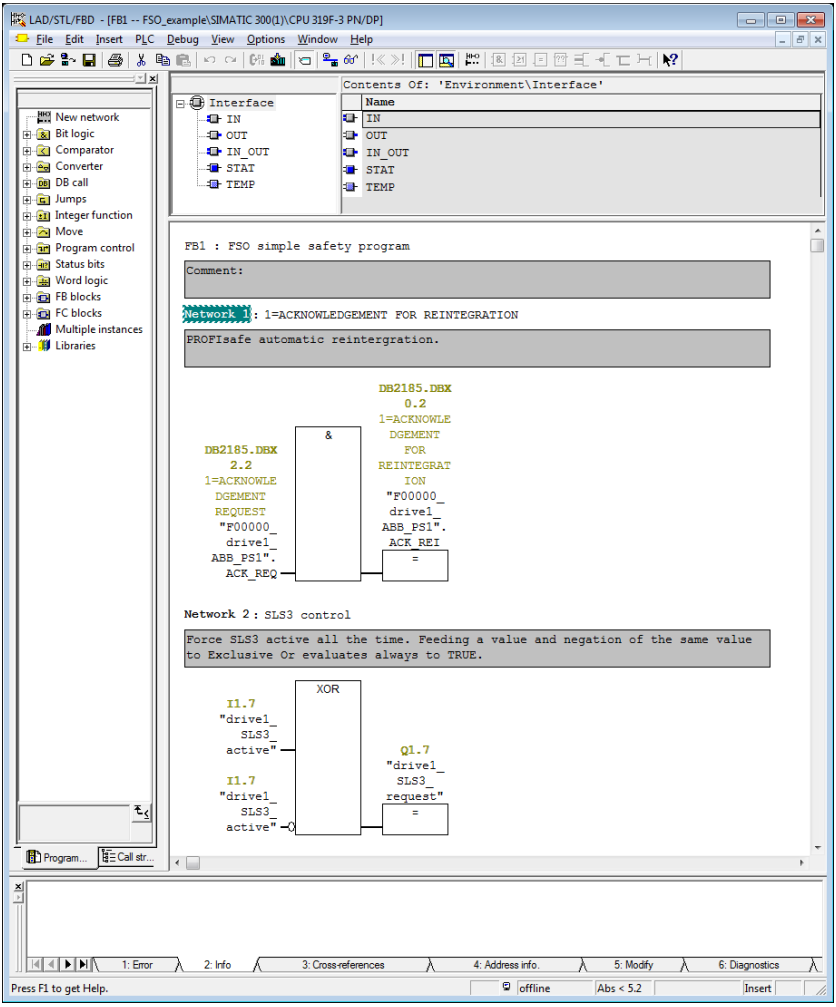


6. In SIMATIC manager, double-click on **OB35**.
7. Add call to FC1 by dragging the FC1 block from the FC blocks folder.
8. Save the block and close the editor.



9. In SIMATIC manager, double-click on **FB1**.
10. Add acknowledgement for reintegration by assigning the value of ACK_REQ to ACK_REI in DB2185.

11. Save the block and close the editor.



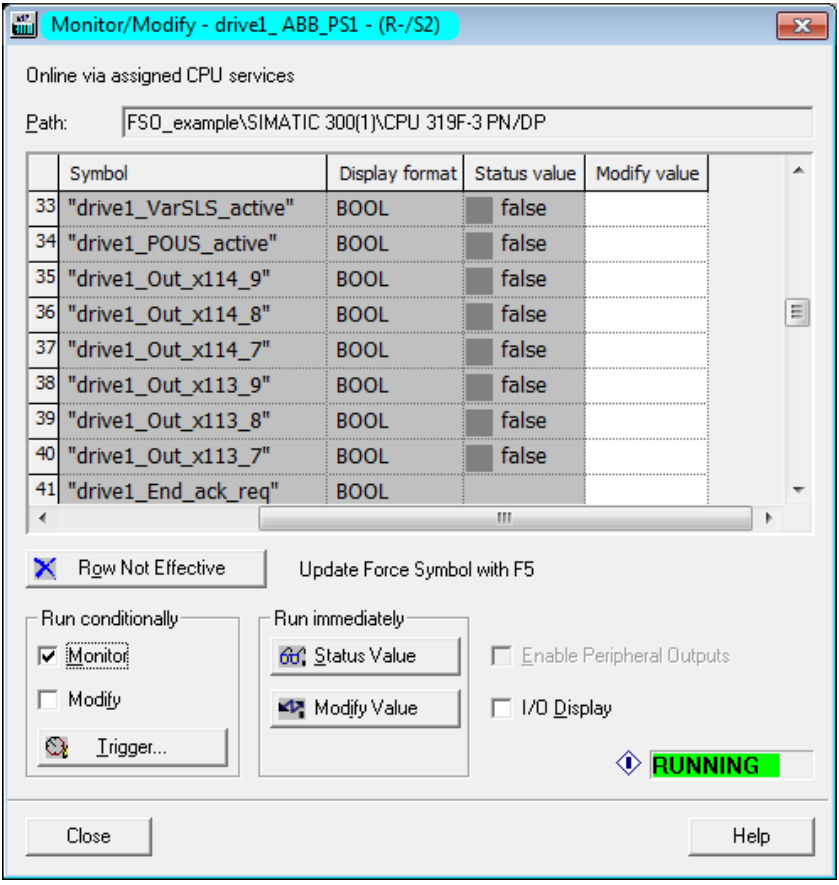
Note: This example program also keeps the SLS3 function active all the time.

12. In SIMATIC Manager, select **Edit safety program** from the **Options** menu.
13. Select **Compile**.
14. Select **Download**. If prompted, accept the inclusion of standard blocks.
15. Switch the controller station to run mode.

Monitoring the PROFIsafe message

It is possible to monitor the contents of the PROFIsafe message. For example:

1. In HW Configuration, select **Monitor/Modify** for the PROFIsafe telegram in Slot 2 of the FENA module.



Fault tracing

Reading diagnostic messages

You can read the PROFIsafe diagnostics messages from:

1. the Event logger of the Drive composer pro PC tool,
2. the Event log of the ACS-AP-x assistant control panel and
3. the error buffers of the PLC system. In this case, make sure that drive parameter *51.21* is set to *Enabled* (see the drive firmware manual).

ABB AC500-S

In the ABB AC500-S system, you can read PROFINET diagnostics messages from Control Builder Plus or with a separate PNIO_DEV_DIAG function block in the “non-safety” PLC program.

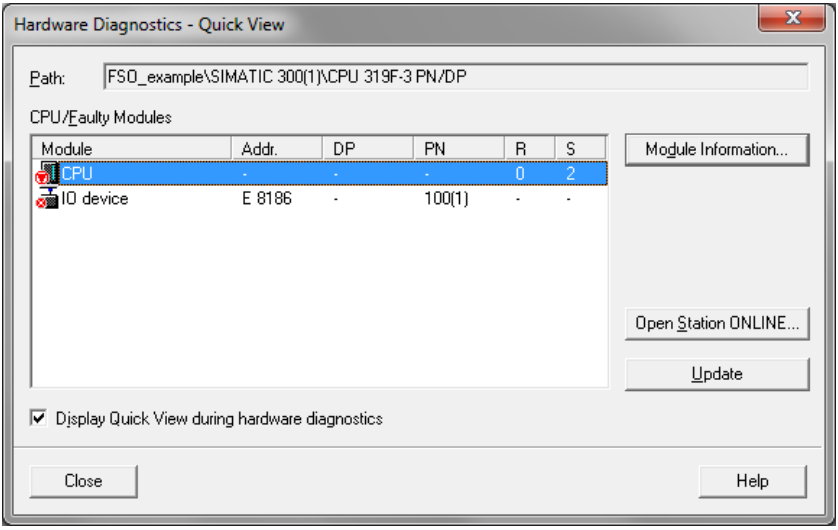
To read the alarm data of the last active alarm from Control Builder Plus:

1. Select **FENA_21**.
2. On the **Diagnostics for Profinet slave** tab, select **Refresh** to read diagnostics messages.

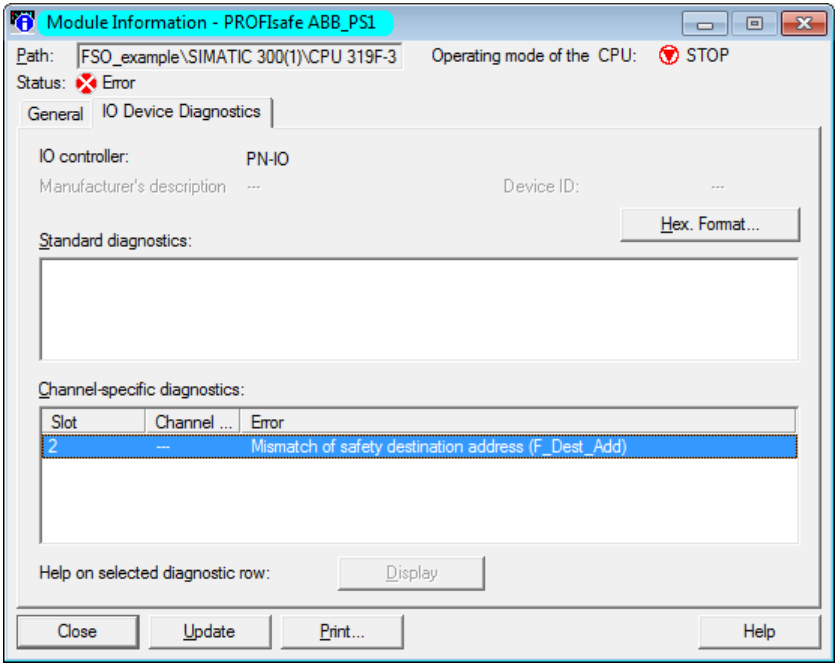
SIMATIC Manager

To read diagnostics messages:

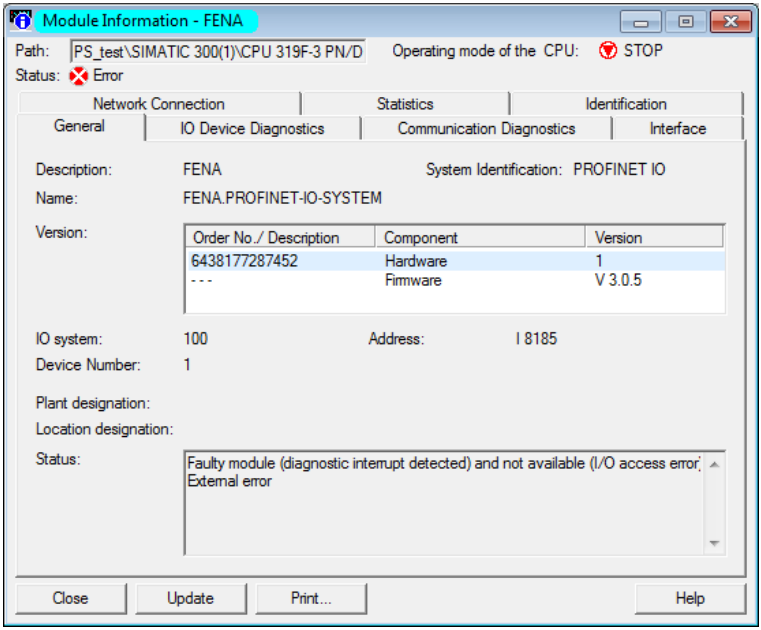
1. In the **PLC** menu, select **Diagnostic/Setting**.
2. Select **Hardware diagnostics**.
3. In the window that opens, select the FENA module of your system.
4. Click the **Module Information** button.



5. To read the diagnostic messages, select the **I/O Device Diagnostics** tab.



6. To check the Device number of the FENA module, select the **General** tab.



Diagnostic messages related to F-Parameters

The diagnostics messages in this table are caused by problems in the F-Parameter processing that takes place only when the controller station sends the F-Parameters to FENA. This happens normally only when the controller station starts up the PROFINET communication with the FENA module.

Value (hex)	Description	Notes
64 (0x0040)	Mismatch of safety destination address (F_Dest_Add).	F_Dest_Add did not match the value configured in the safety parameters (*PROFIsafe. 11 PROFIsafe F_Dest_Add*).
65 (0x0041)	Safety destination address is not valid (F_Dest_Add).	F_Dest_Add of 0 or FFFFh is not allowed. A valid F_Dest_Add is within range 1...65534.
66 (0x0042)	Safety source address is not valid (F_Source_Add).	F_Source_Add of 0 or FFFFh is not allowed. A valid F_Source_Add is within range 1...65534.
67 (0x0043)	Safety watchdog time value is 0 ms (F_WD_Time).	Watchdog time 0 ms is not allowed. A valid F_WD_Time is within range 1...65535.

Value (hex)	Description	Notes
68 (0x0044)	Parameter "F_SIL" exceeds SIL from specific device application.	F_SIL defined for this device at F-Host is not correct. This device supports only F_SIL = 3.
69 (0x0045)	Parameter "F_CRC_Length" does not match the generated values.	F-Parameter checksum length different from 3 octets. This device supports only three (3) octet CRC2.
70 (0x0046)	Parameter "F_Par_Version" set incorrectly.	Version of F-Parameter defined for this device at F-Host is not correct. This device supports only V2.
71 (0x0047)	CRC1 Fault	Checksum CRC1 calculated over the F-Parameters does not match the checksum value in the F-Parameters.
72 (0x0048)	Device-specific diagnosis information	Unsupported PROFINET submodule identification number received from the controller station upon PROFINET connection, or general error in the F-Parameters.

Typical communication errors

This table lists some typical error situations in the PROFINET and PROFIsafe communication.

Fault	Cause	What to do
You cannot start the PROFINET communication.	The FENA station name saved in the FENA does not match the station name of the FENA in the PLC configuration.	Check the station names in both places.
	The FENA IP address saved in the FENA does not match the IP address of the FENA in the PLC configuration.	Check the IP settings in both places.
	The FENA is not configured for the PROFINET communication.	Check drive parameter *51.01* or *54.01*. See the FENA user's manual for details.

Fault	Cause	What to do
You cannot start the PROFIsafe communication.	The drive safety parameters are not set correctly.	In the ACS880 drives, check the values of parameters *200.222 Safety bus type* and *200.223 Safety fieldbus adapter slot*. See section *How to configure the safety communication with PROFIsafe* on page *254* for details.
	The PROFIsafe destination address of the FENA does not match the station name of the FENA in the PLC configuration.	In the ACS880 drives, check the value of parameter *PROFIsafe. 11 PROFIsafe F_Dest_Add*. See section *How to configure the safety communication with PROFIsafe* on page *254* for details.
PROFIsafe communication watchdog time exceeds often.	The watchdog time is too short.	Calculate a new watchdog time. See section *Calculating the watchdog time* on page *192*.
All errors solved but you still cannot start the PROFIsafe communication.	After you have modified the configuration of the safety devices, you may have to reboot of the whole system before the changes take effect.	Reboot the safety PLC. If this does not help, reboot also the FSO module, the FENA module and the drive. To reboot the FSO module: • switch the power off and on, or • use drive parameter *FSO reboot* (parameter *96.09*, see the drive firmware manual). To reboot the FENA module: • switch the power off and on, or • use drive parameter *FBA A/B PAR REFRESH* (parameter *51.27/54.27*, see the drive firmware manual). To reboot the drive: • switch the power off and on, or • use drive parameter *Control board boot* (parameter *96.08*, see the drive firmware manual).

7

Planning for installation

Contents of this chapter

This chapter gives instructions and references to instructions in other manuals for planning the safety system installation, as well as the requirements for installation in the applicable safety standards.

Requirements for designers and installers

- Designers and installers must be trained to understand the requirements and principles of designing and installing safety-related systems.
- Designers and maintainers must be trained to understand the causes and consequences of Common Cause Failures (CCF). See the checklist for the appropriate standard in section *Common cause failure (CCF) checklists* on page *246*.

Mechanical installation

Installation site

The subsystem elements must always be likely to operate within the range of temperature, humidity, corrosion, dust, vibration, etc. for which they are specified, without the use of external environmental control (see section *Ambient conditions* on page *429*).

The FSO and FSE modules must only be used in an environment where no conductive dust or contaminants are present. One way to ensure proper protection against contamination is to use the FSO and FSE modules in at least an IP54 enclosure. For further information on environmental limits, see chapter *Planning the mechanical installation* in the drive hardware manual.

WARNING! If you operate the drive system with a safety module in environmental conditions that are outside of the specified ranges for the safety module, this can cause that a safety function is lost.

Electrical installation

General requirements

Electrical installation of the safety system must be performed according to the practices outlined in chapter *Planning the electrical installation* in the drive hardware manual.

Chapter *Installation checklists* provides additional advice for the planning.

All wiring must be well protected, routed and clamped where practicable.

When installing cabling it must be assured that there is no pulling or pinching on the cables.

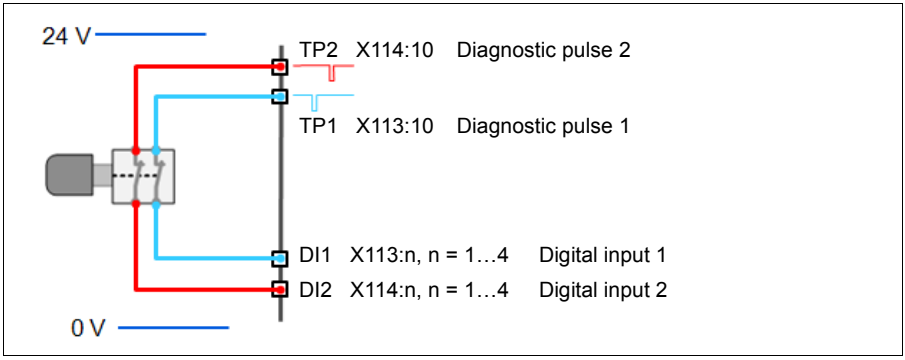
Connections

Inputs and outputs

To design the safety system architecture and select components to be used, it is essential to read and understand the different architecture options (for example single channel / redundancy).

Single inputs can be connected to any connection X113:1…4 or X114:1…4, and they can use either one of the diagnostic pulses X113:10 and X114:10.

Redundant inputs must be connected so that one input is connected to X113:n and uses diagnostic pulse X113:10, and the other is connected to X114:n and uses diagnostic pulse X114:10 (n= 1…4; the same for both inputs).



Note: You can use calculation software to assist in selecting the appropriate architecture that will meet the safety integrity requirements for a particular application. Use, for example, ABB's Functional safety design tool, see *Functional safety design tool user's manual* (3AXD10000102417 [English]).

Power supply connection/cables

The system must be protected against over-voltage and over-current.

The length of the cabling between the FSO and its power supply must be three meters or shorter, or a sufficiently low interference level must be otherwise guaranteed.

Note: The 24 V DC power supply should be equipped with a supply disconnecting device to enable an easy start-up of the FSO module.

Power supply for the FSE module and safety encoders

You have to use the same power supply for the FSE and FSO modules. For more information, see *FSE-31 pulse encoder interface module user's manua*l (3AXD50000016597 [English]).

If an internal safety encoder failure occurs, the safety encoder goes into the Safe state. To recover from these situations, you have to be able to reboot the safety encoder (for example, by switching the power off and on). We recommend that you use the same power supply for the safety encoder and the FSE and FSO modules.

Ensuring the EMC compatibility

The system must only be used in the EMC environment it is designed for, or necessary mitigations must be applied.

Selecting control cables

For the control cables to on-field devices, it is recommended that shielded cabling is used. Double-shielded cable is the best alternative for low-voltage digital signals but single-shielded twisted multi-pair cable is also usable.

See section *Control connection data* on page *427* and chapter *Planning the electrical installation* in the drive hardware manual.

Routing the cables

See chapter *Planning the electrical installation* in the drive hardware manual. Obey especially these rules:

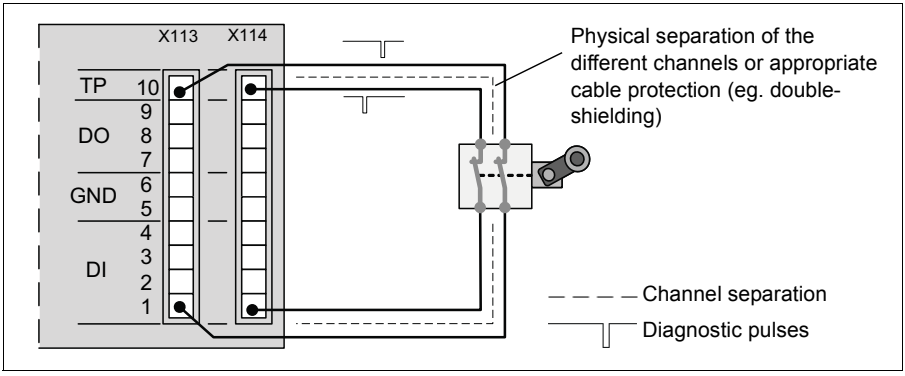
- When using redundant signaling, take care to avoid common cause failures in the cables. This can be done by routing the two channels through two well-apart routes, or by protecting the cabling appropriately, for example by using double-shielded cables.
- Never mix 24V-level signals with non-ELV-signals or power feeds in the same cable.
- Safety Related Electronic Control System (SRECS) signal cables for the individual channels must be routed separately from the other channels at all positions or sufficiently shielded.
- SRECS signal and electrical energy power cables must be separated at all positions or sufficiently shielded.
- Cross-connection between the channels of the subsystem must be prevented.
- Signal paths must be physically separated (for example, separation in wiring).

Standard function and wiring examples

Passive switch

Examples:

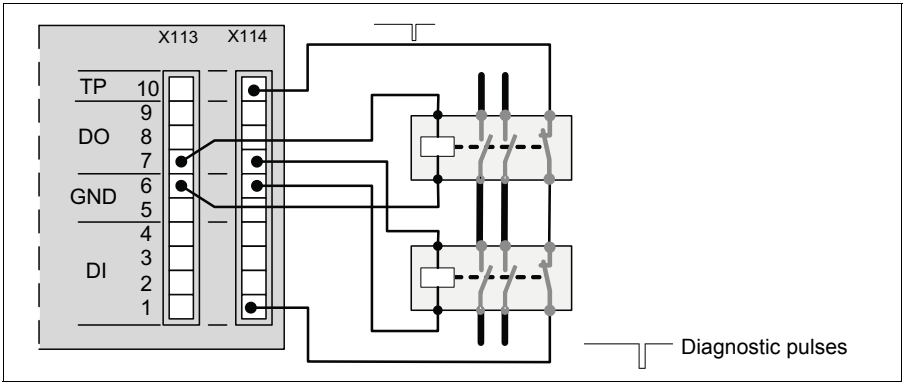
- Limit switch
- Emergency stop button



Relay / contactor output with feedback

Examples:

- Brake control
- Door/gate unlock

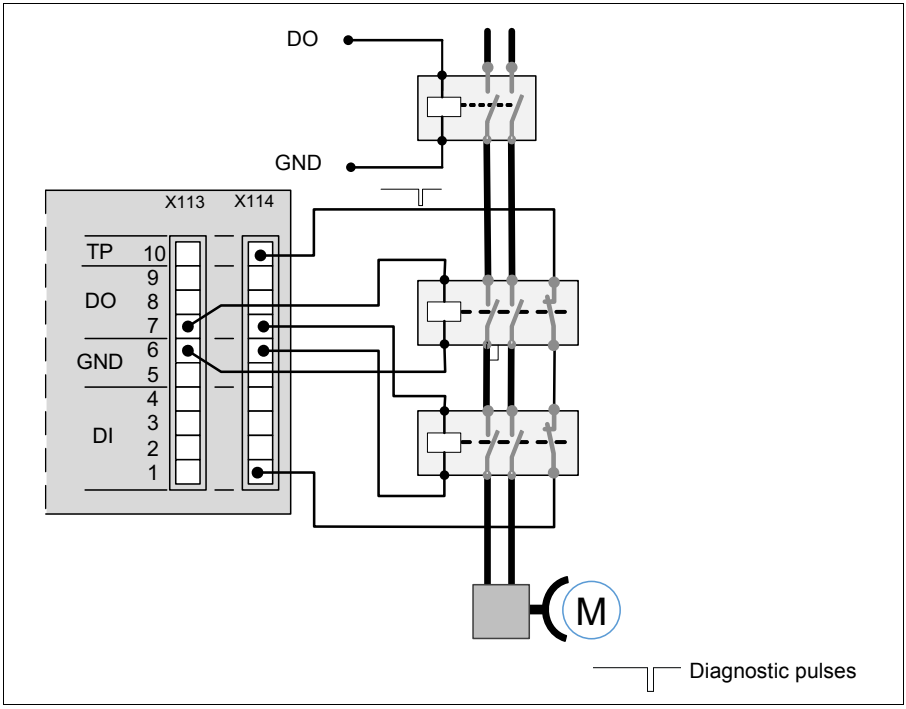


Safe brake control (SBC)

In this figure normal and safe brake controls are connected in series. Both are independent and redundant 2-channel solutions.

The safe brake control needs a feedback from the brake system. The SBC feedback can be from a relay/contactor or from the mechanical brake itself.

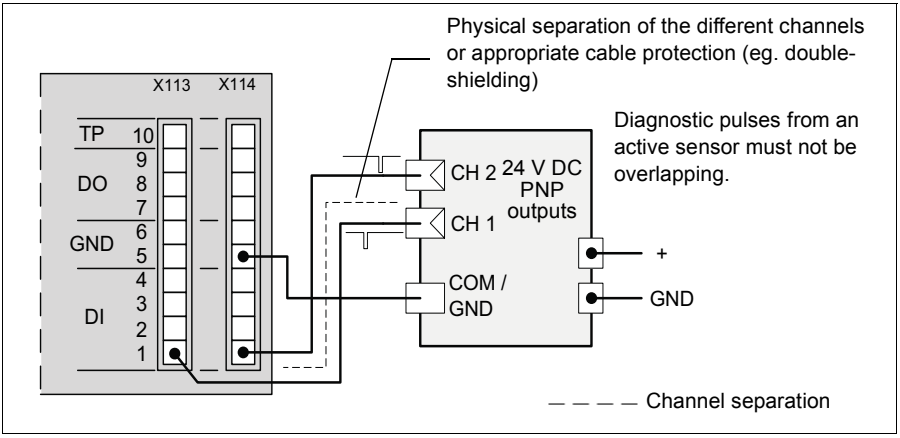
Note: If also the drive can control the brake, the feedback must not be from the mechanical brake.



Active sensors / input signals from solid state devices

Examples:

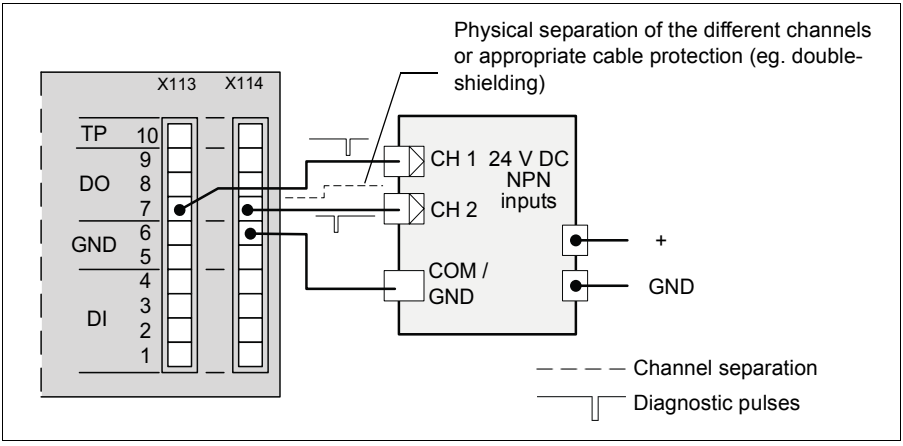
- PLC 24 V DC PNP
- Light curtain OSSD



Outputs to solid state devices

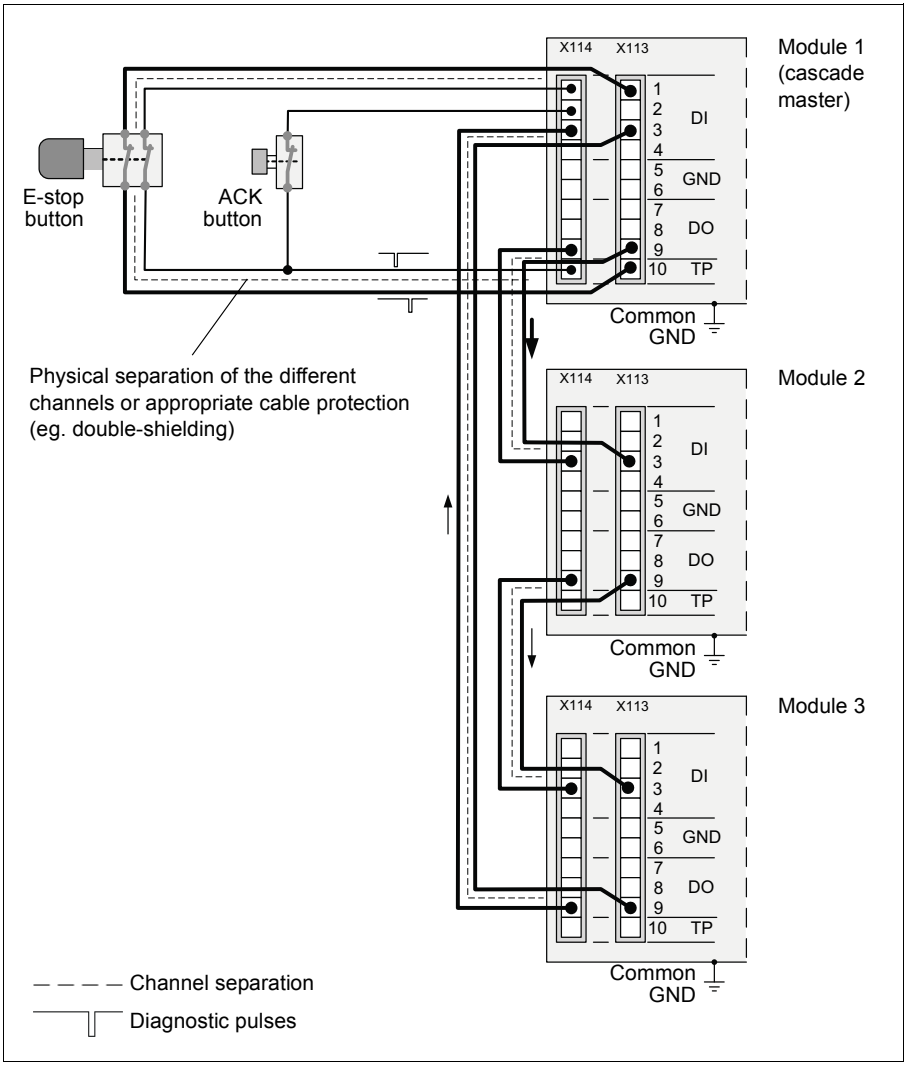
Example:

- PLC 24 V DC NPN



Cascade

Example:



8

Installation

Contents of this chapter

This chapter gives examples of how to connect the FSO module to the ACS880.

WARNING! The supply voltage for the FSO module is 24 V DC. If the FSO module is supplied with a higher voltage, for example 230 V or 115 V, it is damaged and must be replaced.

WARNING! To connect the FSO module to the drive, use only wire kits delivered by ABB.

Unpacking

If you have ordered the FSO module option separately, it is delivered in its own package. The package contains:

- the FSO module (1)
- connector plugs and attachment screws (2)
- FSO data cable (3)
- STO cable (4)
- connector for the power supply wires (5)
- mounting plate for ZCU-14 (6); the default mounting plate for ZCU-12 is attached to the module
- user's manual (not shown in the figure).

Checking the delivery

Check that all parts are in the package and that there are no signs of damage. Notify the shipper immediately if you find damaged components. Do not use damaged parts; they must be replaced.

Check that the FSO module is of the correct type, see section *Type designation label* on page *39*.

Mechanical installation

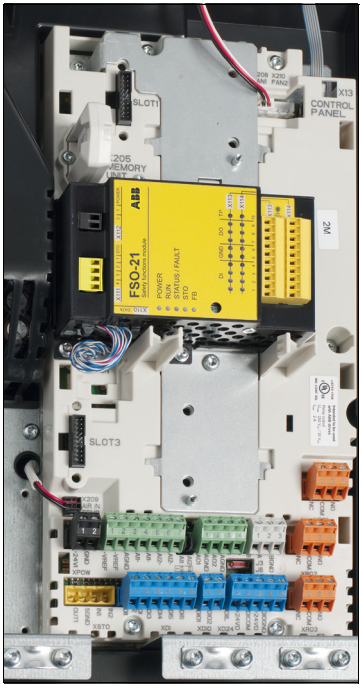
If you have ordered the FSO module option with the drive, it is delivered with the FSO already installed and the FSO data cable connected, so you can go directly to section *Electrical installation* on page *240*.

If you have ordered the FSO module option separately, it is delivered in its own package. Install the FSO mechanically on the drive as described in chapter *Electrical installation* in the drive hardware manual.

Note: Do not install the FSO module on the FEA-03 F-series extension adapter.

If necessary, remove the default mounting plate from the FSO module and replace it with the other mounting plate in the package.

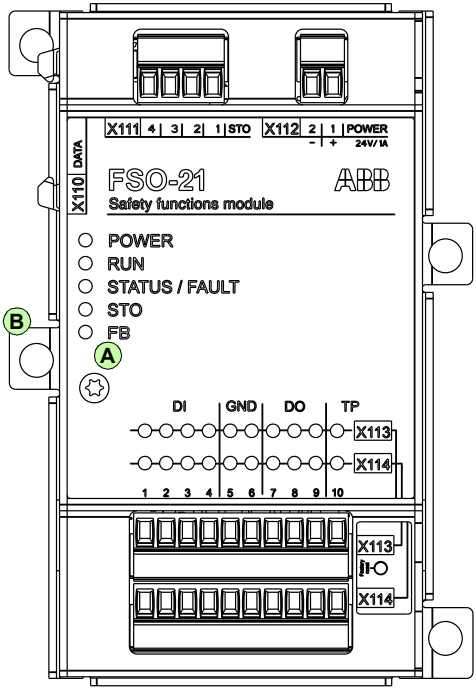
Depending on the type of the drive, the location of the module may be for example one of the following:



Electrical installation

Terminals

The connections are shown in the figure below.



A	Electronics grounding screw	
B	Enclosure grounding screw, at one of the mounting points, depending on the drive type	

X110:		
	DATA	Data connection to the drive control unit

X111:		
1	STO	STO 24 V
2	STO	STO ground
3	STO	STO1LO drive internal signal
4	STO	STO2LO drive internal signal

X112:		
1	POWER	24 V
2	POWER	0 V

X113:		
1	DI	Channel 1 digital input 1
2	DI	Channel 1 digital input 2
3	DI	Channel 1 digital input 3
4	DI	Channel 1 digital input 4
5	GND	Signal ground
6	GND	Signal ground
7	DO	Channel 1 digital output 1
8	DO	Channel 1 digital output 2
9	DO	Channel 1 digital output 3
10	TP	Channel 1 diagnostic pulse out

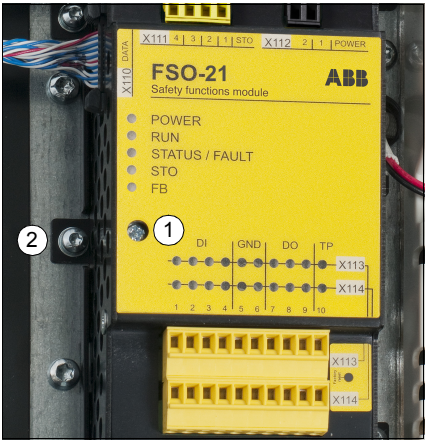
X114:		
1	DI	Channel 2 digital input 1
2	DI	Channel 2 digital input 2
3	DI	Channel 2 digital input 3
4	DI	Channel 2 digital input 4
5	GND	Signal ground
6	GND	Signal ground
7	DO	Channel 2 digital output 1
8	DO	Channel 2 digital output 2
9	DO	Channel 2 digital output 3
10	TP	Channel 2 diagnostic pulse out

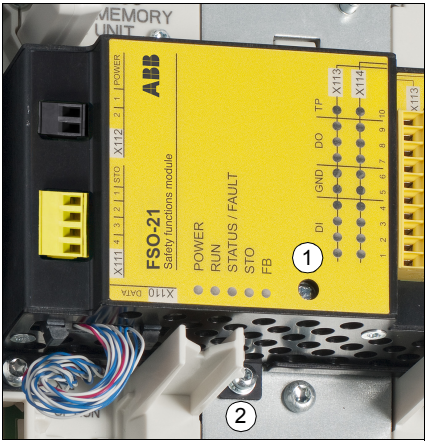
Note: The signal grounds (X113:5, X113:6, X114:5, X114:6) are not suitable for grounding the cable shields.

Connection procedure

To connect the FSO module to the drive:

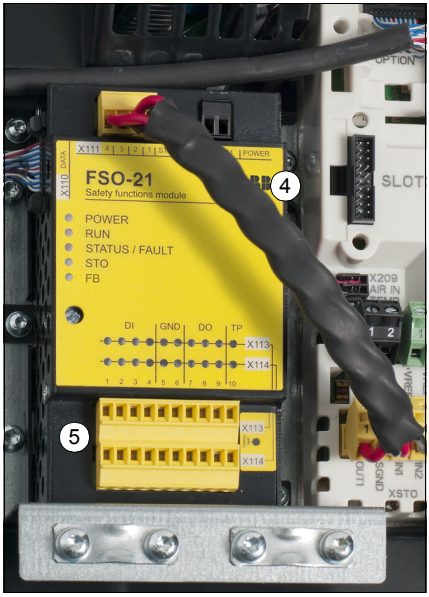
1. Make sure that the FSO electronics grounding screw is properly tightened.
2. Make sure that the FSO enclosure grounding screw is properly tightened.

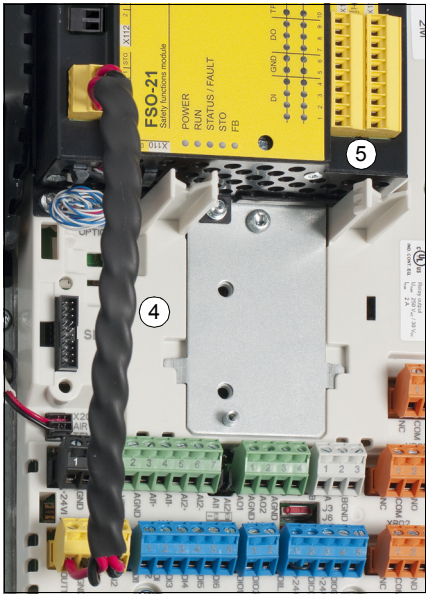




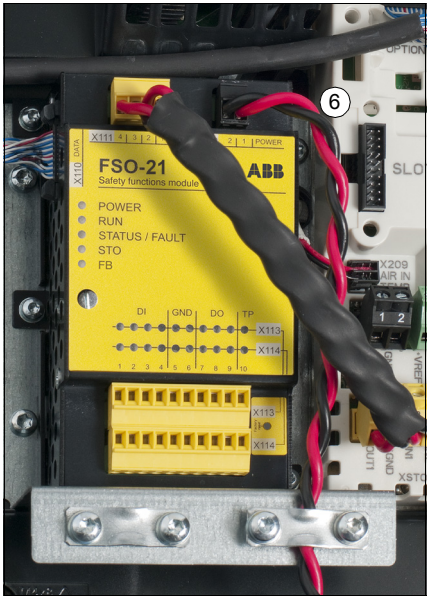
3. Make sure that the FSO data cable (terminal X110) is connected to the drive.

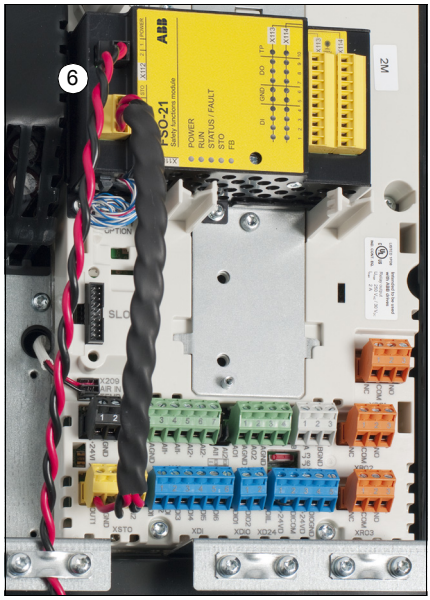
4. Connect the supplied four-wire cable to the FSO terminal X111 and plug the other end of the cable to the drive STO connection. Use the tightening torque of 0.24 Nm (2.1 lbf·in) for the FSO terminals.
5. Connect the digital inputs, digital outputs, diagnostic pulses and ground at the FSO terminals X113 and X114 according to the application. Use the tightening torque of 0.24 Nm (2.1 lbf·in).





6. Connect the power supply wires to the FSO terminal X112. Use the tightening torque of 0.24 Nm (2.1 lbf·in) for the FSO terminals.





9

Installation checklists

Contents of this chapter

This chapter contains a checklist for checking the mechanical and electrical installation of the FSO module and refers to common cause failure checklists in standards.

Checklists

Check the mechanical and electrical installation of the FSO module before start-up. Go through the checklists below together with another person. Read chapter *Safety* before you work on the safety system.

General checklist

Check
MECHANICAL INSTALLATION (See chapter *Planning for installation* and section *Installation*: *Unpacking*.)
☐ The ambient operating conditions are within the allowed range.
☐ Drives with separate inverter and supply units: Make sure that you have installed the FSO module in the inverter unit.
☐ The FSO and FSE modules are fastened properly.
☐ The mechanical connection of the encoder antenna to the motor axle is secure. The FSE module cannot diagnose mechanical failures outside the encoder, for example, an axle slippage.
☐ Transportation stops and packing material have been removed from the installation area.
ELECTRICAL INSTALLATION (See chapter *Planning for installation* and section *Installation*: *Electrical installation*.)
☐ The drive and the FSO module are properly grounded to the same potential.
☐ If a PELV power supply is used, its ground has to be in the same potential as the drive ground.
☐ Appropriate supply (input power) fuses are installed.
☐ Signal wiring between the drive and the FSO module is routed separately from the power supply wiring and high power cables (drive supply and motor cabling).
☐ Signal wiring is appropriately clamped, marked and protected.

Common cause failure (CCF) checklists

Check measures against common cause failures (CCF). There is one checklist in EN ISO 13849-1 and another in EN/IEC 62061. The checklists are useful for both the planning of the installation and the actual installation.

10

Configuration

Contents of this chapter

This chapter describes the password usage, outlines the configuration process and gives examples of how to configure the FSO module to implement each safety function as described in chapter *Safety functions*.

Competence

The person who configures the safety functions in the FSO module must be a competent person as required by IEC 61508-1 clause 6. In this context, the person must have adequate expertise and knowledge of functional safety, the safety functions as well as the configuration of the FSO module. We recommend our training courses on the FSO module.

Password

You need a password to be able to upload the parameters from the FSO and download the modified parameters from your PC to the FSO and the drive.

The password is set to “12345678” at the factory. The password must contain 4…8 digits. When you change it, do not forget the new password; otherwise you have to do a factory reset to the FSO which clears the configuration and resets the parameters to the factory defaults. The password is reset to the default “12345678”.

Configuring the FSO module

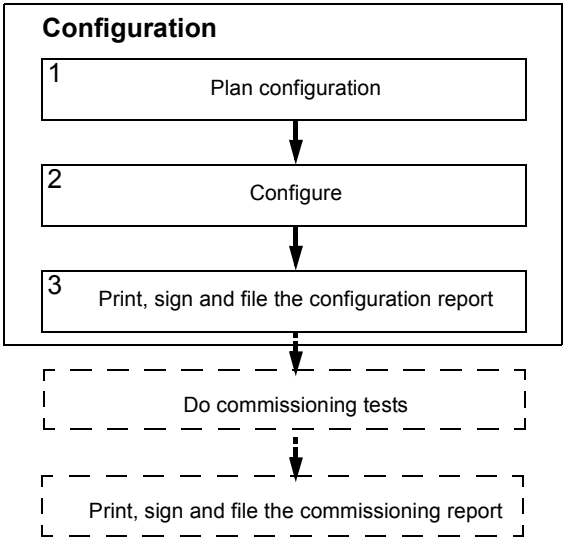
The FSO parameters are set with the Drive composer pro PC tool. The names of the FSO parameters and parameter settings are shown in the manual as they appear on the screen when using the tool. See *Drive composer PC tool user's manual* (3AUA0000094606 [English]) for instructions on using the tool.

You must always check all parameter values to make sure that they are suitable for your application. The pre-set values in a delivered FSO module or factory default values are not valid for any safety application as such.

Note: Configuration is only possible when the drive is not modulating or the FSO is in the Safe state.

Note: After you initially start up the FSO and also after you later modify any application parameters or the configuration, you must check the safety of the entire system by doing a verification according to the system safety verification plan and by doing a validation of the correct operation of the safety application. See chapter *Verification and validation*.

To configure the FSO, do the steps shown in the diagram below:



1. Plan the configuration (parameter values) according to the safety system, installation, wiring, etc.
2. Set the parameter values in the Drive composer pro PC tool.
   a. Power up the drive and make sure that the motor is not running.
   b. Connect your PC to the drive, start the Drive composer pro PC tool and select **Safety settings**.
   c. Open the parameters for setting:
      - First start-up: Upload the parameters from the FSO to the PC tool (button **Upload from FSO**). A password is required.
        Make a backup copy of the pre-set safety file (button **Save safety file**).
      - Existing configuration: Open the configuration file (button **Open safety file**).

   Note: When you upload parameters from the FSO module to the PC tool, the FSO goes into the Configuration mode and indicates a fault (7A8B). You can exit the Configuration mode by rebooting the FSO module (by switching the power off and on, with the **Boot FSO** button or with drive parameter *96.09 FSO reboot*) or by downloading the parameters to the FSO (steps 2.e - g below).

   d. Set the parameter values.
      - General parameters: Start from the general parameters. Check at least that the motor parameters are correct.
      - Encoder interface (if used): Configure the encoder parameters before you configure any safety functions.
      - Safety fieldbus communication (if used): Set up the communication between the safety PLC and FSO module.
      - I/O: Check that the I/O parameters are set according to the installation (wiring) plan. Set diagnostic pulsing for I/Os when necessary. Check possible safety relays and cascade connections.

        Note: Make sure that the diagnostic pulsing settings are compatible with all devices in the system (for example, switches, light curtains and PLCs).
      - Safety functions: You must at least check and set the parameters related to the STO and SSE functions, regardless of what you use the FSO for or which safety functions you use. The FSO can activate the STO and SSE functions in internal fault situations. The STO and SSE functions are essential for the FSO to be able to make the system safe.

e. After configuring all necessary functions, do these two steps:
   - Save the configuration to your PC (button **Save safety file**).
   - Download the configuration to the FSO (button **Download to FSO and validate**). A password is required.

f. After downloading, the FSO and the tool validate the configuration, and the tool asks you to confirm the validation.

g. The tool then automatically takes the changes in use.

h. Change the password to protect the settings (button **Change password**). A password is required.
   Note: The motor must be stopped when you change the password.

3. After validation, print the report from the configuration, including all the values of the parameters and CRC. Sign and file the report according to your safety management plan. **Note**: You can use the safety report in the Drive composer pro PC tool for this purpose.

Note: Make sure you saved the safety file after validation for later use. The safety file is not included in the drive backup process.

Note: If you want to clear the configuration and start again from the factory setup, do a factory reset. See section *Factory reset* on page *242*.

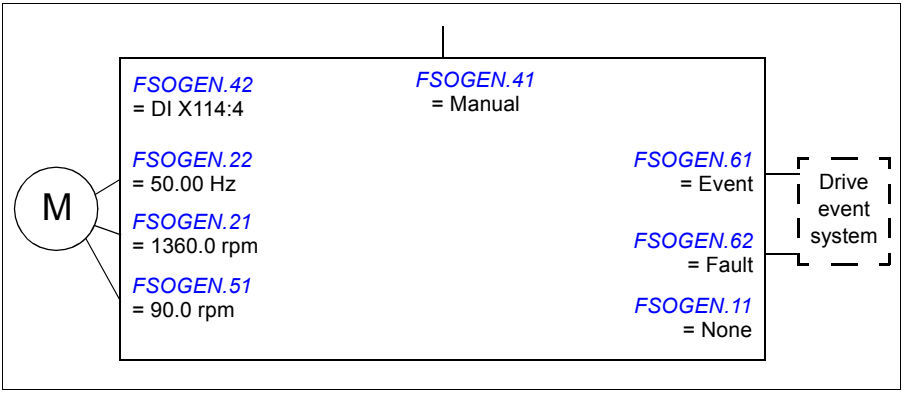
Configuring general settings

How to configure general settings

To configure the general settings, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter group *FSOGEN* on page *180*.

Example: The figure below shows an example I/O set-up:

- After power-up the acknowledgement can only be performed manually (*FSOGEN.41 Power-up acknowledgement* = *Manual*).
- Acknowledgement button is connected to input X114:4 (*FSOGEN.42 Acknowledgement button input* = *DI X114:4*).
- *FSOGEN.22 Motor nominal frequency* = *50.00 Hz*.
- *FSOGEN.21 Motor nominal speed* = *1360.0 rpm*.
- *FSOGEN.51 Zero speed without encoder* = *90.0 rpm* (when an encoder is used: *FSOGEN.52 Zero speed with encoder*).
- External requests ending in the drive STO are reported to the drive as events (*FSOGEN.61 STO indication ext request* = *Event*).
- Safety function limit hits are reported as faults (*FSOGEN.62 STO indication safety limit* = *Fault*).
- No output connected for the completion of stop functions (STO, SSE, SS1) (*FSOGEN.11 Stop completed output* = *None*).



Configuring the safety encoder interface

How to configure the safety encoder interface

To configure the safety encoder interface, set the drive and FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *Safety*, *S_ENCGEN*, *Enc module settings* (91) and *Encoder 1 configuration* (92) on pages *322* - *358* and the drive firmware manual.

Example: The pulse encoder interface module type is FSE-31 and it is installed in Slot 2 on the drive control board. One HTL encoder is used.

Set these drive parameters in the **Parameters** view of the Drive composer pro PC tool:

- The motor speed feedback during motor control is from Encoder 1:
  90.41 Motor feedback selection = Encoder 1
- The drive generates a warning if an encoder failure occurs:
  90.45 Motor feedback fault = Warning.
- Encoder cable channels A, B and Z are monitored for wiring faults:
  92.21 Encoder cable fault mode = A, B, Z.

Set these FSO parameters in the **Safety settings** view of the Drive composer pro PC tool:

- Communication with the FSE module activated:
  200.231 FSE 3X act and par version = Version 1
- One safety encoder is connected to the FSE module:
  200.232 Number of encoders = Single encoder CH1.
- Safety encoder activated:
  S_ENCGEN. 01 Safe pulse encoder version = Version 1
- The FSO module activates the drive STO function if there is a problem with the FSE module: *S_ENCGEN. 11 FSE diagnostic failure reaction = STO*
- Cross comparison tolerance: 5 rpm (sets how much the axle speed of the motor can change within 1 ms)
  S_ENCGEN. 14 Enc speed cross comp tolerance = 5 rpm
- Rotation direction not changed:
  S_ENCGEN. 41 Gear numerator encoder 1 = 1
- *91.11 Module 1 type = FSE-31*
- *91.12 Module 1 location = 2*
- *92.01 Encoder 1 type = HTL1*
- *92.02 Encoder 1 source = Module 1*
- Number of HTL pulses per rotation: *92.10 Pulses/revolution = 1024 ppr*.
  Note: Make sure that the value is according to the encoder nameplate.

- The maximum pulse frequency range of Encoder 1:
  92.17 Accepted pulse freq of encoder 1 = *220 kHz*.

  Note: You can use this formula to define the value:
  r_max x ppr_enc + 10%, where

  - r_max = the maximum motor speed (rpm) used in the application (or the motor nominal speed)
  - ppr_enc = Pulses/revolution of the safety pulse encoder (parameter *92.10*).

  Set the parameter value in kHz.

  Example: When r_max = 1000 rpm and ppr_enc = 1024,
  92.17 Accepted pulse freq of encoder 1 becomes 19 kHz:

  - 1.1 x (1024 x 1000 rpm / 60) = 18.773 (19).

Download the parameters to the FSO module and validate the safety encoder configuration before you configure any safety functions.

Configuring the safety fieldbus communication

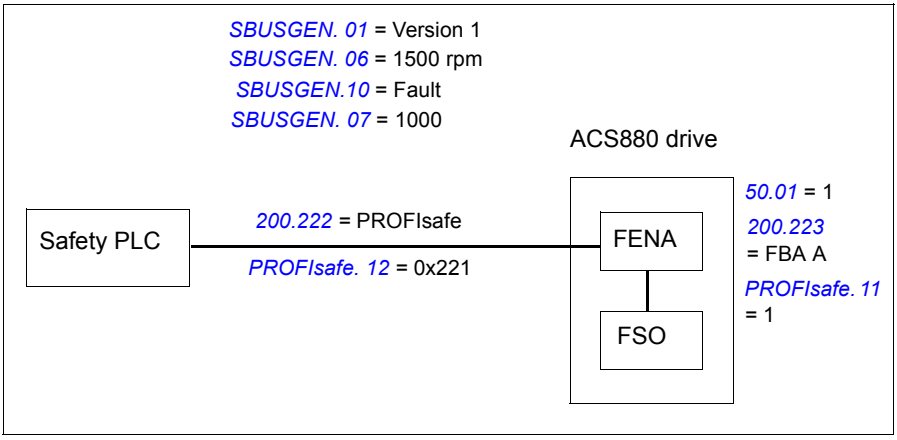
How to configure the safety communication with PROFIsafe

To configure the safety fieldbus communication between the FSO module and a safety PLC, set the FSO parameters shown in the figure below to appropriate values using the Drive composer pro PC tool. See parameter groups *Safety* on page *322*, *SBUSGEN* on page *364* and *PROFIsafe* on page *365*.

In addition, you must install the FENA-21 fieldbus adapter module to the drive and set up the safety communication network between the modules as described in chapter *PROFIsafe*.

Example:

- PROFIsafe communication activated
  (*SBUSGEN. 01 SBUS activity and version* = *Version 1* and *200.222 Safety bus type* = *PROFIsafe*)
- Speed scaling: 1500 rpm
  (*SBUSGEN. 06 Safety fieldbus speed scaling* = *1500 rpm*)
- When an encoder is used: Position scaling: 1000
  (*SBUSGEN. 07 Safety fieldbus position scaling* = *1000*)
- the FSO module generates a fault message if the module is passivated due to safety fieldbus problems
  (*SBUSGEN.10 STO indication passivation* = *Fault*)
- the FENA module is connected to option slot 1
  (*200.223 Safety fieldbus adapter slot* = *FBA A* and *50.01 FBA A enable* = *1*)
- PROFIsafe profile ABB_PS1 in use
  (*PROFIsafe. 12 PROFIsafe telegram type* = *0x221*)
- IP address of the FENA module: 1
  (*PROFIsafe. 11 PROFIsafe F_Dest_Add* = *1*)



Configuring I/O

How to configure I/O

To configure the I/O, set the FSO parameters shown in the figure below to appropriate values using the Drive composer pro PC tool. See parameter group *SAFEIO* on page *201*.

The location of the input and output terminals on the FSO module is shown in section *Layout* on page *27*.

Inputs

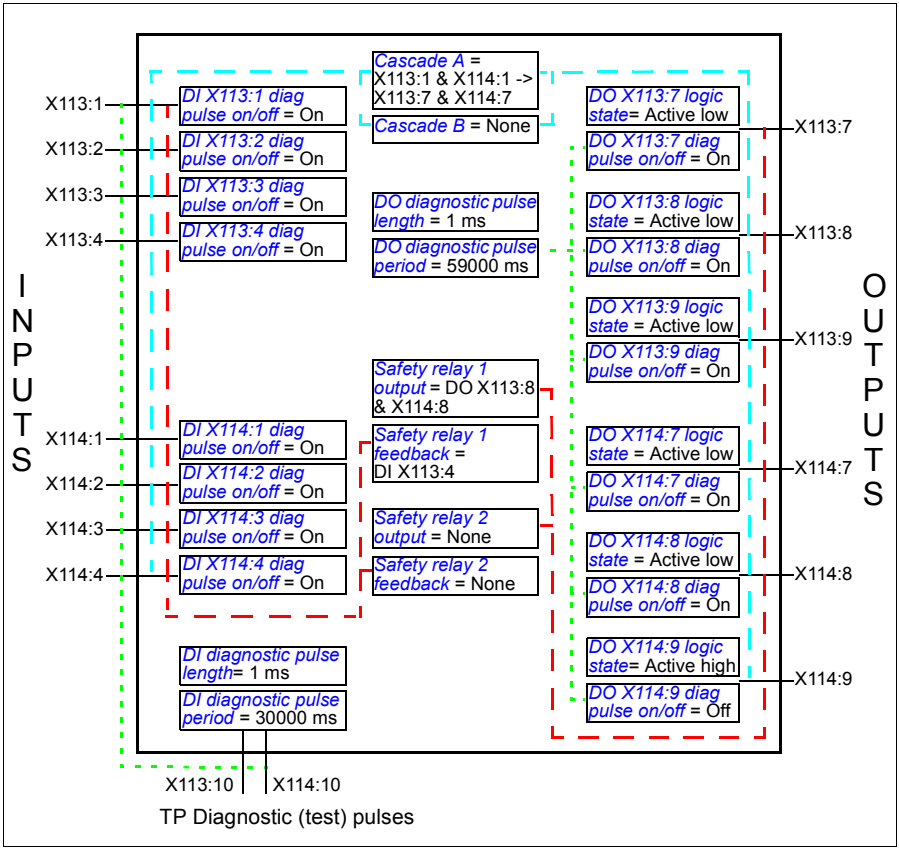
Set the length and period of the diagnostic pulse for the digital inputs. Select for each input whether the diagnostic pulse is on or off.

Outputs

Set the logic state for each digital output. Set the length and period of the diagnostic pulse for the digital outputs. Select for each output whether the diagnostic pulse is on or off.

Example: The figure below shows an example I/O set-up:

- All inputs use diagnostic pulses with 1 ms width and 30 s period.
- One redundant cascaded connection from input 1 to output 7
- One safety relay (always redundant) connected to output 8 with feedback connected to input 3
- All outputs, except X114:9, have active low logic state and diagnostic pulsing on. Pulse width 1 ms and period 59 s.
- Output X114:9 has active high logic state and diagnostics pulses are not used.



Note: The safety relay inputs and outputs must be configured so that in the Safe state the circuit is disconnected (0 V).

How to configure a cascaded system

This example shows how to configure the SSE function in a cascaded system (Cascade A) as shown in section *Cascade* on page *55*.

1. Define one of the FSO modules as the master and the other FSO modules are followers:
   - In the master FSO: *SAFEIO.11 M/F mode for cascade* = *A = master, B = master.*
   - In the follower FSOs: *SAFEIO.11 M/F mode for cascade* = *A = follower, B = follower.*
2. Connect a digital input to the corresponding digital output in the cascaded system (single cascade X113:2 -> X113:8):
   - *SAFEIO.12 Cascade A* = *X113:2 -> X113:8.*
3. Set the acknowledgement method in the master FSO modules (*Manual*):
   - *STO.02 STO acknowledgement* = *Manual*
4. Set the acknowledgement method in the follower FSO modules (*Automatic*).
   - *STO.02 STO acknowledgement* = *Automatic*
5. Set the digital inputs and outputs of the SSE function as defined for the cascaded system:
   - The SSE function is activated from a redundant digital input in the master FSO (*SSE.11 SSE input A* = *DI X113:1&X114:1*)
   - The SSE function is cascaded with a single connection in the follower FSOs (*SSE.12 SSE input B* = *DI X113:2*, *SSE.21 SSE output* = *DO X113:8*).
     Note: Do not use the completed output of the safety function as the cascaded output (parameter (*SSE.22 SSE completed output* = *None*).
6. Set the digital input for the acknowledgement button in the master FSO module:
   - *FSOGEN.42 Acknowledgement button input* = *DI X113:4.*
7. Set the other parameters related to the SSE function as defined in section *Configuring SSE* on page *284*.

Parameter settings in the master FSO

Index	Name/Value	Description
SAFEIO.11	*M/F mode for cascade*	Sets the master/follower mode of the FSO module for both cascade connections A and B separately. In this example, only cascade connection A is used.
	A = master, B = master	This module is the master on cascade connection A and B.
SAFEIO.12	*Cascade A*	Sets the cascade connection A for the FSO module. For each FSO module in cascade A, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output).
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8
SAFEIO.13	*Cascade B*	Sets the cascade connection B for the FSO module.
	None	Not cascaded
STO.02	*STO acknowledgement*	Sets the acknowledgement method used in the STO, SSE and SS1 functions. See section *Acknowledgement methods* on page *48* for more information on different acknowledgement methods.
	Manual	The FSO module reads the external STO acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*.
SSE.11	*SSE input A*	Sets the digital input that is connected to the primary input of the SSE function.
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1
SSE.12	*SSE input B*	Sets the digital input that is connected to the secondary input of the SSE function.
	None	No input connected
SSE.21	*SSE output*	Sets the digital output that indicates the activity of the SSE function. Active from the SSE request until the function has been acknowledged.
	DO X113:8	Single output X113:8
SSE.22	*SSE completed output*	Sets the digital output that indicates the completion of the SSE function.
	None	No output connected
FSOGEN.42	*Acknowledgement button input*	Sets the digital input that is connected to the button for acknowledgement operations.
	DI X113:4	Single input X113:4

Parameter settings in the follower FSOs

Index	Name/Value	Description
SAFEIO.11	*M/F mode for cascade*	Sets the master/follower mode of the FSO module for both cascade connection A and B separately. In this example, only cascade connection A is used.
	A = follower, B = follower	This module is a follower on cascade connection A and B.
SAFEIO.12	*Cascade A*	Sets the cascade connection A for the FSO module. For each FSO module in cascade A, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output).
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8
SAFEIO.13	*Cascade B*	Sets the cascade connection B for the FSO module.
	None	Not cascaded
STO.02	*STO acknowledgement*	Sets the acknowledgement method used in the STO, SSE and SS1 functions.
	Automatic	The FSO module generates the STO acknowledgement signal automatically after the STO, SSE or SS1 request has been removed and the stop function is completed (output defined by parameter *FSOGEN.11 STO completed output* is active).
SSE.11	*SSE input A*	Sets the digital input that is connected to the primary input of the SSE function.
	None	No input connected
SSE.12	*SSE input B*	Sets the digital input that is connected to the secondary input of the SSE function.
	DI X113:2	Single input X113:2
SSE.21	*SSE output*	Sets the digital output that indicates the activity of the SSE function. Active from the SSE request until the function has been acknowledged.
	DO X113:8	Single output X113:8
SSE.22	*SSE completed output*	Sets the digital output that indicates the completion of the SSE function.
	None	No output connected

How to configure safety relays

If you want to control a safety relay or contactor with the FSO module, define the use of the related I/O with these parameters. See also section *Relay / contactor output with feedback* on page *233*.

Index	Name/Value	Description
SAFEIO.21	*Safety relay 1 output*	Sets the digital output connected to the safety relay 1.
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8
SAFEIO.22	*Safety relay 1 feedback*	Sets the digital feedback input of safety relay 1.
	DI X113:4	Single input X113:4
SAFEIO.23	*Safety relay 1 feedback type*	Sets the type of the feedback signal for safety relay 1.
	Mechanically linked NC contacts	Feedback of the safety relay is NC (inverted state compared with the relay).
SAFEIO.24	*Safety relay 2 output*	Sets the digital output for safety relay 2.
	None	No output connected
SAFEIO.25	*Safety relay 2 feedback*	Sets the digital feedback input of safety relay 2.
	None	No input connected
SAFEIO.26	*Safety relay 2 feedback type*	Sets the type of the feedback signal for safety relay 2.
	Mechanically linked NC contacts	Feedback of the safety relay is NC (inverted state compared with the relay).

In addition, you have to connect the safety relay to the desired safety function. Set the same digital output as you set for the safety relay as the output of the desired safety function. In this example, safety relay 1 is connected to the SBC function.

Index	Name/Value	Description
SBC.21	*SBC output*	Sets the digital output that is connected to the SBC output (brake relays).
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8

Configuring SBC

When you use the SBC function (brake) with other safety functions of the FSO module, it is always combined with the drive STO function. That is, the SBC function is activated before, at the same time with or after the drive STO function.

You can configure the SBC in the STO, SSE and SS1 functions:

- If you configure the SBC in the STO function, this also takes it into use in the SSE with immediate STO function.
- If you configure the SBC in the SS1 function, this also takes it into use in the SSE with emergency ramp function.

SBC at zero speed limits

When you configure the SBC function in the STO function, the SBC is activated also when the drive STO is activated at the zero speed in the SSE and SS1 functions. Depending on how the SBC is configured, the SBC is activated before or at the same time with the drive STO function. See section *Safe torque off (STO)* on page *57*.

SBC at trip limit hits

The FSO module activates the SSE function after trip limit hits in the SLS, SMS and SDI functions. You can configure the SSE function either with immediate STO (stop category 0) or with emergency ramp (stop category 1), see section *Safe stop emergency (SSE)* on page *93*. If you want that the SBC is activated at trip limit hits, you have to configure the SBC function in the correct SSE function.

Note: Make sure that you dimension the brake correctly for these situations.

SBC at monitoring limit hits

The FSO module activates the STO function after time or ramp monitoring limit hits in the SS1, SSE with emergency ramp, SLS and SDI functions. If you want that the SBC is activated at monitoring limit hits, you have to configure the SBC function in the STO function.

Brake failure situations

To make sure that the system is set to safe state also if the brake fails to operate, set parameter *STO.14* to a suitable value. If the safety function is not completed before this time has elapsed, the system is set to the safe state.

How to configure the SBC in the STO function

Use these parameters to configure the SBC:

1. Set the how the brake is used with parameter *SBC.11 STO SBC usage*:
   - *None*: the SBC is not used
   - *Delayed brake* (the value can be positive, zero or negative)
   - *Speed limit* (possible only when an encoder is used).
2. Set the correct delay with parameter *SBC.12 STO SBC delay*:
   - If the value is zero (*0 rpm*), the FSO activates the SBC and drive STO functions at the same time.
   - It the value is positive, the FSO activates the SBC after the drive STO. See section *How to configure SBC after STO* on page *266*.
   - If the value is negative, the FSO activates the SBC before the drive STO. See section *How to configure SBC before STO* on page *268*.
3. If you use the speed limit activated SBC function, set the correct SBC speed limit with parameter *SBC.14 STO SBC speed*.
   - The drive STO function is activated when the STO request is received and the SBC when the SBC speed limit is reached. See section *How to configure STO with speed limit activated SBC* on page *270*).

See also section *How to fine-tune when SBC speed limits are detected* on page *317*.

How to configure the SBC in the SS1 function

Use these parameters to configure the SBC:

1. Set the correct SBC speed limit with parameter *SBC.15 SSE/SS1 SBC speed*:
   - If the value is zero (*0 rpm*) the SBC is not used in the SS1 and SSE with emergency ramp functions.
   - If the value positive (the corresponding negative value is used in the opposite direction), the FSO activates the SBC and drive STO functions at the same time when the speed limit is reached. See section *How to configure SS1 with speed limit activated SBC* on page*276*.
2. You can also set a negative delay with parameter *SBC.12 STO SBC delay*:
   - If the value is negative, the FSO activates the SBC at the speed limit (set with parameter *SBC.15 SSE/SS1 SBC speed*) and the drive STO after this delay. See section *How to configure SS1 with speed limit activated SBC, SBC before STO* on page *280*.
   - If the value is zero (*0 ms*) or positive, the FSO activates the SBC and drive STO functions at the same time when the speed limit is reached.

   Note: If parameter *SBC.11 STO SBC usage* is *Delayed brake,* the same parameter *SBC.12 STO SBC delay* is used also in the STO and SSE with immediate STO functions (see section *How to configure the SBC in the STO function* on page *262*). In the SS1 (and SSE with emergency ramp) function, this parameter is relevant always when parameter *SBC.15 SSE/SS1 SBC speed* is not zero.

Monitoring limit hits in the SS1 function

When you configure the SBC in the SS1 (and SSE with emergency ramp) function, this does not take the SBC into use in the STO function. Therefore, the SBC is not activated in limit hit situations if parameter *SBC.11 STO SBC usage* is *None.* For limit hit situations, you have to configure the SBC also in the STO function. See section *How to configure the SBC in the STO function* on page *262*.

See also section *How to fine-tune when SBC speed limits are detected* on page *317*.

Configuring STO

To configure the STO function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *STO* on page *328* and *SBC* on page *332*.

For more information on the STO and SBC functions, see page *58*.

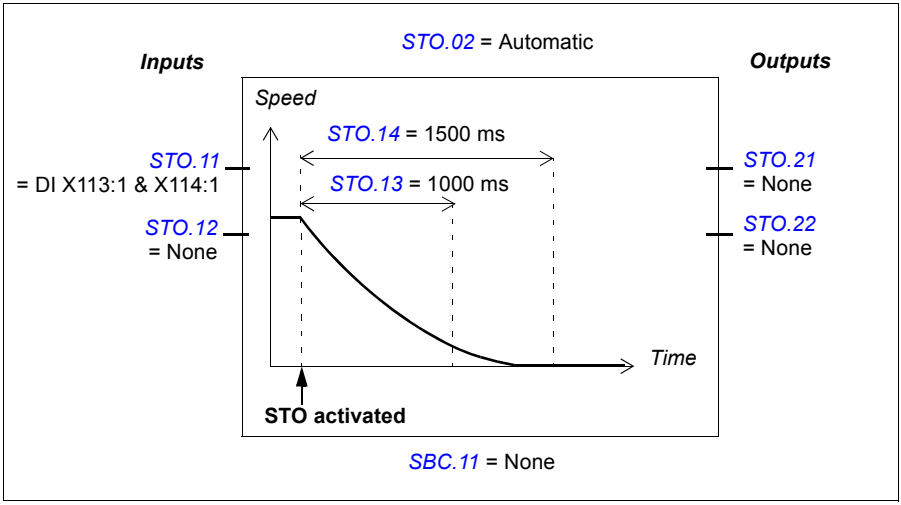
Note: Always set the parameters related to the STO function to have the correct monitoring limit hit and fault reaction behavior.

Note: If an encoder failure occurs, the FSO module activates the STO function. For these situations, you have to configure the STO function also without an encoder (set parameter *STO.14 Time to zero speed with STO and modoff* or *SBC.13 SBC time to zero speed* to a suitable value according to your application).

How to configure STO

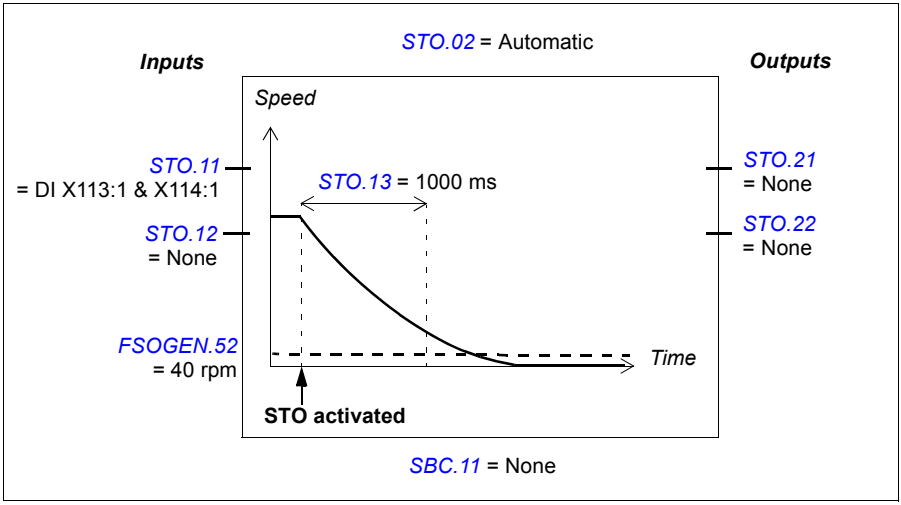
Example 1 (without an encoder): The figure below shows an example of a simple STO function set-up when an encoder is not used:

- redundant emergency stop button connected to input (*STO.11 STO input A* = *DI X113:1 & X114:1*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- estimated time in which the motor coasts to a stop from the maximum speed is 1500 ms (*STO.14 Time to zero speed with STO and modoff* = *1500 ms*)
- the fly-start feature is in use, that is, you can restart the drive before the motor has stopped (*STO.13 Restart delay after STO* = *1000 ms*)
- no output connected
- no brake (*SBC.11 STO SBC usage* = *None*).



Example 2 (with an encoder): The figure below shows an example of a simple STO function set-up when an encoder is used. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

- redundant emergency stop button connected to input (*STO.11 STO input A* = DI X113:1 & X114:1)
- automatic acknowledgement (*STO.02 STO acknowledgement* = Automatic)
- zero speed limit at which the motor has stopped is 40 rpm (parameter *FSOGEN.52 Zero speed with encoder* = *40 rpm*)
- the fly-start feature is in use, that is, you can restart the drive before the motor has stopped (*STO.13 Restart delay after STO* = *1000 ms*)
- no output connected
- no brake (*SBC.11 STO SBC usage* = *None*).

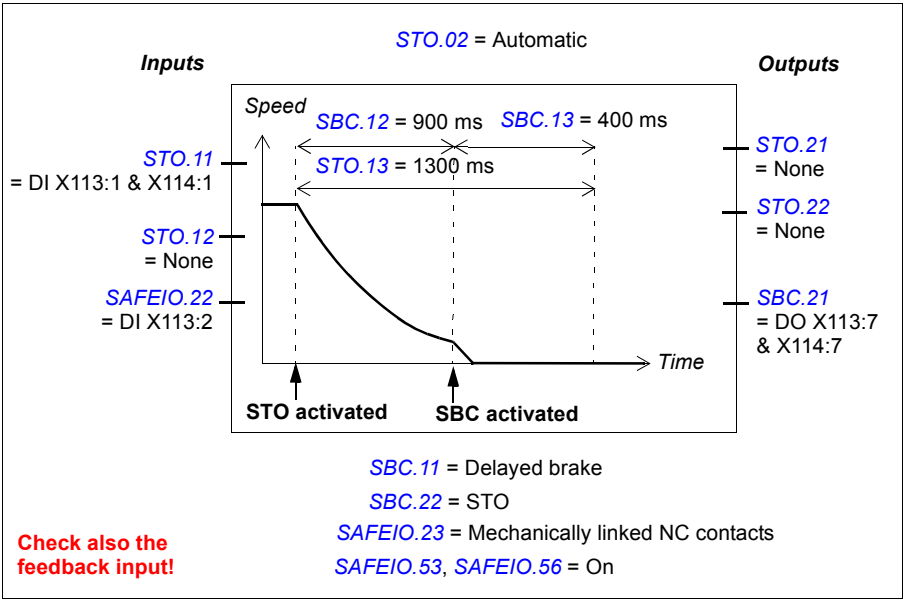


How to configure SBC after STO

For more information on the SBC after STO function, see page 60.

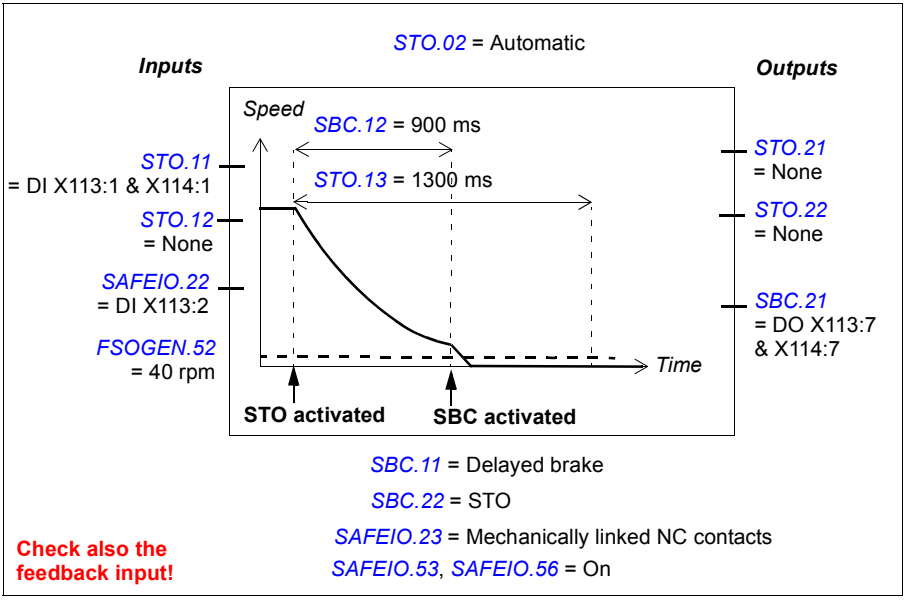
Example 1 (without an encoder): The figure below shows an example of the SBC after the STO function set-up when an encoder is not used:

- STO delayed brake with positive delay 900 ms (*SBC.11 STO SBC usage* = Delayed brake, *SBC.12 STO SBC delay* = 900 ms)
- redundant emergency stop button connected to input (*STO.11 STO input A* = DI X113:1 & X114:1)
- automatic acknowledgement (*STO.02 STO acknowledgement* = Automatic)
- estimated time in which the motor brakes to a stop from the maximum speed: 400 ms (*SBC.13 SBC time to zero speed* = 400 ms)
- the fly-start feature is in not use, that is, you cannot start the motor before it has stopped (*STO.13 Restart delay after STO* = 1300 ms)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output =* DO X113:7 & X114:7, *SAFEIO.53* and *SAFEIO.56* = On)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = STO)
- feedback from the brake is connected to digital input X113:2 (*SAFEIO.22 Safety relay 1 feedback* = DI X113:2)
- feedback input type NC (inverted state compared with the brake relay) (*Safety relay 1 feedback type* = Mechanically linked NC contacts).



Example 2 (with an encoder): The figure below shows an example of the SBC after the STO function set-up when an encoder is used. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

- STO delayed brake with positive delay 900 ms (*SBC.11 STO SBC usage* = *Delayed brake*, *SBC.12 STO SBC delay* = *900 ms*)
- redundant emergency stop button connected to input (*STO.11 STO input A* = *DI X113:1 & X114:1*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = Automatic)
- zero speed limit at which the motor has stopped: 40 rpm (parameter *FSOGEN.52 Zero speed with encoder* = *40 rpm*)
- the fly-start feature is in not use, that is, you cannot start the motor before it has stopped (*STO.13 Restart delay after STO* = *1300 ms*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- feedback from the brake is connected to digital input X113:2 (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*Safety relay 1 feedback type* = *Mechanically linked NC contacts*).

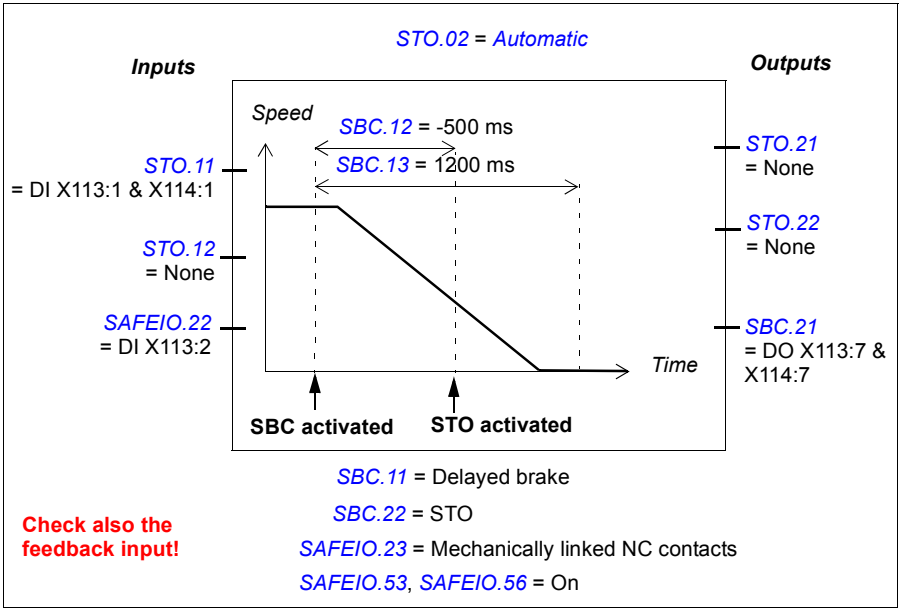


How to configure SBC before STO

For more information on the SBC before STO function, see page 63.

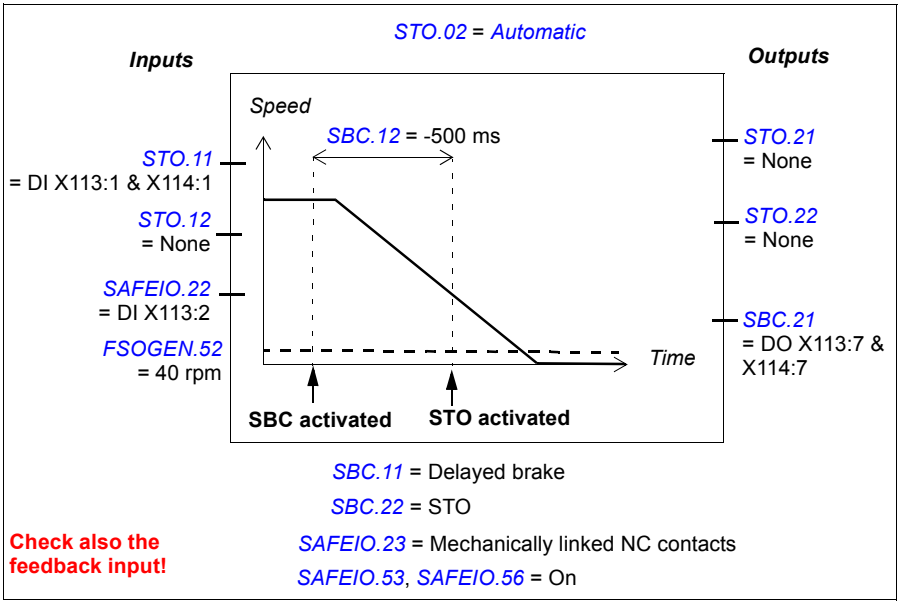
Example 1 (without an encoder): The figure below shows an example of the SBC before the STO set-up when an encoder is not used:

- STO delayed brake with negative delay -500 ms (*SBC.11 STO SBC usage* = *Delayed brake*, *SBC.12 STO SBC delay* = *-500 ms*)
- redundant emergency stop button connected to input (*STO.11 STO input A* = *DI X113:1 & X114:1*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- estimated time in which the motor brakes to a stop from the maximum speed: 1200 ms (*SBC.13 SBC time to zero speed* = *1200 ms*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).



Example 2 (with an encoder): The figure below shows an example of the SBC before the STO set-up when an encoder is used. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

- STO delayed brake with negative delay -500 ms (*SBC.11 STO SBC usage* = *Delayed brake*, *SBC.12 STO SBC delay* = *-500 ms*)
- redundant emergency stop button connected to input (*STO.11 STO input A* = *DI X113:1 & X114:1*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- zero speed limit at which the motor has stopped: 40 rpm (parameter *FSOGEN.52 Zero speed with encoder* = *40 rpm*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).



How to configure STO with speed limit activated SBC

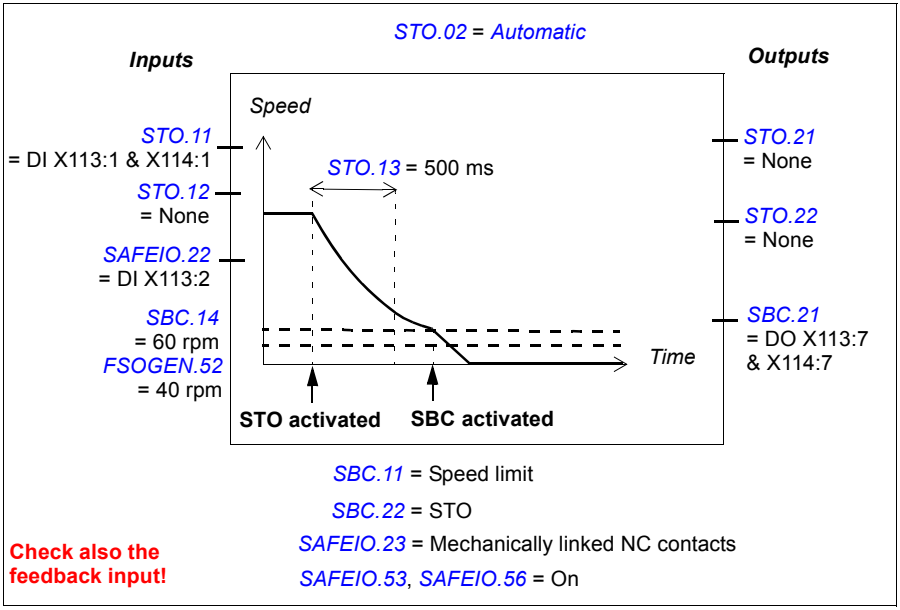
This safety function requires that you use an encoder in the safety application. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

Note: If you configure the STO with speed limit activated SBC function, this activates the same function in the SSE with immediate STO function (see section *How to configure SSE with immediate STO with speed limit activated SBC* on page *286*).

For more information on the STO with speed limit activated SBC, see page *66*.

Example: The figure below shows an example of a set-up of the STO with speed limit activated SBC:

- STO with speed limit activated SBC, speed limit: 60 rpm (*SBC.11 STO SBC usage* = *Speed limit*, *SBC.14 STO SBC speed* = *60 rpm*)
- zero speed limit at which the motor has stopped: 40 rpm (parameter *FSOGEN.52 Zero speed with encoder* = *40 rpm*)
- redundant emergency stop button connected to input (*STO.11 STO input A* = *DI X113:1 & X114:1*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- the fly-start feature is in use, that is, you can restart the drive before the motor has stopped (*STO.13 Restart delay after STO* = *500 ms*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.



Encoder or FSE failure situations

The STO with speed limit activated SBC function (parameter *SBC.11 STO SBC usage* = *Speed limit*) requires the exact motor speed, and when this is not available, the FSO module starts to use the *Delayed brake* selection (parameter *SBC.11 STO SBC usage* = *Delayed brake*).

If parameter *S_ENCGEN. 11 FSE diagnostic failure reaction* = *STO*, the FSO module goes into the Fail-safe mode and actives the STO with speed limit activated SBC function with *Delayed brake*:

- If parameter *SBC.12 STO SBC delay* is positive, the FSO activates the SBC after this time has elapsed from the STO activation.
- If parameter *SBC.12 STO SBC delay* is negative or zero, the FSO actives the SBC when the encoder failure occurs.

If parameter *S_ENCGEN. 11 FSE diagnostic failure reaction* = *No STO*, and there are no active safety functions, the FSO module sends a warning to the drive. If there are active safety functions when the FSO module detects the failure, the FSO module goes into the Fail-safe mode and actives the STO with speed limit activated SBC function with *Delayed brake* (see above).

If parameter *S_ENCGEN. 11 FSE diagnostic failure reaction* = *Est switch not active load*, the FSO module continues operation by using the estimated motor speed until the encoder failure is fixed and the exact motor speed is available again.

- If the encoder failure occurs **before** the STO function is activated, the FSO continues operation using the estimated motor speed and activates the STO and SBC function with *Delayed brake* (see section *How to configure SBC after STO* on page *266*) when the STO function request is received.
- If the encoder failure occurs **while** the STO function is already active, but the *STO SBC speed* has not been reached yet, the FSO module starts to use the *Delayed brake* and activates the SBC accordingly:
  - If parameter *SBC.12 STO SBC delay* is positive, the FSO activates the SBC after this time has elapsed from the STO activation.
  - If parameter *SBC.12 STO SBC delay* is negative or zero, the FSO actives the SBC when the encoder failure occurs.

For more information, see sections *Measured and estimated motor speed* on page *44* and *Configuring the FSO for FSE or encoder failure situations* on page *320*.

Configuring SS1

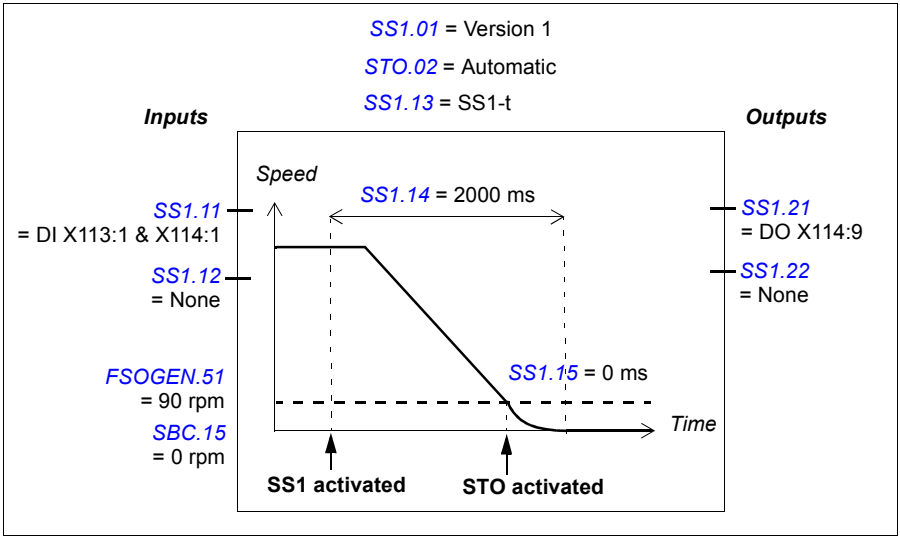
To configure the SS1 function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter group *SS1* on page *339*.

For more information on the SS1 function, see page *68*.

How to configure SS1 with time monitoring (SS1-t)

Example: The figure below shows an example of an SS1-t set-up:

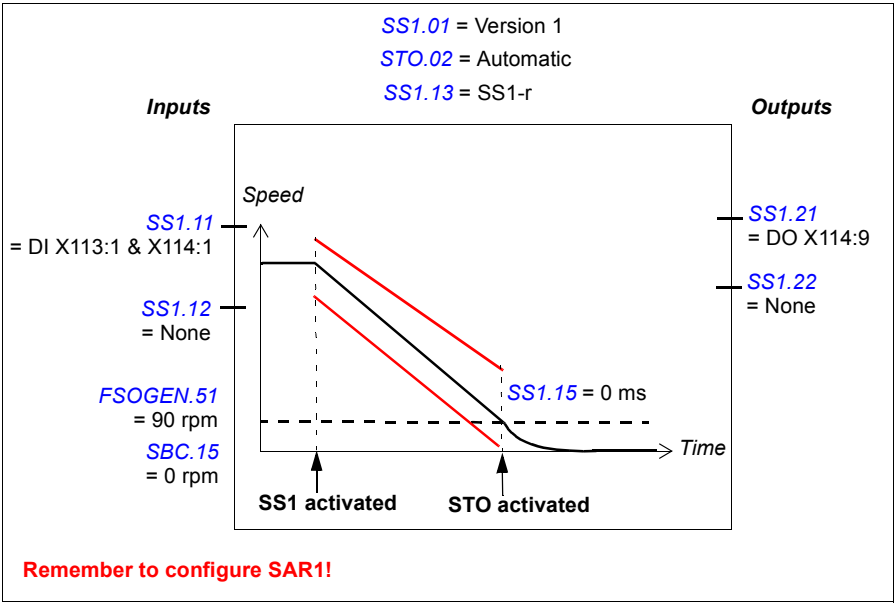
- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1*)
- SAR1 emergency ramp (always with the SS1 function)
- SS1 with time monitored ramp (*SS1.13 SS1 type* = *SS1-t*)
- security delay for activating the drive STO: 2000 ms (*SS1.14 SS1-t delay for STO* = *2000 ms*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = *DO X114:9*)
- zero speed limit for activating the drive STO: 90 rpm (*FSOGEN.51 Zero speed without encoder* = *90 rpm*) (when an encoder is used: *FSOGEN.52 Zero speed with encoder* = *90 rpm*)
- delay for activating STO after the zero speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms*)
- speed limit activated brake not in use (*SBC.15 SSE/SS1 SBC speed* = *0 ms*).
- See also section *Fine-tuning the configuration* on page *314*.


SS1.01 = Version 1
STO.02 = Automatic
SS1.13 = SS1-t
Inputs
Outputs
Speed
SS1.14 = 2000 ms
SS1.11
= DI X113:1 & X114:1
SS1.12
= None
SS1.21
= DO X114:9
SS1.22
= None
FSOGEN.51
= 90 rpm
SBC.15
= 0 rpm
SS1.15 = 0 ms
Time
SS1 activated
STO activated

How to configure SS1 with ramp monitoring (SS1-r)

Example: The figure below shows an example of the SS1-r function set-up:

- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1*)
- SAR1 emergency ramp (always with the SS1 function)
- SS1 with monitored ramp (*SS1.13 SS1 type* = *SS1-r*). See also section *How to configure SARn* on page *294*.
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = DO X114:9)
- zero speed limit for activating the drive STO: 90 rpm (*FSOGEN.51 Zero speed without encoder* = *90 rpm*) (when an encoder is used: *FSOGEN.52 Zero speed with encoder* = *90 rpm*)
- delay for activating STO after the zero speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms*)
- speed limit activated brake not in use (*SBC.15 SSE/SS1 SBC speed* = *0 ms*).
- See also section *Fine-tuning the configuration* on page *314*.

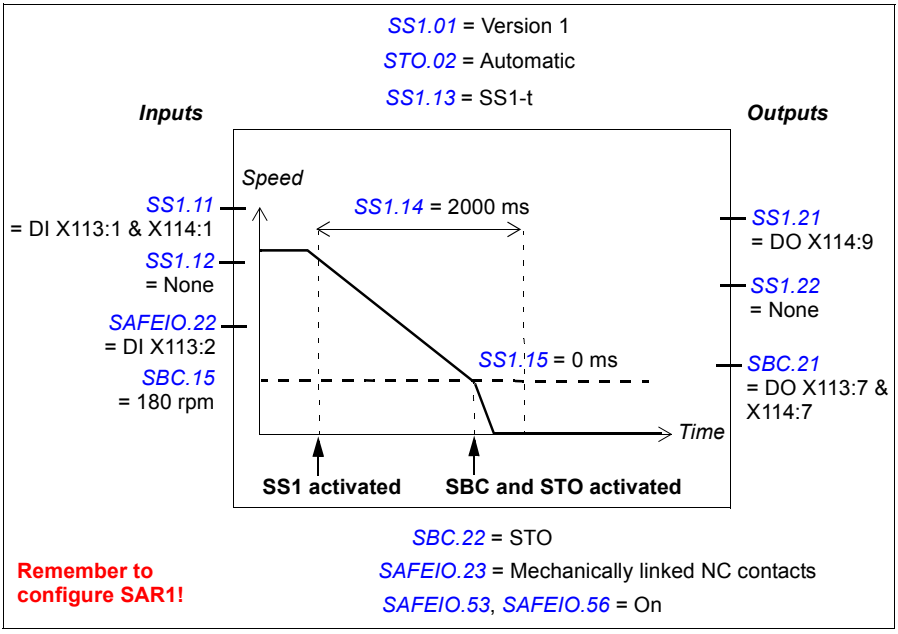


How to configure SS1 with speed limit activated SBC

Note: If you configure the SS1 with speed limit activated SBC function, this activates the same function in the SSE function (see section *How to configure SSE with speed limit activated SBC* on page *289*). This does not activate the SBC in the STO function. If necessary, configure the SBC also in the STO function (see section *Configuring STO* on page *264*). See also the note on page *42*.

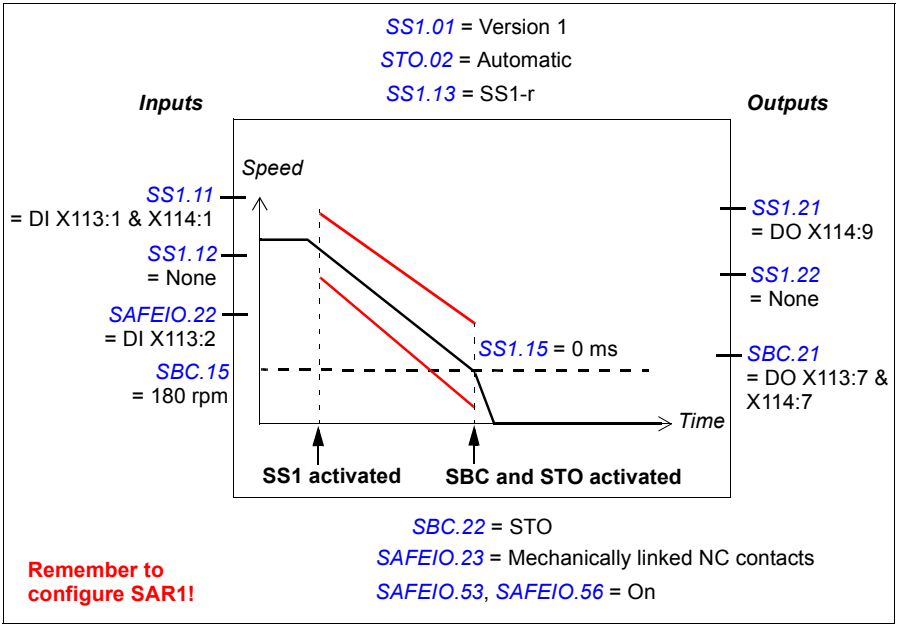
Example 1: The figure below shows an example of the SS1-t function with speed limit activated SBC set-up:

- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1)*
- SS1 with time monitored ramp (*SS1.13 SS1 type* = *SS1-t*)
- SAR1 emergency ramp (always with the SS1 function)
- security delay for activating the drive STO: 2000 ms (*SS1.14 SS1-t delay for STO* = *2000 ms*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = *DO X114:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed below which the brake and STO are activated: 180.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *180 rpm*)
- delay for activating STO after brake is zero (STO and SBC are activated at the same time) (*SBC.12 STO SBC delay* = *0 ms*)
- delay for activating the brake and STO after the SBC speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.


SS1.01 = Version 1
STO.02 = Automatic
SS1.13 = SS1-t
Inputs
Outputs
Speed
SS1.11
= DI X113:1 & X114:1
SS1.12
= None
SAFEIO.22
= DI X113:2
SBC.15
= 180 rpm
SS1.14 = 2000 ms
SS1.15 = 0 ms
Time
SS1.21
= DO X114:9
SS1.22
= None
SBC.21
= DO X113:7 &
X114:7
SS1 activated
SBC and STO activated
SBC.22 = STO
SAFEIO.23 = Mechanically linked NC contacts
SAFEIO.53, SAFEIO.56 = On
Remember to
configure SAR1!

Example 2: The figure below shows an example of the SS1-r function with speed limit activated SBC set-up:

- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1*)
- SAR1 emergency ramp (always with the SS1 function)
- SS1 with monitored ramp (*SS1.13 SS1 type* = *SS1-r*). See also section *How to configure SARn* on page *294*.
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = *DO X114:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed limit below which the brake and STO are activated: 180.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *180 rpm*)
- delay for activating STO after brake is zero (STO and SBC are activated at the same time) (*SBC.12 STO SBC delay* = *0 ms*)
- delay for activating the brake and STO after the SBC speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.


SS1.01 = Version 1
STO.02 = Automatic
SS1.13 = SS1-r
Inputs
Outputs
Speed
SS1.11
= DI X113:1 & X114:1
SS1.12
= None
SAFEIO.22
= DI X113:2
SBC.15
= 180 rpm
SS1.15 = 0 ms
SS1.21
= DO X114:9
SS1.22
= None
SBC.21
= DO X113:7 &
X114:7
Time
SS1 activated
SBC and STO activated
SBC.22 = STO
SAFEIO.23 = Mechanically linked NC contacts
SAFEIO.53, SAFEIO.56 = On
Remember to
configure SAR1!

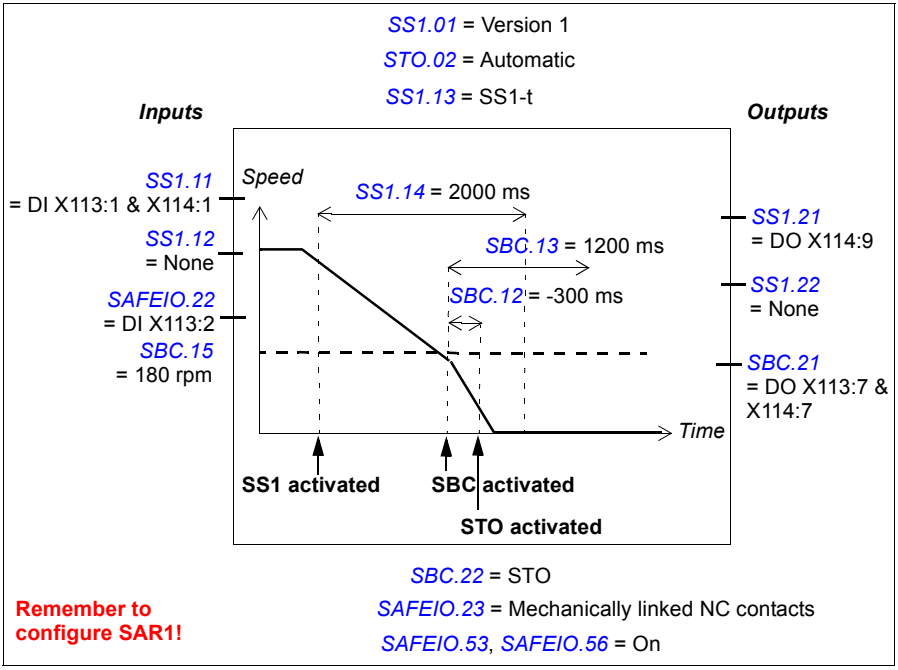
How to configure SS1 with speed limit activated SBC, SBC before STO

Note: If you configure the SS1 with speed limit activated SBC, SBC before STO function, this activates the same function in the SSE function (see section *How to configure SSE with speed limit activated SBC* on page *289*). This does not activate the SBC in the STO function. If necessary, configure the SBC also in the STO function (see section *Configuring STO* on page *264*). See also the note on page *42*.

Example 1: The figure below shows an example of the SS1-t function with speed limit activated SBC, SBC before STO set-up:

- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1*)
- SS1 with time monitored ramp (*SS1.13 SS1 type* = *SS1-t*)
- SAR1 emergency ramp (always with the SS1 function)
- security delay for activating the drive STO: 2000 ms (*SS1.14 SS1-t delay for STO* = *2000 ms*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = *DO X114:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed below which the brake and STO are activated: 180.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *180 rpm*)
- delay for activating STO after brake: -300 ms (only a negative delay is possible, the SBC is activated before STO) (*SBC.12 STO SBC delay* = *-300 ms*)

  Note: The same SBC delay is used in the STO and SS1/SSE functions.
- delay for activating the brake after the SBC speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms,* not shown in the figure)
- when an encoder is used: zero speed limit to define the safety function as completed: 90 rpm (*FSOGEN.52 Zero speed with encoder* = *90 rpm*, not shown in the figure)
- when an encoder is not used: delay to define the safety function as completed, that is, estimated time in which the motor brakes to a stop from the maximum speed: 1200 ms (*SBC.13 SBC time to zero speed* = *1200 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.

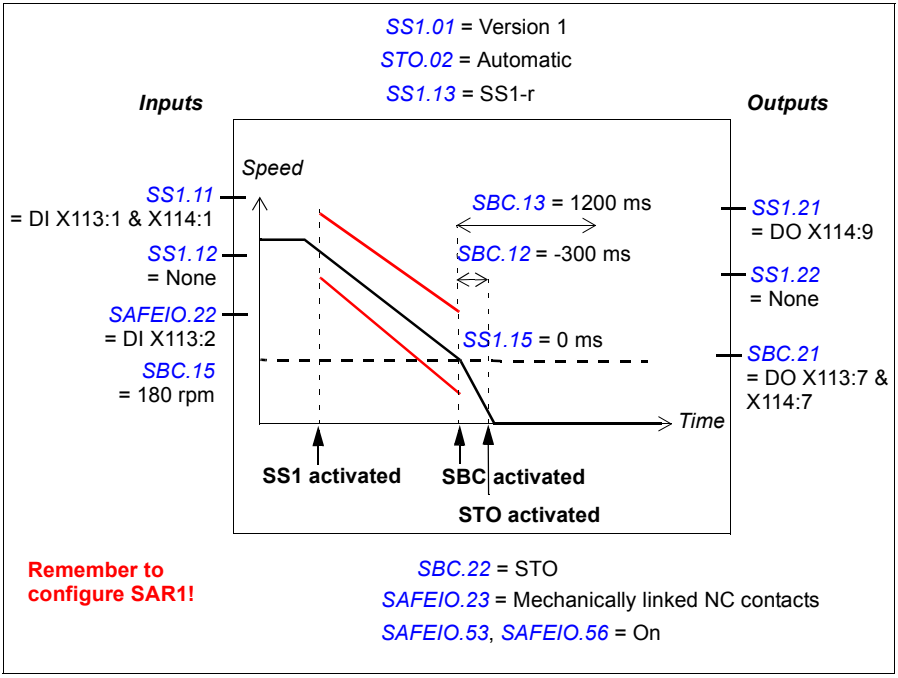


Note: This figure shows the case when an encoder is not used.

Example 2: The figure below shows an example of the SS1-r function with speed limit activated SBC, SBC before STO set-up:

- SS1 function activated (*SS1.01 SS1 activity and version* = *Version 1*)
- SAR1 emergency ramp (always with the SS1 function)
- SS1 with monitored ramp (*SS1.13 SS1 type* = *SS1-r*). See also section *How to configure SARn* on page *294*.
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SS1.11 SS1 input A* = *DI X113:1 & X114:1*)
- single output connected (*SS1.21 SS1 output* = *DO X114:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed limit below which the brake is activated: 180.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *180 rpm*)
- delay for activating STO after brake: -300 ms (only a negative delay is possible, the SBC is activated before STO) (*SBC.12 STO SBC delay* = *-300 ms*)

  Note: The same SBC delay is used in the STO and SS1/SSE functions.
- delay for activating the brake after the SBC speed limit has been reached: 0 ms (*SS1.15 SS1-r ramp zero speed delay for STO* = *0 ms*, not shown in the figure)
- when an encoder is used: zero speed limit to define the safety function as completed: 90 rpm (*FSOGEN.52 Zero speed with encoder* = *90 rpm*, not shown in the figure)
- when an encoder is not used: delay to define the safety function as completed, that is, estimated time in which the motor brakes to a stop from the maximum speed: 1200 ms (*SBC.13 SBC time to zero speed* = *1200 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.



Note: This figure shows the case when an encoder is not used.

Related safety functions

The SS1 function uses SAR1 ramp parameters. See section *Configuring SAR* on page *294*.

The FSO module activates the STO function if the motor speed hits a monitoring limit (time or ramp monitoring). See section *Configuring STO* on page *264*.

Configuring SSE

To configure the SSE function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *SSE* on page *336* and *SBC* on page *332*.

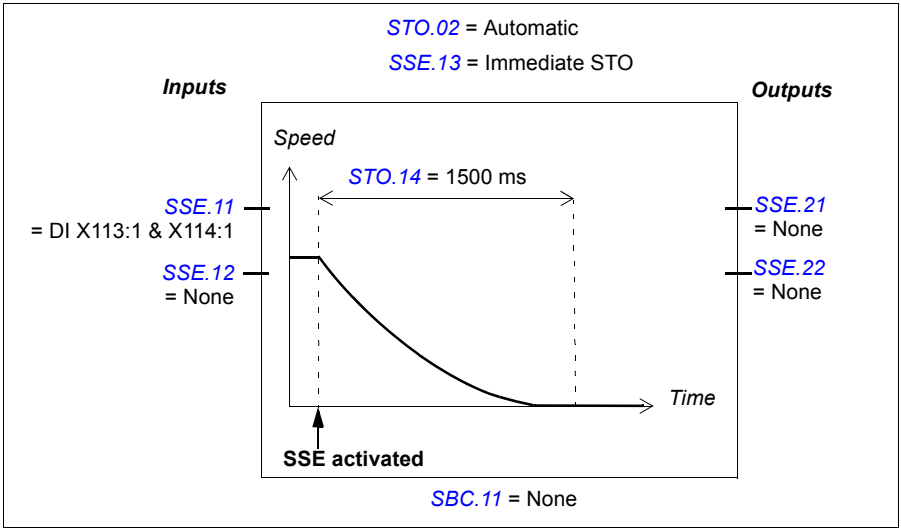
For more information on the SSE function, see page *93*.

Note: Always set the parameters related to the SSE function to have the correct trip limit hit and fault reaction behavior. For example, the FSO module activates the SSE function if an I/O failure occurs.

How to configure SSE with immediate STO

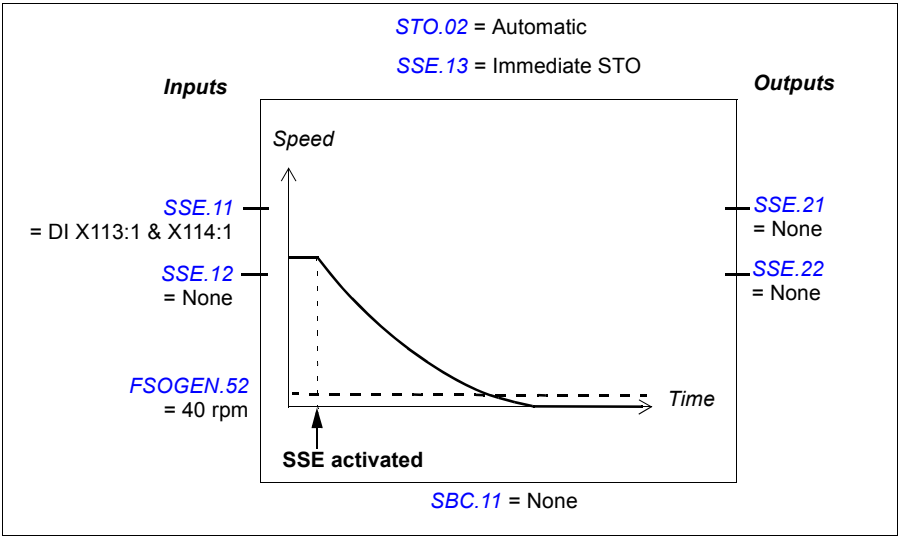
Example 1 (without an encoder): The figure below shows an example of the SSE function with immediate STO set-up when an encoder is not used:

- drive STO is activated immediately after the SSE request (*SSE.13 SSE function* = *Immediate STO*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1*)
- no outputs connected
- delay for restarting the drive: 1500 ms. This is the estimated time in which the motor coasts to a stop from the maximum speed. (*STO.14 Time to zero speed with STO and modoff* = *1500 ms*)
- no brake (*SBC.11 STO SBC usage* = *None*).



Example 2 (with an encoder): The figure below shows an example of the SSE function with immediate STO set-up when an encoder is used. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

- drive STO is activated immediately after the SSE request (*SSE.13 SSE function* = *Immediate STO*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1*)
- no outputs connected
- zero speed limit at which the motor has stopped: 40 rpm (parameter *FSOGEN.52 Zero speed with encoder* = *40 rpm*)
- no brake (*SBC.11 STO SBC usage* = *None*).



How to configure SSE with immediate STO, SBC after or before STO

The configuration is identical to the SBC after or before STO functions with these differences:

- parameter *STO.13 Restart delay after STO* is not used
- SSE input parameters (*SSE.11 SSE input A* and *SSE.12 SSE input B*) are used instead of STO input parameters
- SSE output parameters (*SSE.21 SSE output* and *SSE.22 SSE completed output*) are used instead of STO output parameters.

See sections *How to configure SBC after STO* on page *266* and *How to configure SBC before STO* on page *268*.

For more information on the SSE with immediate STO and SBC after STO function, see page *96*.

For more information on the SSE with immediate STO and SBC before STO function, see page *99*.

How to configure SSE with immediate STO with speed limit activated SBC

This safety function requires that an encoder is used. Configure the safety encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

The configuration is identical to the STO with speed limit activated SBC function with these differences:

- parameter *STO.13 Restart delay after STO* is not used
- SSE input parameters (*SSE.11 SSE input A* and *SSE.12 SSE input B*) are used instead of STO input parameters
- SSE output parameters (*SSE.21 SSE output* and *SSE.22 SSE completed output*) are used instead of STO output parameters.

Note: If you configure the SSE with immediate STO with speed limit activated SBC function, this activates the same function in the STO function (see section *How to configure STO with speed limit activated SBC* on page *270*).

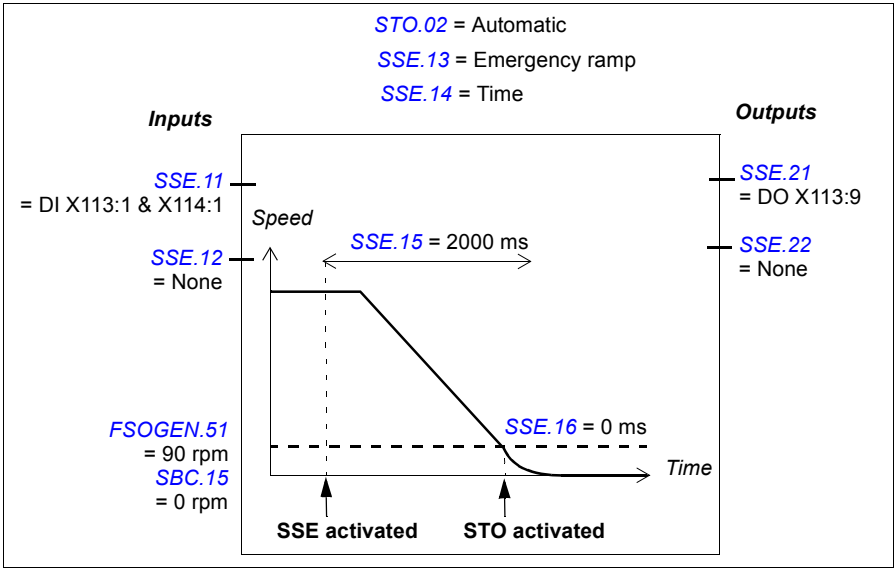
For more information on the SSE with immediate STO with speed limit activated SBC function, see page *102*.

How to configure SSE with time monitoring

For more information on the SSE function with time monitoring, see page *103*.

Example: The figure below shows an example of the SSE function with time monitoring set-up:

- SAR0 emergency ramp (always with the SSE function)
- SSE with time monitored ramp (*SSE.13 SSE function* = *Emergency ramp*, *SSE.14 SSE monitoring method* = *Time*)
- security delay for activating the drive STO: 2000 ms (*SSE.15 SSE delay for STO* = *2000 ms*)
- automatic acknowledgement (*STO.02 STO acknowledgement* = *Automatic*)
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1*)
- single output connected (*SSE.21 SSE output* = *DO X113:9)*
- zero speed limit for activating the drive STO: 90 rpm (*FSOGEN.51 Zero speed without encoder* = *90 rpm*) (when an encoder is used: *FSOGEN.52 Zero speed with encoder* = *90 rpm*)
- delay for activating the drive STO after the speed limit has been reached: 0 ms (*SSE.16 SSE ramp zero speed delay for STO* = *0 ms*)
- speed limit activated brake not in use (*SBC.15 SSE/SS1 SBC speed* = *0 rpm*)
- See also section *Fine-tuning the configuration* on page *314*.

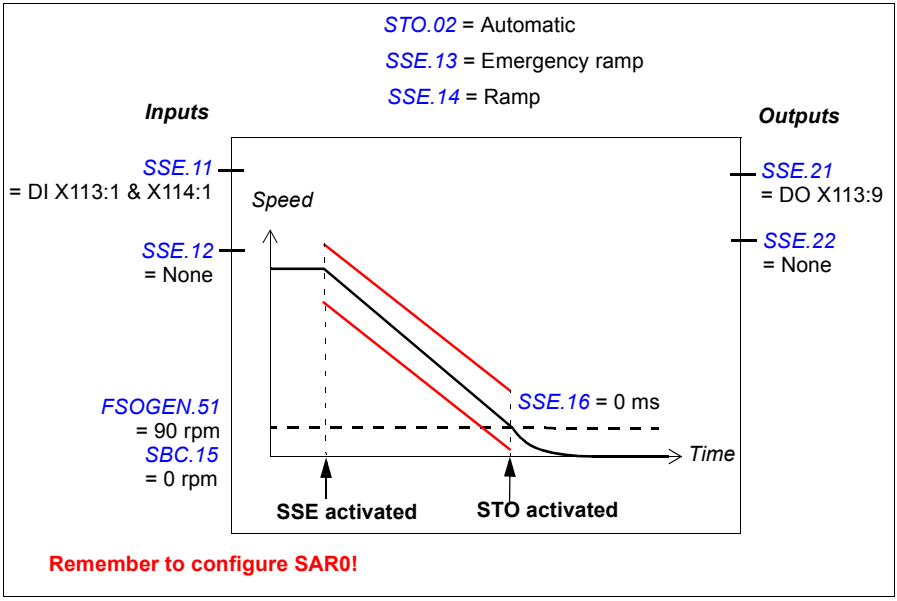


How to configure SSE with ramp monitoring

For more information on the SSE function with ramp monitoring, see page *107*.

Example: The figure below shows an example of the SSE function with ramp monitoring set-up:

- SAR0 emergency ramp (always with the SSE function)
- SSE with emergency ramp (*SSE.13 SSE function* = *Emergency ramp*)
- SSE with monitored ramp (*SSE.14 SSE monitoring method* = *Ramp*). See also section *Configuring SAR* on page *294*.
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1*)
- single output connected (*SSE.21 SSE output* = *DO X113:9*)
- zero speed limit for activating the drive STO: 90 rpm (*FSOGEN.51 Zero speed without encoder* = *90 rpm)* (when an encoder is used: *FSOGEN.52 Zero speed with encoder* = *90 rpm*)
- delay for activating the drive STO after the zero speed limit has been reached: 0 ms (*SSE.16 SSE ramp zero speed delay for STO* = *0 ms*)
- speed limit activated brake not in use (*SBC.15 SSE/SS1 SBC speed* = *0 rpm*).
- See also section *Fine-tuning the configuration* on page *314*.

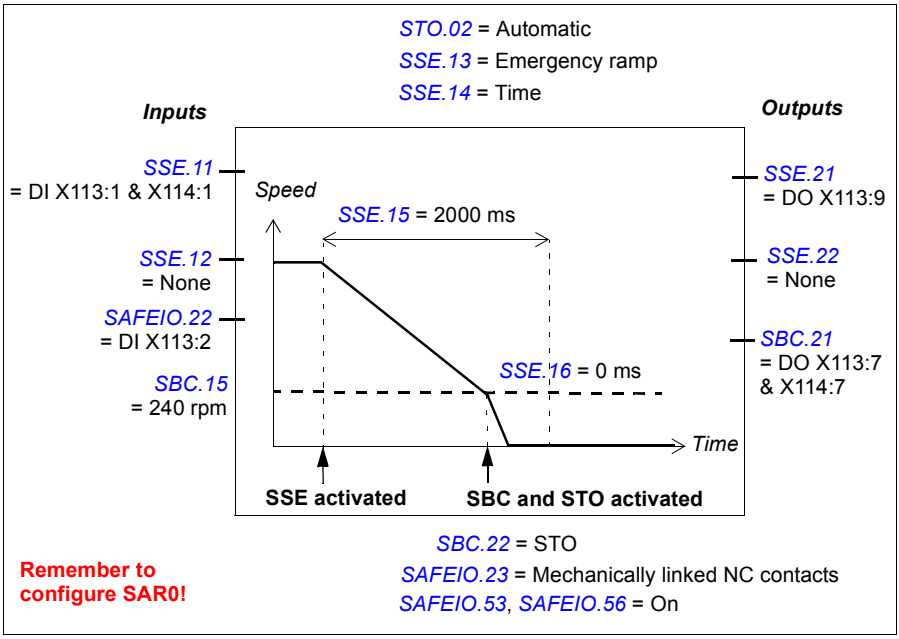


How to configure SSE with speed limit activated SBC

Note: If you configure the SSE with speed limit activated SBC function, this activates the same function in the SS1 function (see section *How to configure SS1 with speed limit activated SBC* on page *276*). This does not activate the SBC in the STO function. If necessary, configure the SBC also in the STO function (see section *Configuring STO* on page *264*). See also the note on page *42*.

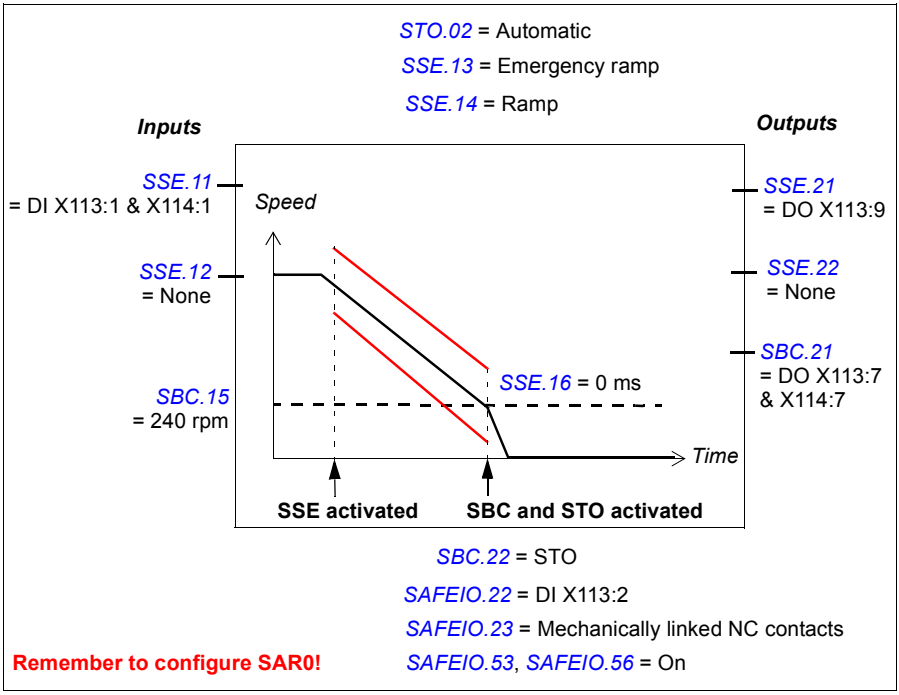
Example 1: The figure below shows an example of the SSE with emergency ramp function with speed limit activated SBC set-up with time monitoring:

- SSE with emergency ramp (*SSE.13 SSE function* = *Emergency ramp*)
- SAR0 emergency ramp (always with the SSE function, see also section *Configuring SAR* on page *294*)
- time monitored ramp (*SSE.14 SSE monitoring method* = *Time*)
- security delay for activating the drive STO: 2000 ms (*SSE.15 SSE delay for STO* = *2000 ms*)
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1)*
- single output connected (*SSE.21 SSE output* = *DO X113:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed below which the brake and STO are activated 240.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *240 rpm*)
- delay for activating STO after brake is zero (STO and SBC are activated at the same time) (*SBC.12 STO SBC delay* = *0 ms*)
- delay for activating the brake and drive STO after the speed limit has been reached 0 ms (*SSE.16 SSE ramp zero speed delay for STO* = *0 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.


STO.02 = Automatic
SSE.13 = Emergency ramp
SSE.14 = Time
Inputs
Outputs
SSE.11
= DI X113:1 & X114:1
SSE.12
= None
SAFEIO.22
= DI X113:2
SBC.15
= 240 rpm
Speed
SSE.15 = 2000 ms
SSE.16 = 0 ms
Time
SSE activated
SBC and STO activated
SSE.21
= DO X113:9
SSE.22
= None
SBC.21
= DO X113:7
& X114:7
SBC.22 = STO
SAFEIO.23 = Mechanically linked NC contacts
SAFEIO.53, SAFEIO.56 = On
Remember to
configure SAR0!

Example 2: The figure below shows an example of the SSE with emergency ramp function with speed limit activated SBC set-up with ramp monitoring:

- SSE with emergency ramp (*SSE.13 SSE function* = *Emergency ramp*)
- SAR0 emergency ramp (always with the SSE function)
- SAR0 monitored ramp (*SSE.14 SSE monitoring method* = *Ramp*, see also section *Configuring SAR* on page *294*)
- redundant emergency stop button connected to input (*SSE.11 SSE input A* = *DI X113:1 & X114:1*)
- single output connected (*SSE.21 SSE output* = *DO X113:9*)
- brake connected to redundant output, diagnostic pulses activated (*SBC.21 SBC output* = *DO X113:7 & X114:7*, *SAFEIO.53* and *SAFEIO.56* = *On*)
- speed limit activated brake in use, speed below which the brake and STO are activated 240.0 rpm (*SBC.15 SSE/SS1 SBC speed* = *240 rpm*)
- delay for activating STO after brake is zero (STO and SBC are activated at the same time) (*SBC.12 STO SBC delay* = *0 ms*)
- delay for activating the brake and drive STO after the speed limit has been reached 0 ms (*SSE.16 SSE ramp zero speed delay for STO* = *0 ms*)
- STO is activated if brake feedback fails (*SBC.22 SBC feedback action* = *STO*)
- brake feedback input connected to input (*SAFEIO.22 Safety relay 1 feedback* = *DI X113:2*)
- feedback input type NC (inverted state compared with the brake relay) (*SAFEIO.23 Safety relay 1 feedback type* = *Mechanically linked NC contacts*).
- See also section *Fine-tuning the configuration* on page *314*.


STO.02 = Automatic
SSE.13 = Emergency ramp
SSE.14 = Ramp
Inputs
Outputs
SSE.11
= DI X113:1 & X114:1
SSE.12
= None
SBC.15
= 240 rpm
Speed
SSE.16 = 0 ms
Time
SSE activated
SBC and STO activated
SSE.21
= DO X113:9
SSE.22
= None
SBC.21
= DO X113:7
& X114:7
SBC.22 = STO
SAFEIO.22 = DI X113:2
SAFEIO.23 = Mechanically linked NC contacts
SAFEIO.53, SAFEIO.56 = On
Remember to configure SAR0!

How to configure SSE with speed limit activated SBC, SBC before STO

The configuration of the SSE with speed limit activated SBC, SBC before STO is identical to the configuration of the same SS1 function with these differences:

- SSE input parameters (*SSE.11 SSE input A* and *SSE.12 SSE input B*) are used instead of SS1 input parameters
- SSE output parameters (*SSE.21 SSE output* and *SSE.22 SSE completed output*) are used instead of SS1 output parameters.
- type of the SSE function must be set: SSE with emergency ramp (*SSE.13 SSE function* = *Emergency ramp*)
- SAR0 emergency ramp and monitoring limits are used instead of SAR1 parameters (see section *Configuring SAR* on page *294*).
- monitoring method is set with parameter (*SSE.14 SSE monitoring method* = *Time* or *Ramp*)
- security delay for activating the drive STO is set with parameter *SSE.15 SSE delay for STO*
- delay for activating the brake after the speed limit has been reached is set with parameter *SSE.16 SSE ramp zero speed delay for STO*.

Note: If you configure the SSE with speed limit activated SBC function, this activates the same function in the SS1 function (see section *How to configure SS1 with speed limit activated SBC, SBC before STO* on page *280*). This does not activate the SBC in the STO function. If necessary, configure the SBC also in the STO function (see section *Configuring STO* on page *264*). See also the note on page *42*.

For more information on the SSE with speed limit activated SBC, SBC before STO SBC function, see page *119*.

Related safety functions

The SSE function uses SAR0 ramp parameters. See section *Configuring SAR* on page *294*.

The FSO module activates the STO function if the motor speed hits a monitoring limit (SSE with time or ramp monitoring). See section *Configuring STO* on page *264*.

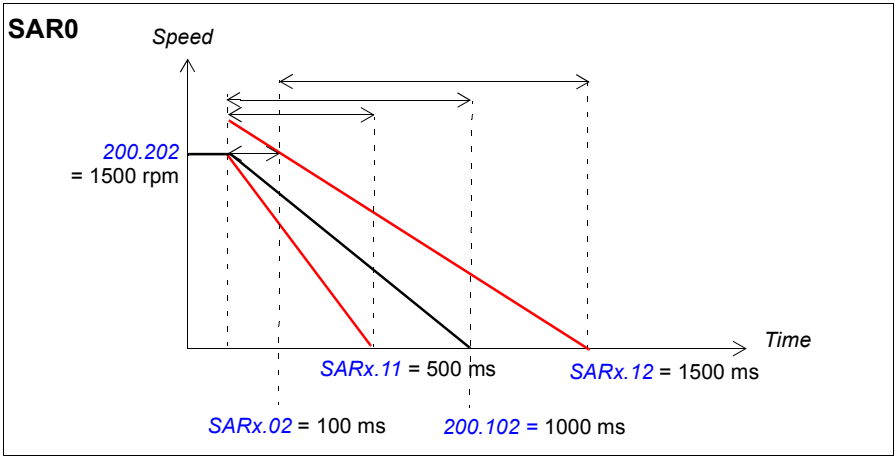
Configuring SAR

How to configure SARn

To configure the SARn (n = 0…1), set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *Safety* on page *322* and *SARx* on page *348*. See also section *Ramp monitoring* on page *51*.

Example: The figure below shows an example of a SAR0 monitoring set-up:

- SAR0
- ramp time from Scaling speed to zero: 1000 ms (*200.102 SAR0 ramp time to zero* = *1000 ms*)
- Scaling speed: 1500 rpm (*200.202 SAR speed scaling* = *1500 rpm*)
- initial range for monitoring: 100 ms (*SARx.02 SAR initial allowed range* = *100 ms*)
- minimum allowed ramp time: 500 ms (*SARx.11 SAR0 min ramp time to zero* = *500 ms*)
- maximum allowed ramp time: 1000 ms (*SARx.12 SAR0 max ramp time to zero* = *1500 ms*).



Configuring SLS

To configure the SLSn (n = 1…4), set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *Safety* on page *322* and *SLSx* on page *342*.

For more information on the SLS function, see page *127*.

Depending on the application, set the negative and positive SLS and SLS trip limits separately.

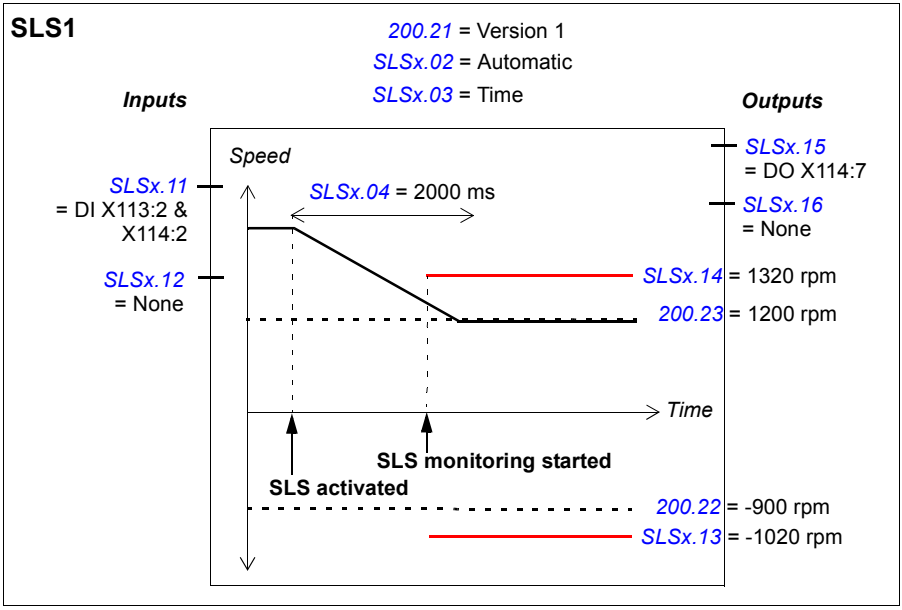
How to configure SLSn with time monitoring

Example: The figure below shows an example of the SLS1 function with time monitoring set-up:

- SLS1 function activated (*200.21 SLS1 activity and version* = *Version 1*)
- time monitored deceleration ramp (*SLSx.03 SLS activation monitoring method* = *Time*)
- deceleration ramp according to drive parameters (always with time monitoring)
- SLS activation delay: 2000 ms (*SLSx.04 SLS time delay* = *2000 ms*)
- automatic acknowledgement (*SLSx.02 SLS acknowledgement* = *Automatic*)
- redundant SLS activation button connected to input (*SLSx.11 SLS1 input A* = *DI X113:2 & X114:2*)
- single output connected (*SLSx.15 SLS1 output A* = *DO X114:7*)
- positive limits: SLS 1200.0 rpm, trip limit 1320.0 rpm (*200.23 SLS1 limit positive* = *1200 rpm*, *SLSx.14 SLS1 trip limit positive* = *1320 rpm*).
- negative limits: SLS -900.0 rpm, trip limit -1020.0 rpm (*200.22 SLS1 limit negative* = *-900 rpm*, *SLSx.13 SLS1 trip limit negative* = *-1020 rpm*).
- See also section *Fine-tuning the configuration* on page *314*.

Note: The difference between the SLS limit and the corresponding SLS trip limit must be at least 0.1 rpm.

Note: If you also use the SMS function, the SLS trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.


SLS1
200.21 = Version 1
SLSx.02 = Automatic
SLSx.03 = Time
Inputs
Outputs
Speed
SLSx.11
= DI X113:2 &
X114:2
SLSx.04 = 2000 ms
SLSx.15
= DO X114:7
SLSx.16
= None
SLSx.12
= None
SLSx.14 = 1320 rpm
200.23 = 1200 rpm
Time
SLS monitoring started
SLS activated
200.22 = -900 rpm
SLSx.13 = -1020 rpm

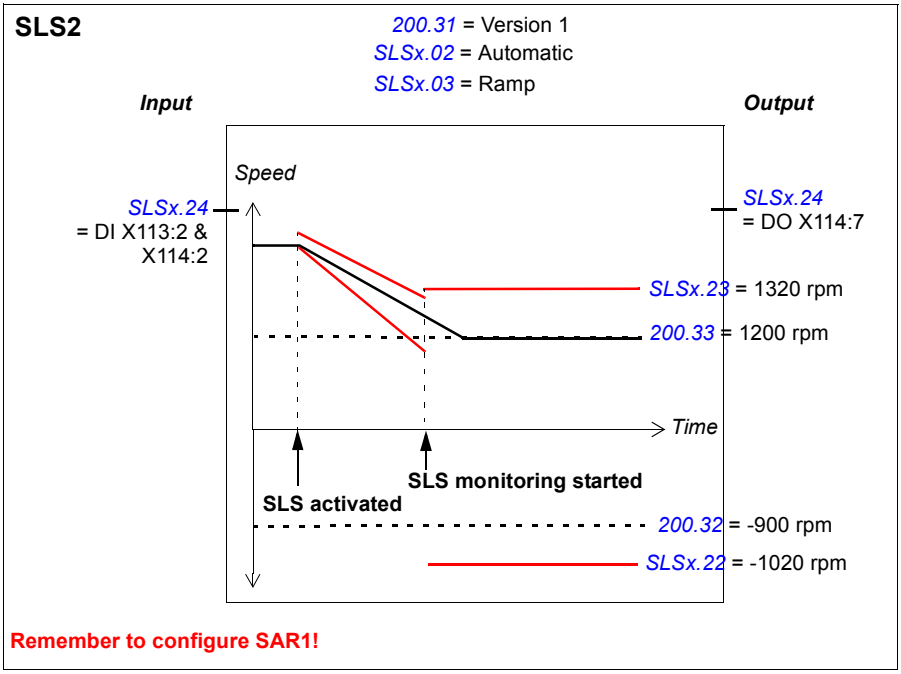
How to configure SLSn with ramp monitoring

Example: The figure below shows an example of the SLS2 function with ramp monitoring set-up:

- SLS2 function activated (*200.31 SLS2 activity and version* = *Version 1*)
- monitored deceleration ramp (*SLSx.03 SLS activation monitoring method* = *Ramp*)
- deceleration ramp and monitoring limits according SAR1 parameters (see section *Configuring SAR* on page *294*)
- automatic acknowledgement (*SLSx.02 SLS acknowledgement* = *Automatic*)
- redundant SLS activation button connected to input (*SLSx.21 SLS2 input* = *DI X113:2 & X114:2*)
- single output connected (*SLSx.24 SLS2 output* = *DO X114:7*)
- positive limits: SLS 1200.0 rpm, trip limit 1320.0 rpm (*200.33 SLS2 limit positive* = *1200 rpm,* *SLSx.23 SLS2 trip limit positive* = *1320 rpm*).
- negative limits: SLS -900.0 rpm, trip limit -1020.0 rpm (*200.32 SLS2 limit negative* = *-900 rpm,* *SLSx.22 SLS2 trip limit negative* = *-1020 rpm*).
- See also section *Fine-tuning the configuration* on page *314*.

Note: The difference between the SLS limit and the corresponding SLS trip limit must be at least 0.1 rpm.

Note: If you also use the SMS function, the SLS trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.



Related safety functions

The SLS1…4 functions use SAR1 parameters to monitor and/or define the deceleration ramp (SLS with ramp monitoring). See section *Configuring SAR* on page *294*.

The FSO module activates the STO function if the motor speed hits a ramp monitoring limit during the deceleration ramp (SLS with ramp monitoring). See section *Configuring STO* on page *264*.

The FSO module activates the SSE function if the motor speed hits a trip limit. See section *Configuring SSE* on page *284*.

Configuring Variable SLS

This safety function requires that a safety PLC is connected to the FSO module via the PROFIsafe communication bus. For more information, see chapter *PROFIsafe* and section *Configuring the safety fieldbus communication* on page *254*.

To configure the Variable SLS function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *Safety* on page *322* and *SLSx* on page *342*.

The Variable SLS function uses the SLS4 limits of the FSO module. Depending on the application, set the negative and positive SLS and trip limits separately.

The FSO module scales the SLS4 trip limit so that the difference between the new limits does not become too small. For more information, see section *Defining the scaled SLS4 limit and SLS4 trip limits* on page *303*.

For more information on the Variable SLS function, see page *137*.

How to configure Variable SLS with time monitoring

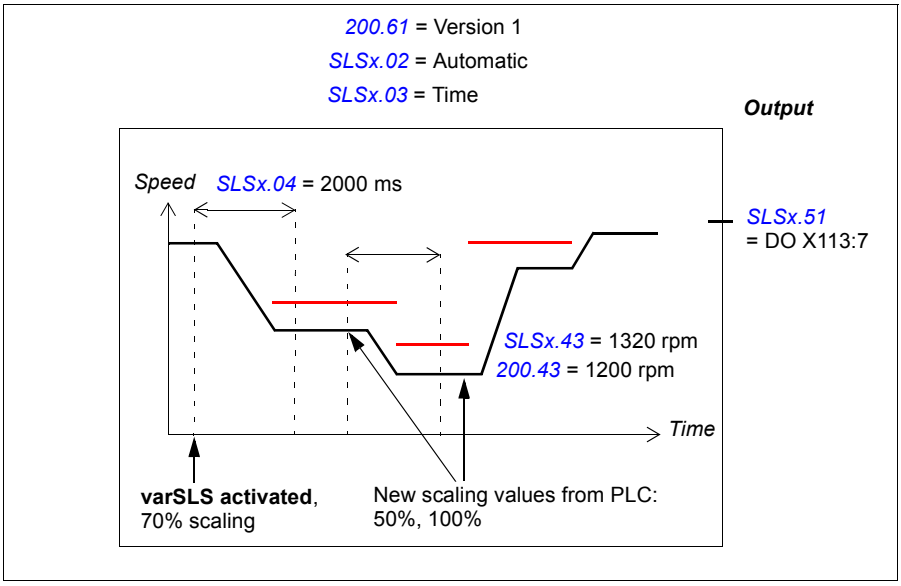
Example: The figure below shows an example of the Variable SLS function with time monitoring set-up:

- Variable SLS function activated
  (*200.61 SLS variable activity and version* = *Version 1*)
- automatic acknowledgement (*SLSx.02 SLS acknowledgement* = *Automatic*)
- time monitored deceleration ramp
  (*SLSx.03 SLS activation monitoring method* = *Time*)
- deceleration and acceleration ramps according to drive parameters
- SLS activation delay: 2000 ms (*SLSx.04 SLS time delay* = *2000 ms*)
- single output connected (*SLSx.51 Variable SLS output* = *DO X114:7*)
- positive limits: SLS 1200.0 rpm, trip limit 1320.0 rpm
  (*200.43 SLS4 limit positive* = *1200 rpm,*
  SLSx.43 SLS4 trip limit positive = *1320 rpm*).
- negative limits: SLS 0 rpm, trip limit: -Zero speed limit
  (*FSOGEN.51 Zero speed without encoder* or when an encoder is used:
  FSOGEN.52 Zero speed with encoder), not shown in the figure)
  (*200.42 SLS4 limit negative* = *0 rpm,*
  SLSx.42 SLS4 trip limit negative = *-90 rpm*).
- See also section *Fine-tuning the configuration* on page *314*.

Note: The difference between the SLS limit and the corresponding SLS trip limit must be at least 0.1 rpm.

These values are defined in the safety program:

- only positive limits are scaled: Positive_Scaling = *0*, Negative_Scaling = *1*
- scaling values from the safety PLC: 70%, 50%, 100%
  (value set in Variable_SLS_limit = *7000, 5000, 10000*).



How to configure Variable SLS with ramp monitoring

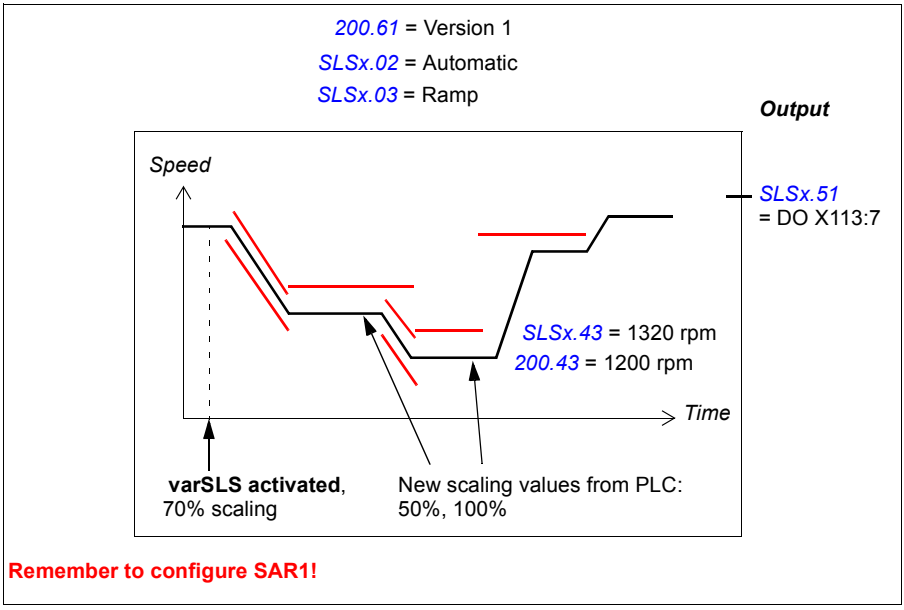
Example: The figure below shows an example of the Variable SLS function with ramp monitoring set-up:

- Variable SLS function activated
  (*200.61 SLS variable activity and version* = *Version 1*)
- automatic acknowledgement (*SLSx.02 SLS acknowledgement* = *Automatic*)
- monitored deceleration ramp
  (*SLSx.03 SLS activation monitoring method* = *Ramp*)
- deceleration ramp and ramp monitoring limits according to SAR1 parameters, acceleration ramp according to drive parameters
- single output connected (*SLSx.51 Variable SLS output* = *DO X114:7*)
- positive limits: SLS 1200.0 rpm, trip limit 1320.0 rpm
  (*200.43 SLS4 limit positive* = *1200 rpm,*
  SLSx.43 SLS4 trip limit positive = *1320 rpm*).
- negative limits: SLS 0 rpm, trip limit: -Zero speed limit
  (*FSOGEN.51 Zero speed without encoder* or when an encoder is used:
  FSOGEN.52 Zero speed with encoder), not shown in the figure)
  (*200.42 SLS4 limit negative* = *0 rpm,*
  SLSx.42 SLS4 trip limit negative = *-90 rpm)*.
- See also section *Fine-tuning the configuration* on page *314*.

Note: The difference between the SLS limit and the corresponding SLS trip limit must be at least 0.1 rpm.

These values are defined in the safety program:

- only positive limits are scaled: Positive_Scaling = *0*, Negative_Scaling = *1*
- scaling values from the safety PLC: 70%, 50%, 100%
  (value set in Variable_SLS_limit = *7000, 5000, 10000*).



Defining the scaled SLS4 limit and SLS4 trip limits

Because the same scaling percentage is used to scale both the original SLS4 limit and SLS4 trip limit, this affects the difference between new, scaled SLS4 limit and SLS4 trip limits. The FSO scales the SLS4 trip limit so that the difference between the new limits does not become too small.

The FSO module first scales the original SLS4 and SLS4 trip limits with the given percentage. If necessary, the new, scaled SLS4 trip limit is the adjusted according to these rules:

- If the difference between *original SLS4 and SLS4 trip limits* < 25 rpm
  -> the difference between the scaled limits must be at least the same as the original difference. See **Example 1** below.
- If the difference between *original SLS4 and SLS4 trip limits* > 25 rpm
  -> the difference between the limits must be at least 25 rpm. See **Example 2** below.
- The scaled SLS4 trip limit must always be at least the zero speed value (parameter *FSOGEN.51*).

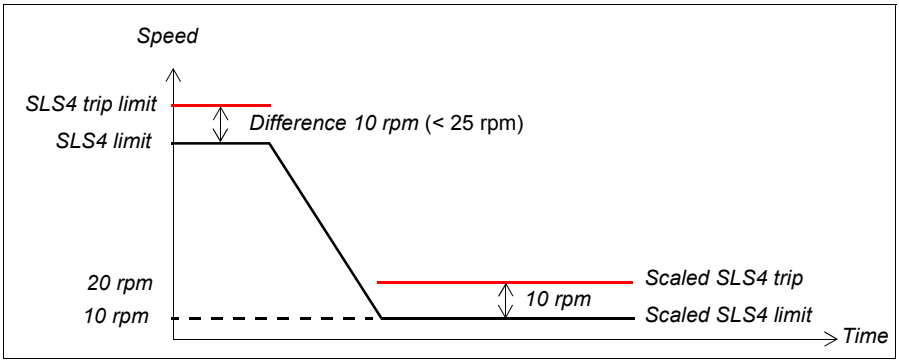
If an encoder is used, the rules become:

- If the difference between *original SLS4 and SLS4 trip limits* < 5 rpm
  -> the difference between the scaled limits must be at least the same as the original difference.
- If the difference between *original SLS4 and SLS4 trip limits* > 5 rpm
  -> the difference between the limits must be at least 5 rpm. See **Example 3** below.
- The scaled SLS4 trip limit must always be at least the zero speed value (parameter *FSOGEN.52*).

Example 1 (no encoder): The original SLS4 and SLS4 trip limits are: 100 and 110 rpm. The scaling value is 10%. The zero speed value is 10 rpm.

- *original SLS4 limit - original SLS4 trip limit* = 10 rpm. This is smaller than 25 rpm, so 10 rpm becomes the “limiting difference”.
  Scaling by 10%: SLS4 limit -> 10 rpm, SLS4 trip limit -> 11 rpm (difference 1 rpm).
  Difference 10 rpm: SLS4 limit = 10 rpm, SLS4 trip limit -> 20 rpm

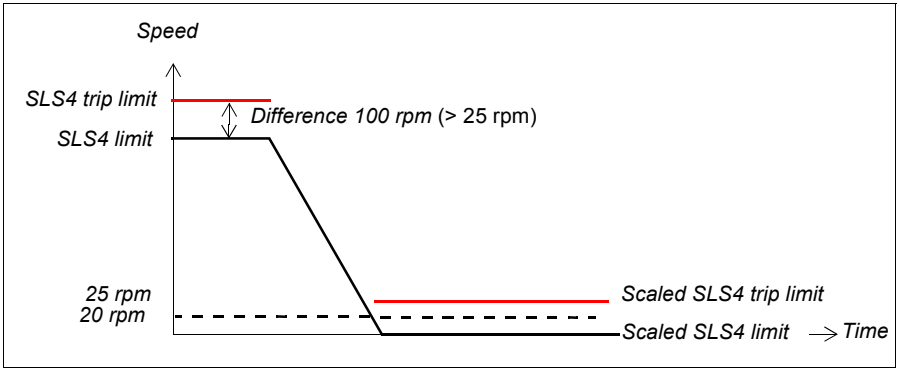
  In this case, the scaled SLS4 and SLS4 trip limits become 10 and 20 rpm, respectively. The difference between the scaled SLS4 and SLS4 trip limits is 10 rpm, and the scaled SLS4 trip limit is above the zero speed value (10 rpm).



Example 2 (no encoder): The original SLS4 and SLS4 trip limits are: 1000 and 1100 rpm. The scaling value is 0%. The zero speed value is 20 rpm.

- *original SLS4 limit - original SLS4 trip limit* = 100 rpm. This is greater than 25 rpm, so 25 rpm becomes the “limiting difference”.
  Scaling by 0%: SLS4 limit -> 0 rpm, SLS4 trip limit -> 0 rpm (difference 0 rpm)
  Difference 25 rpm: SLS4 limit = 0 rpm, SLS4 trip limit -> 25 rpm

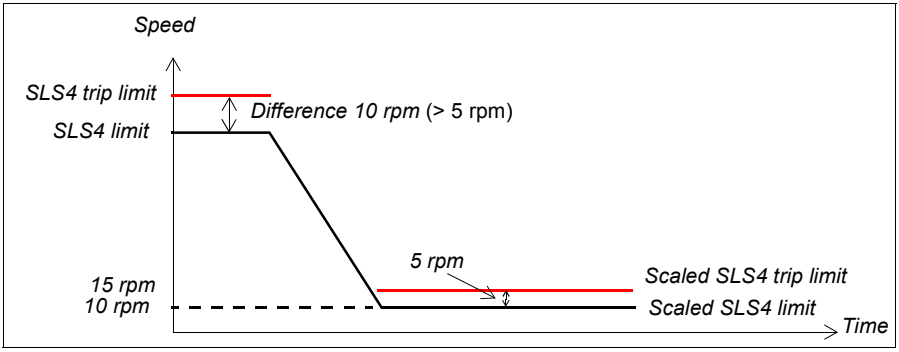
  In this case, the scaled SLS4 and SLS4 trip limits become 0 and 25 rpm, respectively. The difference between the scaled SLS4 and SLS4 trip limits is 25 rpm, and the scaled SLS4 trip limit is above the zero speed value (20 rpm).



Example 3 (with encoder): The original SLS4 and SLS4 trip limits are: 100 and 110 rpm. The scaling value is 10%. The zero speed value is 10 rpm.

- *original SLS4 limit* - *original SLS4 trip limit* = 10 rpm. This is greater than 5 rpm, so 5 rpm becomes the “limiting difference”.
  Scaling by 10%: SLS4 limit -> 10 rpm, SLS4 trip limit -> 11 rpm (difference 1 rpm)
  Difference 5 rpm: SLS4 limit = 10 rpm, SLS4 trip limit -> 15 rpm

  In this case, the scaled SLS4 and SLS4 trip limits become 10 and 15 rpm, respectively. The difference between the scaled SLS4 and SLS4 trip limits is 5 rpm, and the scaled SLS4 trip limit is above the zero speed value (10 rpm).



Related safety functions

The Variable SLS function uses SAR1 parameters to monitor and/or define the deceleration ramp (Variable SLS with ramp monitoring). See section *Configuring SAR* on page *294*.

The FSO module activates the STO function if the motor speed hits a ramp monitoring limit during the deceleration ramp (Variable SLS with ramp monitoring). See section *Configuring STO* on page *264*.

The FSO module activates the SSE function if the motor speed hits a trip limit. See section *Configuring SSE* on page *284*.

Configuring SMS

To configure the SMS, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter groups *SMS* on page *348* and *Safety* on page *322*.

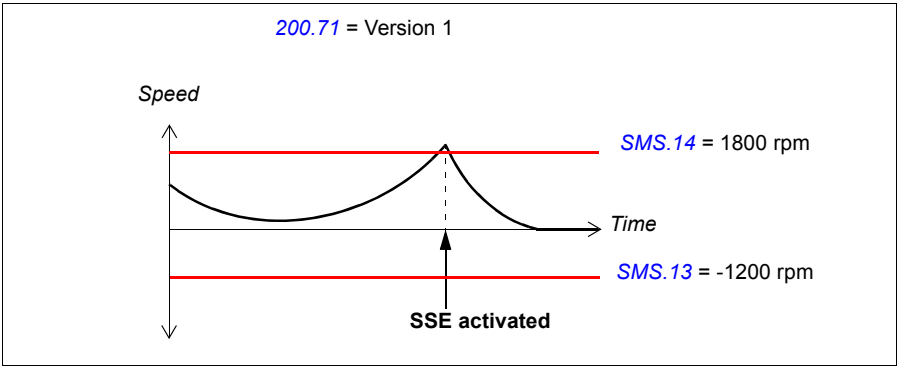
There are two different versions of the SMS function. Select the required version with parameter *200.71 SMS activity and version*.

For more information on the SMS function, see page *142*.

How to configure SMS, version 1

Example: The figure below shows an example of the SMS, version 1 set-up:

- SMS function version 1 activated (*200.71 SMS activity and version* = *Version 1*)
- positive limit 1800.0 rpm (*SMS.14 SMS trip limit positive e* = *1800 rpm*)
- negative limit -1200.0 rpm (*SMS.13 SMS trip limit negative* = *-1200 rpm*)
- SSE function configured as immediate STO (*SSE.13 SSE function* = *Immediate STO*).
- See also section *Fine-tuning the configuration* on page *314*.

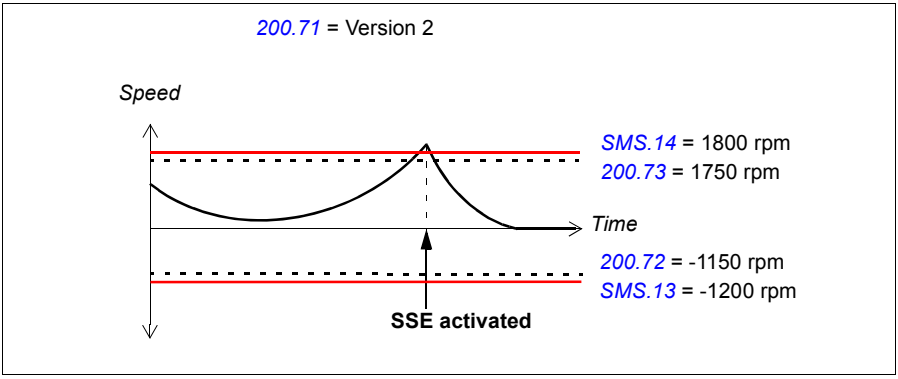


How to configure SMS, version 2

Example: The figure below shows an example of the SMS, version 2 set-up:

- SMS function version 2 activated (*200.71 SMS activity and version* = *Version 2*)
- SMS limit positive (*200.73 SMS limit positive* = *1750*)
- SMS limit negative (*200.72 SMS limit negative* = *-1150*)
- SMS trip limit positive 1800.0 rpm (*SMS.14 SMS trip limit positive* = *1800 rpm*)
- SMS trip limit negative -1200.0 rpm (*SMS.13 SMS trip limit negative* = *-1200 rpm*)
- SSE function configured as immediate STO (*SSE.13 SSE function* = *Immediate STO*).
- See also section *Fine-tuning the configuration* on page *314*.

Note: If you also use an SLS function, the SMS positive and negative trip limits must be more than the speed defined by the corresponding SLS positive trip limit and less than the speed defined by the corresponding SLS negative trip limit, respectively.



Related safety functions

The FSO module activates the SSE function if the motor speed hits an SMS trip limit. See section *Configuring SSE* on page *284*.

Configuring POUS

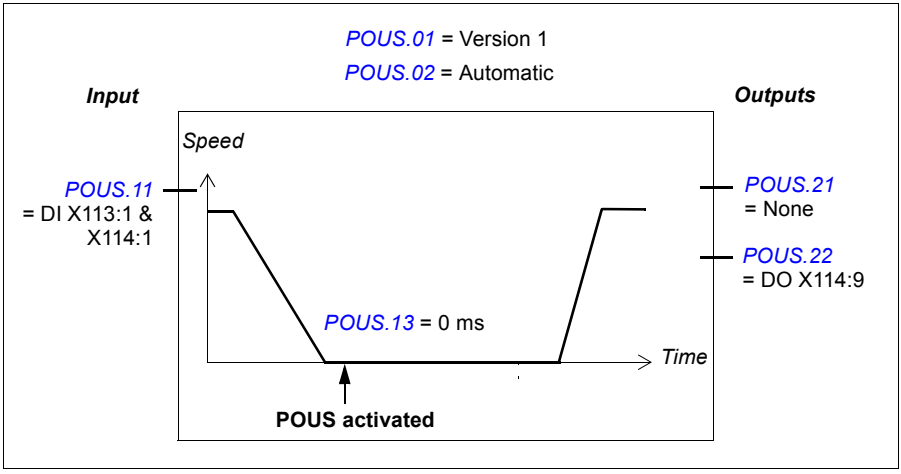
How to configure POUS

To configure the POUS function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter group *POUS* on page *335*.

For more information on the POUS function, see page *145*.

Example: The figure below shows an example of the POUS function set-up:

- POUS function activated (*POUS.01 POUS activity and version* = *Version 1*)
- automatic acknowledgement (*POUS.02 POUS acknowledgement* = *Automatic*)
- redundant POUS switch connected to inputs X113:1 and DIX114:1 (*POUS.11 POUS input* = *DI X113:1 & X114:1*)
- An additional security delay: 0 (*POUS.13 POUS delay for completion* = *0 ms*)
- POUS completed output (for example, an indication lamp) connected to single output: X114:9 (*POUS.22 POUS completed output* = *DO X114:9*).



Configuring SSM

To configure the SSM function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter group *SSMx* on page *353*.

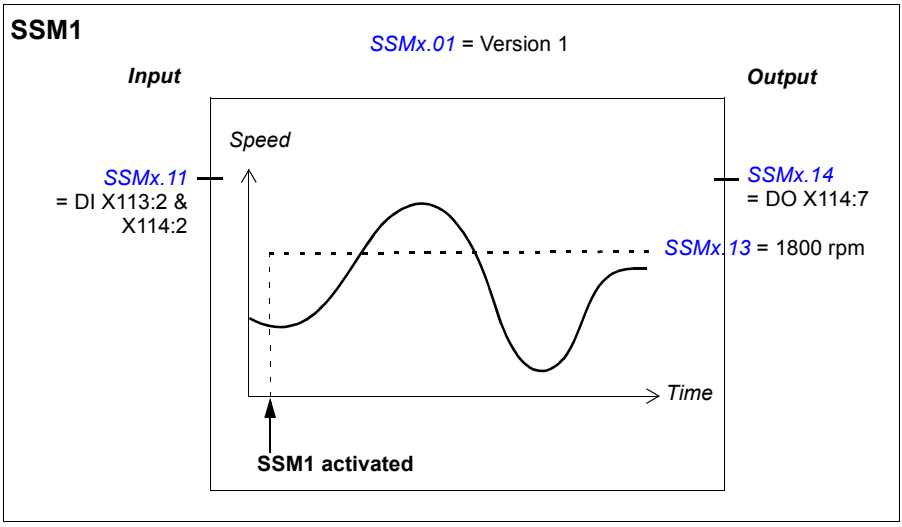
You can use the SSM function either with or without an encoder. For more information on the SSM function, see page *147*. If you use an encoder, you must configure the encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

Note: Depending on the application, set the negative and positive SSM limits separately.

How to configure SSM

Example: The figure below shows an example of an SSM1 set-up. Only the positive SSM1 limit is configured.

- SSM1 function activated (*SSMx.01 SSM1 activity and version* = *Version 1)*
- redundant SSM activation button connected to input (*SSMx.11 SSM1 input* = *DI X113:2 & X114:2*)
- single output connected (*SSMx.14 SSM1 output* = *DO X114:7*)
- SSM1 positive limit 1800.0 rpm (*SSMx.13 SSM1 limit positive* = *1800 rpm*)
- SSM1 negative limit 0 rpm (*SSMx.12 SSM1 limit negative* = *0 rpm*).
- **When an encoder is not used**: Time to zero speed: 1500 ms. This is the estimated time in which the motor coasts to a stop from the maximum speed (*STO.14 Time to zero speed with STO and modoff* = *1500 ms*, not shown in the figure).



Configuring SDI

To configure the SDI function, set the FSO parameters listed below to appropriate values using the Drive composer pro PC tool. See parameter group *SDI* on page *348*.

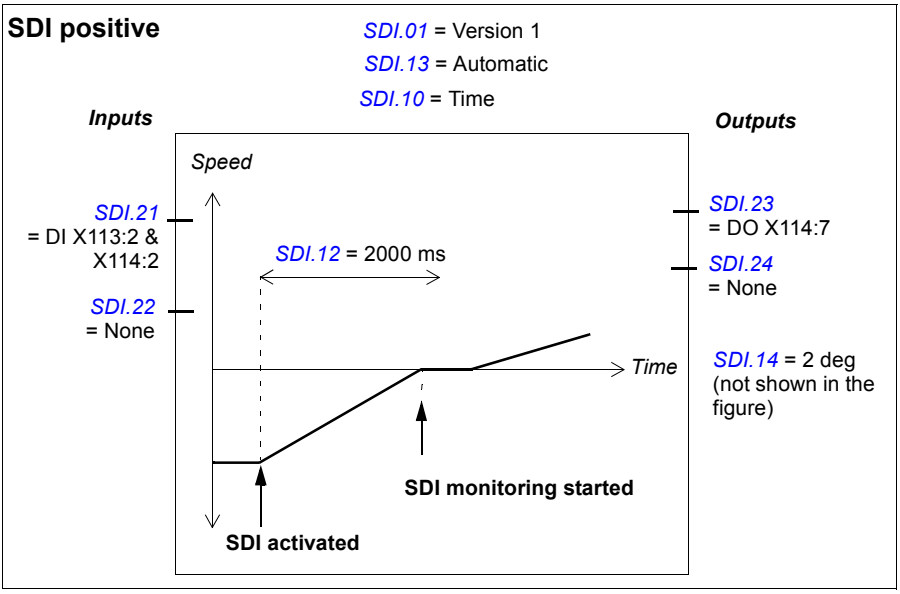
This safety function requires that an encoder is used. Configure the encoder interface first (see section *Configuring the safety encoder interface* on page *252*).

For more information on the SDI function, see page *151*.

How to configure SDI with time monitoring

Example: The figure below shows an example of an SDI positive function with time monitoring set-up:

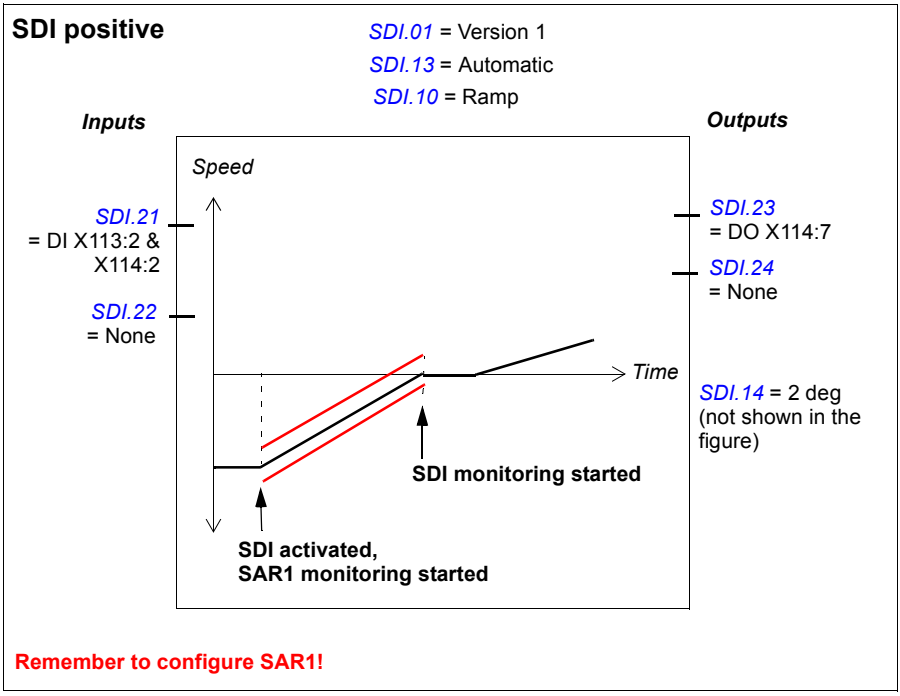
- Version 1 of SDI functions activated (*SDI.01 SDI version* = *Version 1*)
- SDI positive function activated (*SDI.02 SDI positive activity* = *Enabled*)
- time monitored ramp (*SDI.10 SDI activation monitoring method* = *Time*)
- deceleration ramp according to drive parameters (always with time monitoring)
- SDI activation delay 2000 ms (*SDI.12 SDI delay* = *2000 ms*)
- SDI tolerance into the forbidden direction 2 degrees (*SDI.14 SDI tolerance limit degree* = *2 deg*)
- automatic acknowledgement (*SDI.13 SDI acknowledgement* = *Automatic*)
- redundant activation button connected to input (*SDI.21 SDI positive input A* = *DI X113:2 & X114:2*)
- single output connected (*SDI.23 SDI positive output A* = *DO X114:7*).



How to configure SDI with ramp monitoring

Example: The figure below shows an example of an SDI positive function with ramp monitoring set-up:

- Version 1 of SDI functions activated (*SDI.01 SDI version* = *Version 1*)
- SDI positive function activated (*SDI.02 SDI positive activity* = *Enabled*)
- monitored deceleration ramp (*SDI.10 SDI activation monitoring method* = *Ramp*)
- deceleration ramp and monitoring limits according SAR1 parameters (see section *Configuring SAR* on page *294*)
- SDI tolerance into the forbidden direction 2 degrees (*SDI.14 SDI tolerance limit degree* = *2 deg*)
- automatic acknowledgement (*SDI.13 SDI acknowledgement* = *Automatic*)
- redundant activation button connected to input (*SDI.21 SDI positive input A* = *DI X113:2 & X114:2*)
- single output connected (*SDI.23 SDI positive output A* = *DO X114:7*).



Related safety functions

The SDI functions use SAR1 parameters to monitor and/or define the deceleration ramp (SDI with ramp monitoring). See section *Configuring SAR* on page *294*.

The FSO module activates the STO function if the motor speed hits a ramp monitoring limit during the deceleration ramp (SDI with ramp monitoring). See section *Configuring STO* on page *264*.

The FSO module activates the SSE function if the motor rotation reaches the SDI tolerance limit degree. See section *Configuring SSE* on page *284*.

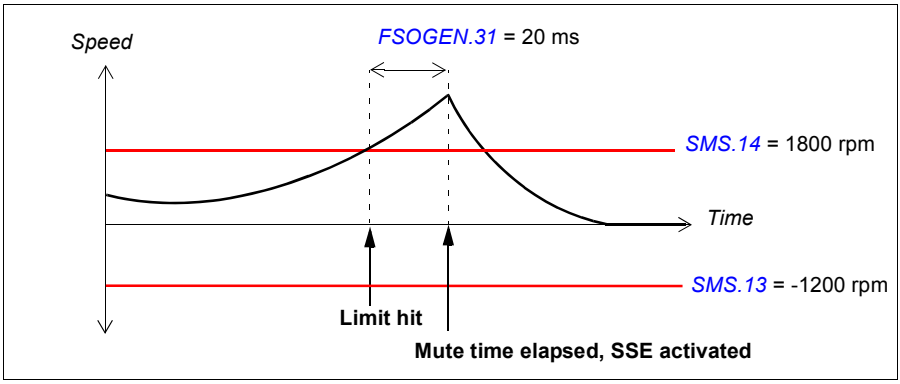
Fine-tuning the configuration

To minimize the effect of small transient variations in the speed measurement data, you can fine-tune the operation of the safety functions with “mute times” (parameter *FSOGEN.31 Transient mute time*), and when you use an encoder, also parameters *FSOGEN.32 Zero speed delay time* and *FSOGEN.33 Monitoring start delay*).

How to fine-tune limit hit situations

Example: SMS trip limit hit.

- parameter *FSOGEN.31 Transient mute time* = *20 ms*. The same parameter is used with and without an encoder.



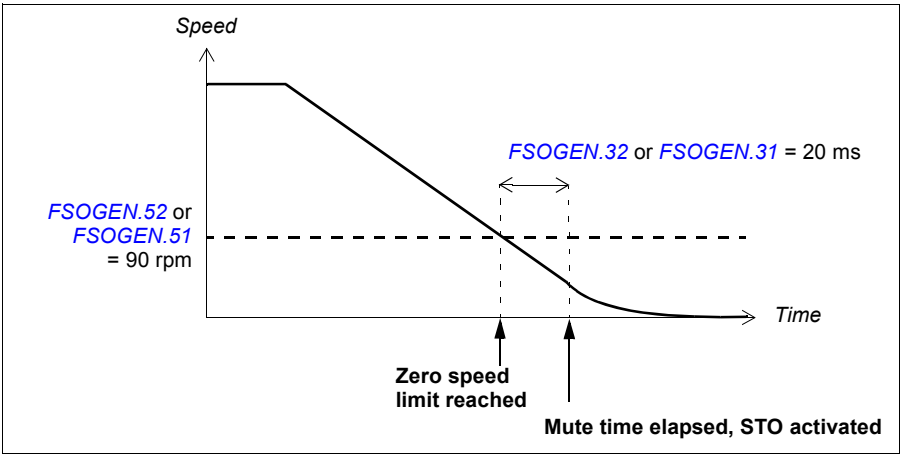
This applies also to:

- trip limit hits in the SLS1...4 and Variable SLS functions
- ramp monitoring limit hits in the SS1, SSE and SLS functions
- Variable SLS indication when the motor speed is decelerated to a new SLS limit.

How to fine-tune when zero speed limits are detected

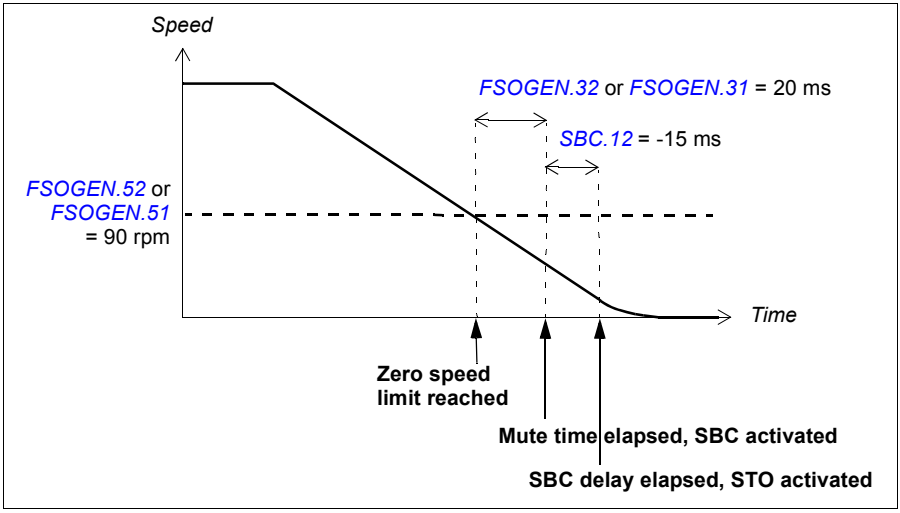
Example 1: Zero speed limit in reached in the SS1 function (and SSE with emergency ramp), the SBC is not used.

- **With an encoder**: parameter *FSOGEN.32 Zero speed delay time* = *20 ms*
- **Without an encoder**: parameter *FSOGEN.31 Transient mute time* = *20 ms*.



Example 2: Zero speed limit in reached in the SS1 function (and SSE with emergency ramp), a negative SBC delay (parameter *SBC.12 STO SBC delay*) is configured in the STO function:

- **With an encoder**: parameter *FSOGEN.32 Zero speed delay time* = *20 ms*
- **Without an encoder**: parameter *FSOGEN.31 Transient mute time* = *20 ms*.

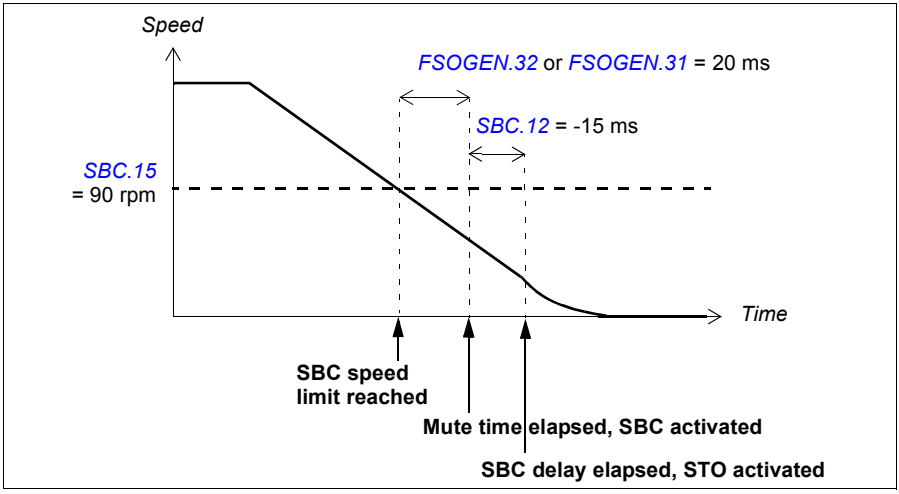


Note: If the SBC delay (parameter *SBC.12 STO SBC delay*) is positive or zero (*0 ms*), the SBC and STO functions are activated at the same time.

How to fine-tune when SBC speed limits are detected

Example 1: SBC speed limit (parameter *SBC.15*) is reached in the SS1 function (and SSE with emergency ramp), a negative SBC delay (parameter *SBC.12 STO SBC delay*) is configured in the SS1 function:

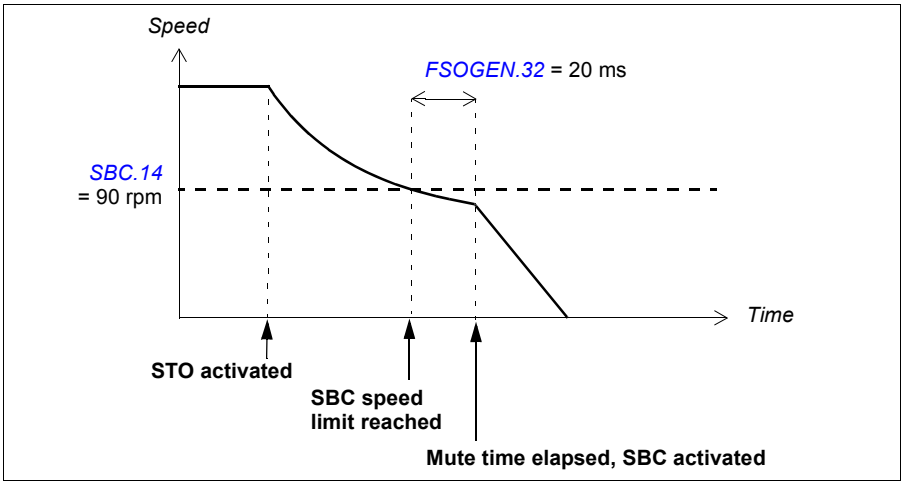
- **With an encoder**: parameter *FSOGEN.32 Zero speed delay time* = *20 ms*
- **Without an encoder**: parameter *FSOGEN.31 Transient mute time* = *20 ms*.



Note: If the SBC delay (parameter *SBC.12 STO SBC delay*) is positive or zero (*0 ms*), the SBC and STO functions are activated at the same time.

Example 2: SBC speed limit (parameter *SBC.14 STO SBC speed*) is reached in the STO function (and SSE with immediate STO), requires an encoder:

- **With an encoder**: parameter *FSOGEN.32 Zero speed delay time* = *20 ms*.

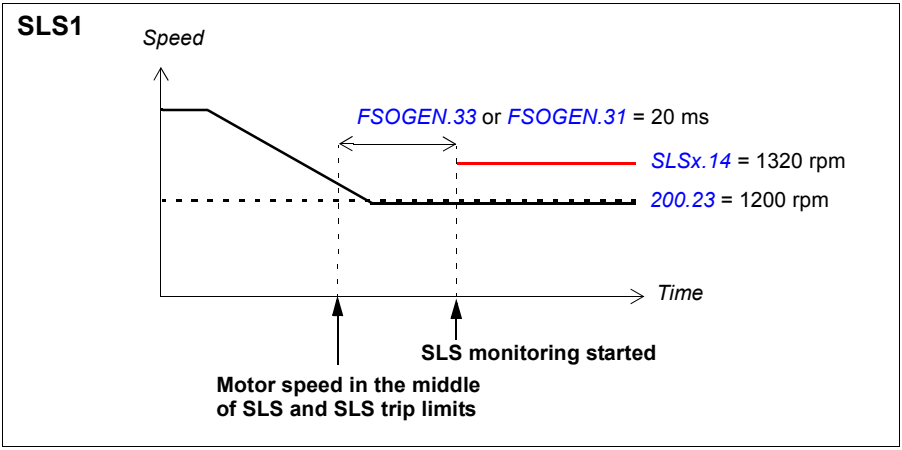


How to fine-tune when monitoring is started

Example: The start of SLS monitoring in the SLS1 function.

- **With an encoder**: parameter *FSOGEN.33 Monitoring start delay* = *20 ms*
- **Without an encoder**: parameter *FSOGEN.31 Transient mute time* = *20 ms.*

Note: The SLS indication goes on after this delay.



Configuring the FSO for FSE or encoder failure situations

For the FSE module or encoder failure situations, you can configure the FSO module so that it either:

- goes into the Fail-safe mode and actives the STO function:
  S_ENCGEN. 11 FSE diagnostic failure reaction = *STO*
- sends a warning to the drive (if there are no active safety functions):
  S_ENCGEN. 11 FSE diagnostic failure reaction = *No STO*
- continues operation by using the estimated motor speed until the encoder failure is fixed and the exact motor speed is available again:
  S_ENCGEN. 11 FSE diagnostic failure reaction = *Est switch not active load.*

For more information and restrictions, see section *Measured and estimated motor speed* on page *44*.

If you select *S_ENCGEN. 11 FSE diagnostic failure reaction* = *Est switch not active load,* make sure that you configure all safety functions so that they operate correctly both with and without an encoder. Note especially these parameters and restrictions:

- You must set two zero speed limits: *FSOGEN.51 Zero speed without encoder* and *FSOGEN.52 Zero speed with encoder.*
- The SLS trip limits cannot be below these zero speed limits.
- You must set parameters *STO.14 Time to zero speed with STO and modoff* and *SBC.13 SBC time to zero speed* to suitable values.
- The “mute times” are different with and without an encoder (see section *Fine-tuning the configuration* on page *314*).
- If you use the speed limit activated SBC function (*SBC.11 STO SBC usage* = *Speed limit*), the FSO starts to use the time controlled brake (*SBC.11 STO SBC usage* = *Delayed brake*) when an encoder or FSE failure occurs. Set parameter *SBC.12 STO SBC delay* to a suitable value. For more information, see section *How to configure STO with speed limit activated SBC* on page *270*.
- You cannot use this feature with the SDI function.

11

Parameters

Contents of this chapter

This chapter describes the parameters and the status and control words of the FSO module.

FSO-21 parameters

The following table lists the FSO-21 parameters: The parameter row shows the parameter index, name, description and factory default value. The subsequent rows show the parameter value range or names, descriptions and numerical values of the selectable named alternatives. You can view and modify these parameters in the Safety settings window of the Drive composer pro PC tool.

Note: The factory default values shown in the table can be different from the pre-set parameter values in a delivered FSO (ordered with a plus code, eg, +Q972). For more information, see section *Factory reset* on page *423*.

Note: We recommend that you set drive parameter *31.22 STO indication run/stop* to value *3, 4* or *5*. This setting prevents the drive from making a fault every time the FSO opens the drive STO circuit. You can configure the FSO module so that it generates the necessary faults to the drive event system.

For additional information on parameters and their settings, see the drive firmware manual.

Index	Name/Value	Description	Factory default
Safety		**General drive safety parameters**	
200.21	SLS1 activity and version	Activates or deactivates the SLS1 function and shows the version of the SLS1 function.	*Disabled*
	Disabled	Deactivates the SLS1 function.	
	Version 1	Activates version 1 of the SLS1 function.	
200.22	SLS1 limit negative	Sets the SLS1 negative speed limit for the drive	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
200.23	SLS1 limit positive	Sets the SLS1 positive speed limit for the drive	0.0 rpm
	0.0…35880.0 rpm	Speed	
200.31	SLS2 activity and version	Activates or deactivates the SLS2 function and shows the version of the SLS2 function.	*Disabled*
	Disabled	Deactivates the SLS2 function.	
	Version 1	Activates version 1 of the SLS2 function.	
200.32	SLS2 limit negative	Sets the SLS2 negative speed limit for the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
200.33	SLS2 limit positive	Sets the SLS2 positive speed limit for the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	
200.41	SLS3 activity and version	Activates or deactivates the SLS3 function and shows the version of the SLS3 function.	*Disabled*
	Disabled	Deactivates the SLS3 function.	
	Version 1	Activates version 1 of the SLS3 function.	
200.42	SLS3 limit negative	Sets the SLS3 negative speed limit for the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
200.43	SLS3 limit positive	Sets the SLS3 positive speed limit for the drive	0.0 rpm
	0.0…35880.0 rpm	Speed	
200.51	SLS4 activity and version	Activates or deactivates the SLS4 function and shows the version of the SLS4 function.	*Disabled*
	Disabled	Deactivates the SLS4 function.	
	Version 1	Activates version 1 of the SLS4 function.	
200.52	SLS4 limit negative	Sets the SLS4 negative speed limit for the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
200.53	SLS4 limit positive	Sets the SLS4 positive speed limit for the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	

Index	Name/Value	Description	Factory default
200.61	SLS variable activity and version	Activates or deactivates the Variable SLS function and shows the version of the Variable SLS function. **Note**: This function can be activated only when the safety fieldbus is installed.	*Disabled*
	Disabled	Deactivates the Variable SLS function.	
	Version 1	Activates version 1 of the Variable SLS function.	
200.71	SMS activity and version	Activates or deactivates the SMS function and shows the version of the SMS function.	*Disabled*
	Disabled	Deactivates the SMS function.	
	Version 1	Activates version 1 of the SMS function. See section *SMS function, version 1* on page *143*.	
	Version 2	Activates version 2 of the SMS function. See section *SMS function, version 2* on page *144*.	
200.72	SMS limit negative	Sets the negative speed limit for the SMS function. **Note**: This parameter is used only in version 2 of the SMS function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
200.73	SMS limit positive	Sets the positive speed limit for the SMS function. **Note**: This parameter is used only in version 2 of the SMS function.	0.0 rpm
	0.0…35880.0 rpm	Speed	
200.101	SAR0 version	Shows the version of the SAR0 function.	*Version 1*
	Version 1	Version 1.	
200.102	SAR0 ramp time to zero	Sets the target time for the SAR0 ramp (used in the SSE function). Target time = Time in which the drive decelerates the motor from speed *200.202 SAR speed scaling* to zero.	1 ms
	1…1,800,000 ms	Time	
200.111	SAR1 version	Shows the version of the SAR1 function.	*Version 1*
	Version 1	Version 1.	

Index	Name/Value	Description	Factory default
200.112	SAR1 ramp time to zero	Sets the target time for the SAR1 ramp (used in the SS1 and SLS functions). Target time = Time in which the drive decelerates the motor from speed *200.202 SAR speed scaling* to zero. **Note**: With value *0 ms*, the drive (parameter *23.23 Emergency stop time*) defines the safe stop ramp. The FSO module monitors the actual ramp using SAR1 parameters (ramp monitoring) or parameter *SS1.14 SS1-t delay for STO* (time monitoring).	1 ms
	0…1,800,000 ms	Time.	
200.201	Drive general settings version	Shows the version of the drive general safety settings (includes parameters *200.202*, *200.222*, *200.223* and *200.254*).	*Version 1*
	Version 1	Version 1.	
200.202	SAR speed scaling	Sets a speed value that the FSO module uses as a reference point in ramp time calculations. See section *Ramp monitoring* on page *51*.	1500 rpm
	0…35880 rpm	Speed	
200.222	Safety bus type	Sets the type of the safety fieldbus (if used). **Note**: To activate the safety fieldbus, you must also set parameter *SBUSGEN. 01 SBUS activity and version* to value *Version 1*.	*Not used*
	Not used	The safety fieldbus is not used.	
	PROFIsafe	PROFIsafe	
200.223	Safety fieldbus adapter slot	Sets the slot in which the safety fieldbus adapter is installed. **Note**: The slots on the drive control board are defined by drive parameters *50.01* (FBA A) and *50.31* (FBA B). See the drive firmware manual.	*FBA A*
	FBA A	The safety fieldbus adapter is in slot FBA A.	
	FBA B	The safety fieldbus adapter is in slot FBA B.	
200.231	FSE 3X act and par version	Activates or deactivates the FSE-3x encoder interface and shows the version of the encoder parameter groups (includes groups 91 *Enc module settings* and 92 *Encoder 1 configuration*).	*Disabled*
	Disabled	Deactivates the FSE-3x encoder interface.	
	Version 1	Activates the FSE-3x encoder interface.	

Index	Name/Value	Description	Factory default
200.232	Number of encoders	Sets the number of encoders that are connected to the FSE module and, in the single encoder case, also the channel that it is connected to. **Note**: ACS880 primary control program, version 2.21 supports only one safety pulse encoder, and this parameter is read-only.	*Single encoder CH1*
	Single encoder CH1		
200.254	CRC of the configuration	Shows the FSO configuration checksum.	0
	0…65535	Checksum	

FSOGEN		General FSO parameters	
FSOGEN.01	FSO general settings version	Shows the version of the FSO general parameter group (includes parameter groups *FSOGEN* and *SAFEIO* and parameters *SLSx.02*, *SLSx.03*, *SLSx.04*, *SARx.02*).	*Version 1*
	Version 1	Version 1.	
FSOGEN.11	Stop completed output	Sets the digital output that indicates the completion of any stop function. Active when the FSO module has completed the STO, SSE or SS1 function.	*None*
	None	No input connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
FSOGEN.21	Motor nominal speed	Sets the nominal motor speed.	100.0 rpm
	1.0 …35880.0 rpm	Speed	
FSOGEN.22	Motor nominal frequency	Sets the nominal motor frequency.	1.00 Hz
	1.00…598.00 Hz	Frequency	

Index	Name/Value	Description	Factory default
FSOGEN.31	Transient mute time	Sets the mute time for the drive transient operations. The FSO modules waits for the Transient mute time before it acts after a ramp monitoring or trip limit hit, or after the zero speed limit is reached. Transient mute time must be in line with the system safety response time: it must be less than the system safety response time minus the maximum response time of the FSO. **Example:** When speed monitoring detects a safety function limit hit, the FSO module does not act immediately but it waits for the Transient mute time first. If the speed is still out of the limit after the Transient mute time, the FSO module starts the safety actions (that is, activates the STO or SSE function). See also section *Fine-tuning the configuration* on page *314*. **Note:** You can also use the Transient mute time in applications in which the motor runs a high inertia (mass) load and rapid changes in speed are not possible. When an encoder is used: This parameter is used only in ramp monitoring and trip limit hit situations.	0 ms
	0…1000 ms	Time	
FSOGEN.32	Zero speed delay time	Sets the time for how long the motor speed must stay inside zero speed limits in order to determine the motor as stopped. **Note**: This parameter is relevant only when an encoder is used. Without an encoder, parameter *FSOGEN.31* is used. See also section *Fine-tuning the configuration* on page *314*.	0 ms
	0…1000 ms	Time	
FSOGEN.33	Monitoring start delay	Sets the time for how long the speed must stay in the correct side of a limit in order to determine that the limit is reached and monitoring can be started. **Note**: This parameter is relevant only when an encoder is used. Without an encoder, parameter *FSOGEN.31* is used. See also section *Fine-tuning the configuration* on page *314*.	0 ms
	0…1000 ms	Time	

Index	Name/Value	Description	Factory default
FSOGEN.41	Power-up acknowledgement	Sets the power-up acknowledgement method. **Note**: If a safety function request is active when the FSO module is rebooted, the request must be removed before the power-up acknowledgement is accepted.	*Manual*
	Manual	The FSO module reads an external acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*.	
	Automatic	The FSO module generates the acknowledgement signal automatically after the power-up.	
	Safebus	The FSO module expects an external acknowledgement signal from the safety fieldbus after the power-up.	
	Manual_Safebus	The FSO module expects an external acknowledgement signal either from a digital input or from the safety fieldbus after the power-up.	
FSOGEN.42	Acknowledgement button input	Sets the digital input that is connected to the button for acknowledgement operations.	*None*
	None	No input connected	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
FSOGEN.51	Zero speed without encoder	Sets the general zero speed limit for safety functions when an encoder is not used. In this case, the motor speed is an estimate. Select a suitable value depending on your motor. **Note**: This is the absolute value. The same value is used in both positive and negative directions. **Note**: You cannot set trip limits below this value.	0.0 rpm
	0.0…600.0 rpm	Speed	

Index	Name/Value	Description	Factory default
FSOGEN.52	Zero speed with encoder	Sets the general zero speed limit for safety functions when an encoder is used. In this case, the motor speed is the exact value measured with the encoder. Select a suitable value depending on your motor. **Note**: This is the absolute value. The same value is used in both positive and negative directions. **Note**: You cannot set trip limits below this value.	0.0 rpm
	0.0…600.0 rpm	Speed	
FSOGEN.61	STO indication ext request	Sets the type of the event that the FSO module generates and sends to the drive after external requests that end to a successful activation of the drive STO function (STO, SSE or SS1). **Note:** When the FSO module triggers the STO function in fault situations, it always generates a fault.	*Fault*
	None	No event generated	
	Fault	Fault generated	
	Warning	Warning generated	
	Event	Pure event generated	
FSOGEN.62	STO indication safety limit	Sets the type of the event that the FSO module generates for limit hits in the SLS1, …, SLS4 and SMS functions and for limit hits during ramp and time monitoring of safety ramps SAR0 and SAR1. **Note:** When the FSO module triggers the STO function in fault situations, it always generates a fault.	*Fault*
	None	No event generated	
	Fault	Fault generated	
	Warning	Warning generated	
	Event	Pure event generated	
FSOGEN.254	CRC of the whole configuration	Shows the FSO configuration checksum.	0
	0…65535	Checksum	

STO		Parameters for the STO function	
STO.01	STO version	Shows the version of the STO function.	*Version 1*
	Version 1	Version 1.	

Index	Name/Value	Description	Factory default
STO.02	STO acknowledgement	Sets the acknowledgement method used in the STO, SSE and SS1 functions. See section *Acknowledgement methods* on page *48* for more information on different acknowledgement methods.	*Manual*
	Manual	The FSO module reads the external STO acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*. The FSO module accepts the acknowledgement after the STO, SSE or SS1 request has been removed and the stop function is completed (output defined by parameter *FSOGEN.11 STO completed output* is active).	
	Automatic	The FSO module generates the STO acknowledgement signal automatically after the STO, SSE or SS1 request has been removed and the stop function is completed (output defined by parameter *FSOGEN.11 STO completed output* is active).	
	Safebus	The FSO module expects an external STO acknowledgement signal from the safety fieldbus after the STO, SSE or SS1 request has been removed and the stop function is completed (output defined by parameter *FSOGEN.11 STO completed output* is active).	
	Manual_Safebus	The FSO module expects an external STO acknowledgement signal either from a digital input or from the safety fieldbus after the STO, SSE or SS1 request has been removed and the stop function is completed (output defined by parameter *FSOGEN.11 STO completed output* is active).	
STO.11	STO input A	Sets the digital input that is connected to the primary input of the STO function.	*DI X113:1 & X114:1*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	

Index	Name/Value	Description	Factory default
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
STO.12	STO input B	Sets the digital input that is connected to the secondary input of the STO function. The secondary input is mostly used for the cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
STO.13	Restart delay after STO	Sets the time after which the acknowledgement of the FSO module and restart of the drive are allowed after the FSO has activated the STO function and opened the drive STO circuit. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). This parameter is relevant only when an external request activates the STO function. If you do not want to use the fly-start feature, set this parameter to the same value as parameter *STO.14 Time to zero speed with STO and modoff*.	3,600,000 ms
	0…3,600,000 ms	Time	

Index	Name/Value	Description	Factory default
STO.14	Time to zero speed with STO and modoff	Sets the time after which the acknowledgement is allowed after coast stop in the STO, SSE and SS1 functions (when SBC is not used). Must be configured to the estimated time in which the motor coasts to a stop from the maximum speed. If SBC is used, see parameter *SBC.13 SBC time to zero speed*. If an external request activates the STO function, this parameter sets the time after which the function is completed and the STO completed indication goes on. In this case, parameter *STO.13 Restart delay after STO* defines the time after which the acknowledgement is allowed. If the drive STO is activated or modulation stopped while a monitoring safety function is indicating “unsafe”, after this time acknowledgement is allowed. For example, if the drive STO is activated before an SLS function (with ramp monitoring) has slowed the motor speed below the SLS limit, SLS OK will be indicated after this time has elapsed. See section *SLS trip limit hits* on page *133*. When an encoder is used: This parameter is relevant only if there is an encoder failure and the FSO module activates the STO function.	3,600,000 ms
	0…3,600,000 ms	Time	
STO.21	STO output	Sets the digital output that indicates the status of the STO function in the drive. Active when the STO circuit in the drive is open. **Note**: In a cascade connection, this indicates the activity of the STO function of the FSO module.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	

Index	Name/Value	Description	Factory default
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
STO.22	STO completed output	Sets the digital output that indicates the completion of the STO function. See the diagrams in section *Safe torque off (STO)* on page *57*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

SBC		**Parameters for the SBC function**	
SBC.01	SBC version	Shows the version of the SBC function.	*Version 1*
	Version 1	Version 1.	
SBC.11	STO SBC usage	Sets how the mechanical brake (SBC) is used together with the STO function. **Note**: This parameter is used also in the SSE function when it is configured as *Immediate STO* (parameter *SSE.13 SSE function* = *Immediate STO*).	*Delayed brake*
	None	No brake	
	Delayed brake	Time controlled brake. Parameter *SBC.12 STO SBC delay* defines the delay.	
	Speed limit	The brake is activated below a user-defined speed limit (parameter *SBC.14 STO SBC speed*). Requires that an encoder is used. **Note**: If an encoder or FSE failure occurs, and the STO function is not active, the FSO module starts to use the *Delayed brake* setting. If the STO function is already active, the action depends on the value of parameter *S_ENCGEN. 11 FSE diagnostic failure reaction*. See section *How to configure STO with speed limit activated SBC* on page *270*.	

Index	Name/Value	Description	Factory default
SBC.12	STO SBC delay	Sets the time after which the FSO module activates the SBC after it has activated the drive STO function. A negative value means that the FSO module activates the SBC before the drive STO function. If the value is *0 ms*, the FSO activates the drive STO and SBC functions at the same time. STO function and SSE with immediate STO: This parameter is valid if parameter *SBC.11 STO SBC usage* has value *Delayed brake*. SSE with emergency ramp and SS1 function: This parameter is valid if parameter *SBC.15 SSE/SS1 SBC speed* is not zero. Only a negative value and zero are used. If the value is positive, it is regarded as zero. **Note:** You must include the mechanical brake delays in this value.	3,600,000 ms
	-5000… 3,600,000 ms	Time	
SBC.13	SBC time to zero speed	Sets an additional security delay after which the motor has stopped and the system can be set to a safe state after the FSO module has activated the brake (SBC). Must be configured to the estimated time in which the motor brakes to a stop from the maximum speed. The total delay from the moment the FSO module has activated the drive STO function until the system is in safe sate becomes: *STO SBC delay* (*SBC.12*) + *SBC time to zero speed* (*SBC.13*). **Note**: If the value of *SBC time to zero speed* is less than 800 ms (the feedback delay), the total delay becomes: *STO SBC delay* (*SBC.12*) + 800 ms. When an encoder is used: This parameter is relevant only if there is an encoder failure and the FSO module activates the STO and SBC functions.	3,600,000 ms
	0…3,600,000 ms	Time	

Index	Name/Value	Description	Factory default
SBC.14	STO SBC speed	Sets the speed limit below which the FSO module activates the brake (SBC) in the STO function. Requires that an encoder is used and parameter *SBC.11 STO SBC usage* is set to value *Speed limit*. If the value is *0.0 rpm*, this feature is not in use. **Note**: This is the absolute value. The same value is used in both positive and negative directions.	0.0 rpm
	0.0…1000.0 rpm	Speed	
SBC.15	SSE/SS1 SBC speed	Sets the speed below which the FSO module activates the brake (SBC) while ramping in the SSE and SS1 functions. If the value is *0.0 rpm*, this feature is not in use. **Note**: This is the absolute value. The same value is used in both positive and negative directions.	0.0 rpm
	0.0…1000.0 rpm	Speed	
SBC.21	SBC output	Sets the digital output that is connected to the SBC output (brake relays).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
SBC.22	SBC feedback action	Sets the action that the FSO module takes when there is a problem with the SBC feedback.	*No STO*
	STO	The FSO module goes into the Fail-safe mode and activates the drive STO function.	
	No STO	The FSO module sends a warning to the drive.	
SBC.23	SBC test OK signal	Sets the digital output that indicates the status of the SBC test OK signal. Active when the SBC feedback indicates that the SBC works correctly. **Note**: The feedback delay is 800 ms.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	

Index	Name/Value	Description	Factory default
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

POUS		Parameters for the POUS function	
POUS.01	POUS activity and version	Activates or deactivates the POUS function and shows the version of the POUS function.	*Disabled*
	Disabled	Deactivates the POUS function.	
	Version 1	Activates version 1 of the POUS function.	
POUS.02	POUS acknowledgement	Sets the POUS acknowledgement method.	*Manual*
	Manual	The FSO module reads the POUS acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*. The FSO module accepts the acknowledgement after the POUS request has been removed.	
	Automatic	The FSO module generates the POUS acknowledgement signal automatically after the POUS request has been removed.	
	Safebus	The FSO module expects an external POUS acknowledgement signal from the safety fieldbus after the POUS request has been removed.	
	Manual_Safebus	The FSO module expects an external POUS acknowledgement signal either from a digital input or from the safety fieldbus after the POUS request have been removed.	
POUS.11	POUS input	Sets the digital input that is connected to the POUS input.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	

Index	Name/Value	Description	Factory default
POUS.13	POUS delay for completion	Sets the time after which the POUS complete indication is activated after the POUS request.	0 ms
	0…3,600,000 ms	Time	
POUS.21	POUS output	Sets the digital output that indicates the activity of the POUS function. Active from the POUS request until the function has been acknowledged.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
POUS.22	POUS completed output	Set the digital output that indicates the completion of the POUS function. Active after the time defined by parameter *POUS.13 POUS delay for completion* has elapsed from the POUS request until the POUS request has been removed. **Note**: Connect the POUS indication lamp to this output.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

SSE		Parameters for the SSE function	
SSE.01	SSE version	Shows the version of the SSE function.	*Version 1*
	Version 1	Version 1.	
SSE.11	SSE input A	Sets the digital input that is connected to the primary input of the SSE function.	*None*
	None	No input connected	

Index	Name/Value	Description	Factory default
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SSE.12	SSE input B	Sets the digital input that is connected to the secondary input of the SSE function. The secondary input is mostly used for the cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SSE.13	SSE function	Sets the type of the SSE function.	*Emergency ramp*
	Immediate STO	The FSO module activates the drive STO immediately after the SSE request.	
	Emergency ramp	The FSO module activates the drive STO after an emergency ramp.	
SSE.14	SSE monitoring method	Sets the method used for the SSE emergency ramp monitoring. This parameter is relevant only if parameter *SSE.13 SSE function* is set to *Emergency ramp*.	*Ramp*

Index	Name/Value	Description	Factory default
	Ramp	Ramp monitoring. SAR0 parameters define the emergency ramp and monitoring limits. See parameters *200.102*, *SARx.11*, *SARx.12* and *SARx.02*.	
	Time	Time monitoring. Parameter *200.102 SAR0 ramp time to zero* defines the emergency ramp and it is monitored with parameter *SSE.15 SSE delay for STO*.	
SSE.15	SSE delay for STO	Sets the security delay after which the FSO module actives the STO after the SSE request. This parameter is relevant only if parameter *SSE.13 SSE function* is set to *Emergency ramp*, time monitoring is used (*SSE.14 SSE monitoring method* = *Time*) and the motor speed does not follow the ramp.	3,600,000 ms
	0…3,600,000 ms	Time	
SSE.16	SSE ramp zero speed delay for STO	Sets an extra delay time for the drive STO (and SBC, if used) activation at the zero speed limit in the SSE with emergency ramp function. With this parameter, the FSO module delays the STO activation so that the drive is able to reach the axle zero speed before the FSO module activates the drive STO function. The delay counter starts when the motor speed reaches the zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*). After this delay has elapsed, the FSO module activates the drive STO function. You can use this parameter when the motor rotates a heavy load (high inertia). **Note:** The FSO module activates the drive STO immediately if the drive stops modulating before this delay has passed (that is, the motor actual speed reaches 0 rpm).	30,000 ms
	0…30,000 ms	Time	
SSE.21	SSE output	Sets the digital output that indicates the activity of the SSE function. Active from the SSE request until the function has been acknowledged.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	

Index	Name/Value	Description	Factory default
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SSE.22	SSE completed output	Sets the digital output that indicates the completion of the SSE function. See the diagrams in section *Safe stop emergency (SSE)* on page *93*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

SS1		**Parameters for the SS1 function**	
SS1.01	SS1 activity and version	Activates or deactivates the SS1 function and shows the version of the SS1 function.	*Disabled*
	Disabled	Deactivates the SS1 function.	
	Version 1	Activates version 1 of the SS1 function.	
SS1.11	SS1 input A	Sets the digital input that is connected to the primary input of the SS1 function.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	

Index	Name/Value	Description	Factory default
SS1.12	SS1 input B	Sets the digital input that is connected to the secondary input of the SS1 function. The secondary input is mostly used for the cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SS1.13	SS1 type	Sets the SS1 type, that is, the method used for the SS1 monitoring.	*SS1-r*
	SS1-r	Ramp monitoring. SAR1 parameters define the stop ramp and the monitoring limits. See parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*.	
	SS1-t	Time monitoring. SAR1 parameter *200.112* define the stop ramp and it is monitored with parameter *SS1.14 SS1-t delay for STO*.	
SS1.14	SS1-t delay for STO	Sets the security delay after which the FSO module actives the STO function after the SS1 request. This parameter is relevant only if time monitoring is used and the motor speed does not follow the ramp. See parameter *SS1.13 SS1 type*.	3,600,000 ms
	0…3,600,000 ms	Time	

Index	Name/Value	Description	Factory default
SS1.15	SS1-r ramp zero speed delay for STO	Sets an extra delay time for the drive STO (and SBC, if used) activation at the zero speed limit in the SS1 function. With this parameter, the FSO module delays the STO activation so that the drive is able to reach the axle zero speed before the FSO module activates the STO function. The delay counter starts when the motor speed reaches the zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*). After this delay has elapsed, the FSO module activates the drive STO function. You can use this parameter when the motor rotates a heavy load (high inertia). **Note:** The FSO module activates the drive STO immediately if the drive stops modulating before the delay has passed (that is, the motor actual speed reaches 0 rpm).	12,0000 ms
	0…12,0000 ms	Time	
SS1.21	SS1 output	Sets the digital output that indicates the activity of the SS1 function. Active from the SS1 request until the function has been acknowledged.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SS1.22	SS1 completed output	Sets the digital output that indicates the completion of the SS1 function. See the diagrams in section *Safe stop 1 (SS1)* on page *68*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	

Index	Name/Value	Description	Factory default
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

SLSx		Parameters for the SLS1…4 functions	
SLSx.02	SLS acknowledgement	Sets the acknowledgement method used in the SLS1…4 functions.	*Manual*
	Manual	The FSO module reads the external SLS acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*. The FSO module accepts the acknowledgement after the SLS request has been removed and the SLS limit has been achieved (that is, SLS monitoring is on).	
	Automatic	The FSO module generates the SLS acknowledgement signal automatically after the SLS request has been removed and the SLS limit has been achieved (that is, SLS monitoring is on).	
	Safebus	The FSO module expects an external SLS acknowledgement signal from the safety fieldbus. The FSO module accepts the acknowledgement after the SLS request has been removed and the SLS limit has been achieved (that is, SLS monitoring is on).	
	Manual_Safebus	The FSO module expects an external SLS acknowledgement signal either from a digital input or from the safety fieldbus. The FSO module accepts the acknowledgement after the SLS request has been removed and the SLS limit has been achieved (that is, SLS monitoring is on).	
SLSx.03	SLS activation monitoring method	Sets the monitoring method that is used in SLS activation.	*Ramp*
	Ramp	Ramp monitoring. SAR1 parameters define the deceleration ramp and monitoring limits. See parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*.	
	Time	Time monitoring. The drive (parameter *23.13* or *23.15)* defines the deceleration ramp and it is monitored with parameter *SLSx.04 SLS time delay*.	

Index	Name/Value	Description	Factory default
SLSx.04	SLS time delay	Sets the security delay after which the FSO module actives the SLS monitoring after the SLS request. This parameter is relevant only if time monitoring is used. See parameter *SLSx.03 SLS activation monitoring method*.	0 ms
	0…4,000,000 ms	Time	
SLSx.11	SLS1 input A	Sets the digital input that is connected to the primary input of the SLS function with limits 1.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SLSx.12	SLS1 input B	Sets the digital input that is connected to the secondary input of the SLS function with limits 1. The secondary input is mostly used for cascade connection (only SLS1 can be cascaded). See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	

Index	Name/Value	Description	Factory default
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SLSx.13	SLS1 trip limit negative	Sets the SLS1 negative speed limit that trips the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SLSx.14	SLS1 trip limit positive	Sets the SLS1 positive speed limit that trips the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SLSx.15	SLS1 output A	Sets the digital output that is connected to the primary output of the SLS1 function. Active when SLS1 function is active and the motor speed is below the SLS1 limit (that is, when the SLS1 monitoring is on).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SLSx.16	SLS1 output B	Sets the digital output that is connected to the secondary output of the SLS1 function. Active when SLS1 function is active and the motor speed is below the SLS1 limit (that is, when the SLS1 monitoring is on). The secondary output is mostly used for cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

Index	Name/Value	Description	Factory default
SLSx.21	SLS2 input	Sets the digital input that is connected to the secondary input of the SLS function with limits 2.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SLSx.22	SLS2 trip limit negative	Sets the SLS2 negative speed limit that trips the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SLSx.23	SLS2 trip limit positive	Sets the SLS2 positive speed limit that trips the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SLSx.24	SLS2 output	Sets the digital output that is connected to the output of the SLS2 function. Active when SLS2 function is active and the motor speed is below the SLS2 limit (that is, when the SLS2 monitoring is on).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SLSx.31	SLS3 input	Sets the digital input that is connected to the secondary input of the SLS function with limits 3.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	

Index	Name/Value	Description	Factory default
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SLSx.32	SLS3 trip limit negative	SLS3 negative speed limit that trips the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SLSx.33	SLS3 trip limit positive	Sets the SLS3 positive speed limit that trips the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SLSx.34	SLS3 output	Sets the digital output that is connected to the output of the SLS3 function. Active when SLS3 function is active and the motor speed is below the SLS3 limit (that is, when the SLS3 monitoring is on).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SLSx.41	SLS4 input	Sets the digital input that is connected to the secondary input of the SLS function with limits 4.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	

Index	Name/Value	Description	Factory default
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SLSx.42	SLS4 trip limit negative	Sets the SLS4 negative speed limit that trips the drive.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SLSx.43	SLS4 trip limit positive	Sets the SLS4 positive speed limit that trips the drive.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SLSx.44	SLS4 output	Sets the digital output that is connected to the output of the SLS4 function. Active when SLS4 function is active and the motor speed is below the SLS4 limit (that is, when the SLS4 monitoring is on).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SLSx.51	Variable SLS output	Sets the digital output that is connected to the output of the Variable SLS function. Active when Variable SLS function is active and the motor speed is below the Variable SLS limit (that is, when the Variable SLS monitoring is on).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	

Index	Name/Value	Description	Factory default
	DO X114:9	Single output X114:9	

SMS		Parameters for the SMS function	
SMS.13	SMS trip limit negative	Sets the negative speed limit that trips the drive for the SMS function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SMS.14	SMS trip limit positive	Sets the positive speed limit that trips the drive for the SMS function.	0.0 rpm
	0.0 …35880.0 rpm	Speed	

SARx		Parameters for SARx ramps	
SARx.02	SAR initial allowed range	Sets the initial allowed range for the SARx ramp. This parameter moves the location of the maximum monitoring ramp forward on the time axis, when monitoring is started. The slope of the ramp stays the same as defined with parameters *200.202* and *SARx.12* (SAR0) or *SARx.22* (SAR1). For more information, see section *Ramp monitoring* on page *51*.	0 ms
	0…60,000 ms	Time	
SARx.11	SAR0 min ramp time to zero	Sets the minimum ramp time for the SAR0 ramp monitoring.	0 ms
	0…1,799,999 ms	Time. **Note:** With value *0 ms*, the ramp is not monitored	
SARx.12	SAR0 max ramp time to zero	Sets the maximum ramp time for the SAR0 ramp monitoring.	1 ms
	1…3,600,000 ms	Time	
SARx.21	SAR1 min ramp time to zero	Sets the minimum ramp time for the SAR1 ramp monitoring.	0 ms
	0…1,799,999 ms	Time **Note:** With value *0 ms*, the ramp is not monitored	
SARx.22	SAR1 max ramp time to zero	Sets the maximum ramp time for the SAR1 ramp monitoring.	1 ms
	1…3,600,000 ms	Time	

SDI		Parameters for the SDI functions	
SDI.01	SDI version	Shows the version of the SDI functions (SDI positive and SDI negative).	*Disabled*
	Disabled	Deactivates the SDI functions.	
	Version 1	Version 1.	
SDI.02	SDI positive activity	Activates or deactivates the SDI positive function.	*Disabled*

Index	Name/Value	Description	Factory default
	Disabled	Deactivates the SDI positive function.	
	Enabled	Activates the SDI positive function.	
SDI.03	SDI negative activity	Activates or deactivates the SDI negative function.	*Disabled*
	Disabled	Deactivates the SDI negative function.	
	Enabled	Activates the SDI negative function.	
SDI.10	SDI activation monitoring method	Sets the monitoring method that is used in SDI activation.	*Ramp*
	Ramp	Ramp monitoring. SAR1 parameters define the deceleration ramp and monitoring limits. See parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*.	
	Time	Time monitoring. The drive (parameter *23.13* or *23.15*) defines the deceleration ramp and it is monitored with parameter *SDI.12 SDI delay*.	
SDI.12	SDI delay	Sets the delay for starting SDI monitoring. This parameter is relevant only when parameter *SDI.10 SDI activation monitoring method* is set to *Time*.	0 ms
	0…3,600,000 ms	Time	
SDI.13	SDI acknowledgement	Sets the acknowledgement method used in the SDI function.	*Manual*
	Manual	The FSO module reads the external SDI acknowledgement signal through the digital input defined by parameter *FSOGEN.42 Acknowledgement button input*. The correct rotation direction must be achieved before acknowledgement is accepted.	
	Automatic	The FSO module generates the SDI acknowledgement signal automatically after the SDI request has been removed and the correct rotation direction has been achieved.	
	Safebus	The FSO module expects an external SDI acknowledgement signal from the safety fieldbus after the SDI request has been removed and the correct rotation direction has been achieved.	
	Manual_Safebus	The FSO module expects an external SDI acknowledgement signal either from a digital input or from the safety fieldbus after the SDI request has been removed and the correct rotation direction has been achieved.	

Index	Name/Value	Description	Factory default
SDI.14	SDI tolerance limit degree	Sets the position tolerance for the SDI function. The position of the motor axle cannot move into the forbidden direction more than defined with this parameter. **Note**: This is the absolute value. The same value is used in both positive and negative directions.	0.00 deg
	0.00… 3,600,000.00 deg	Degree	
SDI.21	SDI positive input A	Sets the digital input connected to the SDI primary input for positive rotation.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SDI positive function is always on.	
SDI.22	SDI positive input B	Sets the digital input connected to the SDI secondary input for positive rotation. The secondary output is mostly used for cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	

Index	Name/Value	Description	Factory default
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SDI positive function is always on.	
SDI.23	SDI positive output A	Sets the digital output connected to the SDI positive primary output. Active when the motor rotates in the correct (positive) direction.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SDI.24	SDI positive output B	Sets the digital output that is connected to the secondary output of the SDI positive function. Active when the motor rotates in the correct (positive) direction. The secondary output is mostly used for cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SDI.31	SDI negative input A	Sets the digital input connected to the SDI primary input for negative rotation.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	

Index	Name/Value	Description	Factory default
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SDI negative function is always on.	
SDI.32	SDI negative input B	Sets the digital input connected to the SDI secondary input for negative rotation. The secondary output is mostly used for cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SDI negative function is always on.	
SDI.33	SDI negative output A	Sets the digital output connected to the SDI negative primary output. Active when the motor rotates in the correct (negative) direction.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	

Index	Name/Value	Description	Factory default
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SDI.34	SDI negative output B	Sets the digital output that is connected to the secondary output of the SDI negative function. Active when the motor rotates in the correct (negative) direction. The secondary output is mostly used for cascade connection. See parameters *SAFEIO.12 Cascade A* and *SAFEIO.13 Cascade B*.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

SSMx		Parameters for the SSM1...4 functions	
SSMx.01	SSM1 activity and version	Activates or deactivates the SSM1 function and shows the version of the SSM1 function.	*Disabled*
	Disabled	Deactivates the SSM1 function.	
	Version 1	Activates version 1 of the SSM1 function.	
SSMx.02	SSM2 activity and version	Activates or deactivates the SSM2 function and shows the version of the SSM2 function.	*Disabled*
	Disabled	Deactivates the SSM2 function.	
	Version 1	Activates version 1 of the SSM2 function.	
SSMx.03	SSM3 activity and version	Activates or deactivates the SSM3 function and shows the version of the SSM3 function.	*Disabled*
	Disabled	Deactivates the SSM3 function.	
	Version 1	Activates version 1 of the SSM3 function.	
SSMx.04	SSM4 activity and version	Activates or deactivates the SSM4 function and shows the version of the SSM4 function.	*Disabled*
	Disabled	Deactivates the SSM4 function.	
	Version 1	Activates version 1 of the SSM4 function.	
SSMx.11	SSM1 input	Sets the digital input connected to the SSM1 function.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	

Index	Name/Value	Description	Factory default
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SSM1 function is always on.	
SSMx.12	SSM1 limit negative	Sets the negative speed limit for the SSM1 function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SSMx.13	SSM1 limit positive	Sets the positive speed limit for the SSM1 function.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SSMx.14	SSM1 output	Sets the digital output connected to the SSM1 function. Active when the motor speed is within the SSM1 speed limits.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SSMx.21	SSM2 input	Sets the digital input connected to the SSM2 function.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	

Index	Name/Value	Description	Factory default
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SSM2 function is always on.	
SSMx.22	SSM2 limit negative	Sets the negative speed limit for the SSM2 function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SSMx.23	SSM2 limit positive	Sets the positive speed limit for the SSM2 function.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SSMx.24	SSM2 output	Sets the digital output connected to the SSM2 function. Active when the motor speed is within the SSM2 speed limits.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SSMx.31	SSM3 input	Sets the digital input connected to the SSM3 function.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SSM3 function is always on.	

Index	Name/Value	Description	Factory default
SSMx.32	SSM3 limit negative	Sets the negative speed limit for the SSM3 function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SSMx.33	SSM3 limit positive	Sets the positive speed limit for the SSM3 function.	0.0 rpm
	0.0…35880.0 rpm	Speed	
SSMx.34	SSM3 output	Sets the digital output connected to the SSM3 function. Active when the motor speed is within the SSM3 speed limits.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	
SSMx.41	SSM4 input	Sets the digital input connected to the SSM4 function.	*None*
	None	No input connected	
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
	Always on	The SSM4 function is always on.	
SSMx.42	SSM4 limit negative	Sets the negative speed limit for the SSM4 function.	0.0 rpm
	-35880.0 …0.0 rpm	Speed	
SSMx.43	SSM4 limit positive	Sets the positive speed limit for the SSM4 function.	0.0 rpm
	0.0…35880.0 rpm	Speed	

Index	Name/Value	Description	Factory default
SSMx.44	SSM4 output	Sets the digital output connected to the SSM4 function. Active when the motor speed is within the SSM4 speed limits.	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
	DO X113:7	Single output X113:7	
	DO X113:8	Single output X113:8	
	DO X113:9	Single output X113:9	
	DO X114:7	Single output X114:7	
	DO X114:8	Single output X114:8	
	DO X114:9	Single output X114:9	

S_ENCGEN		**General parameters for safety pulse encoders**	
S_ENCGEN. 01	Safe pulse encoder version	Activates or deactivates the safety encoder and shows the version of parameter group *S_ENCGEN* and parameters *FSOGEN.52* and *SBC.14*.	*Disabled*
	Disabled	Deactivates the safety pulse encoder.	
	Version 1	Activates the safety pulse encoder.	
S_ENCGEN. 11	FSE diagnostic failure reaction	Sets the action taken when there is a problem with the FSE module or the safety encoder.	*STO*
	STO	The FSO module goes into the Fail-safe mode and activates the drive STO function.	
	No STO	If there are no active safety functions, the FSO module sends a warning to the drive. If there are active safety functions, the FSO module goes into the Fail-safe mode.	
	Est switch not active load	With some restrictions, the FSO module sends a warning to the drive and starts to use an estimated value of the motor speed until the failure is fixed. For more information, see section *Switching between the measured and estimated speed values* on page *44*. **Note**: Do not use this selection in applications with active load. See section *Encoderless mode* on page *32*.	
S_ENCGEN. 14	Enc speed cross comp tolerance	Sets the encoder speed cross comparison tolerance. This defines how much the axle speed of the motor can change within 1 ms.	0.0 rpm
	0.0 …500.0 rpm	Speed	

Index	Name/Value	Description	Factory default
S_ENCGEN.41	Gear numerator encoder 1	Sets the rotation direction for the safety encoder. With this parameter, you can change the rotation direction of the motor.	*1*
	1	Positive direction.	
	-1	Negative direction.	

Enc module settings		**Parameters for the safety encoder interface module**	
91.11	Module 1 type	Sets the type of the safety encoder interface module 1.	*None*
	None	The safety encoder interface module is not in use.	
	FSE-31	The type of the safety encoder interface module is FSE-31.	
91.12	Module 1 location	Sets the slot in which the safety encoder interface module is located.	*2*
	1	Slot 1 on the drive control board.	
	2	Slot 2 on the drive control board.	
	3	Slot 3 on the drive control board.	

Encoder 1 configuration		**Parameters for safety encoder 1**	
92.01	Encoder 1 type	Activates the communication with the safety encoder interface module 1 and sets the type for the safety encoder.	*HTL1*
	HTL1	Communication active. Module type: FSE-31. Input: HTL encoder input (X31).	
92.02	Encoder 1 source	Sets the safety encoder interface module that the safety encoder 1 is connected to.	*Module 1*
	Module 1	The safety encoder 1 is connected to interface module 1.	
92.10	Pulses/revolution	Sets the number of HTL pulses per revolution for safety encoder 1.	0
	0…65535	Number of pulses	
92.17	Accepted pulse freq of encoder 1	Sets the maximum pulse frequency range of encoder 1.	0.0 kHz
	0…300 kHz	Frequency	

SAFEIO		**Parameters for FSO inputs and outputs**	
SAFEIO.11	M/F mode for cascade	Sets the master/follower mode of the FSO module for both cascade connections A and B separately.	*A = follower, B = follower*
	A = follower, B = follower	The module is a follower on cascade connection A and a follower on cascade connection B.	

Index	Name/Value	Description	Factory default
	A = master, B = follower	The module is the master on cascade connection A and a follower on cascade connection B.	
	A = follower, B = master	The module is a follower on cascade connection A and the master on cascade connection B.	
	A = master, B = master	The module is the master on cascade connection A and the master on cascade connection B.	
SAFEIO.12	Cascade A	Sets the cascade connection A for the FSO module. For each FSO module in cascade A, the digital input connected to the safety function is also internally connected to the corresponding digital output of the FSO module (digital input -> digital output). This resembles a master/follower connection. See section *Cascade* on page *55*.	*None*
	None	Not cascaded	
	X113:1 & X114:1 -> X113:7 & X114:7	Redundant cascade X113:1 & X114:1 -> X113:7 & X114:7	
	X113:2 & X114:2 -> X113:8 & X114:8	Redundant cascade X113:2 & X114:2 -> X113:8 & X114:8	
	X113:3 & X114:3 -> X113:9 & X114:9	Redundant cascade X113:3 & X114:3 -> X113:9 & X114:9	
	X113:1 -> X113:7	Single cascade X113:1 -> X113:7	
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8	
	X113:3 -> X113:9	Single cascade X113:3 -> X113:9	
	X114:1 -> X114:7	Single cascade X114:1 -> X114:7	
	X114:2 -> X114:8	Single cascade X114:2 -> X114:8	
	X114:3 -> X114:9	Single cascade X114:3 -> X114:9	
SAFEIO.13	Cascade B	Sets the cascade connection B for the FSO module. For each FSO module in cascade B, the digital input connected to the safety function is also internally connected to the corresponding digital output of the FSO module (digital input -> digital output). See section *Cascade* on page *55*.	*None*
	None	Not cascaded	
	X113:1 & X114:1 -> X113:7 & X114:7	Redundant cascade X113:1 & X114:1 -> X113:7 & X114:7	
	X113:2 & X114:2 -> X113:8 & X114:8	Redundant cascade X113:2 & X114:2 -> X113:8 & X114:8	
	X113:3 & X114:3 -> X113:9 & X114:9	Redundant cascade X113:3 & X114:3 -> X113:9 & X114:9	

Index	Name/Value	Description	Factory default
	X113:1 -> X113:7	Single cascade X113:1 -> X113:7	
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8	
	X113:3 -> X113:9	Single cascade X113:3 -> X113:9	
	X114:1 -> X114:7	Single cascade X114:1 -> X114:7	
	X114:2 -> X114:8	Single cascade X114:2 -> X114:8	
	X114:3 -> X114:9	Single cascade X114:3 -> X114:9	
SAFEIO.21	Safety relay 1 output	Sets the digital output connected to the safety relay 1. To connect the safety relay to a certain safety function, you must set the same digital outputs in the output parameter for that safety function. For example, if you set parameter *SBC.21 SBC output* to the same value as you set for the safety relay output, the safety relay is active when the SBC function is active. **Note**: The output must always be redundant. Otherwise the feedback signal of the safety relay is not used (see parameter *SAFEIO.22 Safety relay 1 feedback*).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
SAFEIO.22	Safety relay 1 feedback	Sets the digital feedback input of safety relay 1. Parameter *SAFEIO.23 Safety relay 1 feedback type* sets the type of the feedback input.	*None*
	None	No input connected	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	

Index	Name/Value	Description	Factory default
SAFEIO.23	Safety relay 1 feedback type	Sets the type of the feedback signal for safety relay 1. **Note**: The feedback delay is 800 ms for both feedback types, that is, a feedback signal from the safety relay must be received within 800 ms.	*Mechanically linked NC contacts*
	Mechanically linked NC contacts	Feedback of the safety relay is NC (inverted state compared with the relay).	
	Mechanically linked NO contacts	Feedback of the safety relay is NO (same state compared with the relay).	
SAFEIO.24	Safety relay 2 output	Sets the digital output for safety relay 2. See also parameter *SAFEIO.21 Safety relay 1 output*. **Note**: The output must always be redundant. Otherwise the feedback signal of the safety relay is not used (see *SAFEIO.25 Safety relay 2 feedback*).	*None*
	None	No output connected	
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	
SAFEIO.25	Safety relay 2 feedback	Sets the digital feedback input of safety relay 2. Parameter *SAFEIO.26 Safety relay 2 feedback type* sets the type of the feedback input.	*None*
	None	No input connected	
	DI X113:1	Single input X113:1	
	DI X113:2	Single input X113:2	
	DI X113:3	Single input X113:3	
	DI X113:4	Single input X113:4	
	DI X114:1	Single input X114:1	
	DI X114:2	Single input X114:2	
	DI X114:3	Single input X114:3	
	DI X114:4	Single input X114:4	
SAFEIO.26	Safety relay 2 feedback type	Sets the type of the feedback signal for safety relay 2. **Note**: The feedback delay is 800 ms for both feedback types, that is, a feedback signal from the safety relay must be received within 800 ms.	*Mechanically linked NC contacts*
	Mechanically linked NC contacts	Feedback of the safety relay is NC (inverted state compared with the relay).	

Index	Name/Value	Description	Factory default
	Mechanically linked NO contacts	Feedback of the safety relay is NO (same state compared with the relay).	
SAFEIO.31	DI diagnostic pulse length	Sets the length of the diagnostic pulse for digital inputs.	*1 ms*
	0.5 ms	Length of the diagnostic pulse is 0.5 ms.	
	1 ms	Length of the diagnostic pulse is 1 ms.	
	2 ms	Length of the diagnostic pulse is 2 ms.	
SAFEIO.32	DI diagnostic pulse period	Sets the time during which the FSO module must receive at least one whole diagnostic pulse.	10,000 ms
	50…59,000 ms	Time	
SAFEIO.33	DI X113:1 diag pulse on/off	Sets the diagnostic pulse of digital input X113:1 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.34	DI X113:2 diag pulse on/off	Sets the diagnostic pulse of digital input X113:2 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.35	DI X113:3 diag pulse on/off	Sets the diagnostic pulse of digital input X113:3 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.36	DI X113:4 diag pulse on/off	Sets the diagnostic pulse of digital input X113:4 on or off	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.37	DI X114:1 diag pulse on/off	Sets the diagnostic pulse of digital input X114:1 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.38	DI X114:2 diag pulse on/off	Sets the diagnostic pulse of digital input X114:2 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.39	DI X114:3 diag pulse on/off	Sets the diagnostic pulse of digital input X114:3 on or off	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.40	DI X114:4 diag pulse on/off	Sets the diagnostic pulse of digital input X114:4 on or off	*On*
	Off	Diagnostic pulse off	

Index	Name/Value	Description	Factory default
	On	Diagnostic pulse on	
SAFEIO.51	DO diagnostic pulse length	Sets the length of the diagnostic pulse for digital outputs.	*1 ms*
	0.5 ms	Length of the diagnostic pulse is 0.5 ms.	
	1 ms	Length of the diagnostic pulse is 1 ms.	
	2 ms	Length of the diagnostic pulse is 2 ms.	
SAFEIO.52	DO diagnostic pulse period	Sets the time during which the FSO module must receive at least one whole diagnostic pulse.	10,000 ms
	50…59,000 ms	Time	
SAFEIO.53	DO X113:7 diag pulse on/off	Sets the diagnostic pulse of digital output X113:7 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.54	DO X113:8 diag pulse on/off	Sets the diagnostic pulse of digital output X113:8 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.55	DO X113:9 diag pulse on/off	Sets the diagnostic pulse of digital output X113:9 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.56	DO X114:7 diag pulse on/off	Sets the diagnostic pulse of digital output X114:7 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.57	DO X114:8 diag pulse on/off	Sets the diagnostic pulse of digital output X114:8 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.58	DO X114:9 diag pulse on/off	Sets the diagnostic pulse of digital output X114:9 on or off.	*On*
	Off	Diagnostic pulse off	
	On	Diagnostic pulse on	
SAFEIO.71	DO X113:7 logic state	Sets the logic state of digital output X113:7.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	
SAFEIO.72	DO X113:8 logic state	Sets the logic state of digital output X113:8.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	

Index	Name/Value	Description	Factory default
SAFEIO.73	DO X113:9 logic state	Sets the logic state of digital output X113:9.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	
SAFEIO.74	DO X114:7 logic state	Sets the logic state of digital output X114:7.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	
SAFEIO.75	DO X114:8 logic state	Sets the logic state of digital output X114:8.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	
SAFEIO.76	DO X114:9 logic state	Sets the logic state of digital output X114:9.	*Active low*
	Active low	Active state of the output is low voltage.	
	Active high	Active state of the output is high voltage.	

SBUSGEN		**General parameters for safety fieldbusses**	
SBUSGEN.01	SBUS activity and version	Activates or deactivates the safety fieldbus.	*Disabled*
	Disabled	Deactivates the safety fieldbus.	
	Version 1	Activates version 1 of the safety fieldbus.	
SBUSGEN.06	Safety fieldbus speed scaling	Sets the rpm value that corresponds to 20000 for safety fieldbus communication.	1500.0 rpm
	0.10…30000.0		
SBUSGEN.07	Safety fieldbus position scaling	Sets the scaling value for the axle rotation (base unit 1/1000 grad). If this parameter is set to *1000*, value *400* in the safety fieldbus equals to one full axle revolution. **Note**: This parameter is relevant only when an encoder is used.	1.0
	0.01…30000.0		
SBUSGEN.10	STO indication passivation	Sets the type of the event that the FSO module generates when the FSO module is passivated due to safety fieldbus problems.	*Fault*
	None	No event generated	
	Fault	Fault generated	
	Warning	Warning generated	
	Event	Pure event generated	

Index	Name/Value	Description	Factory default
PROFIsafe		**Parameters for PROFIsafe**	
PROFIsafe. 11	PROFIsafe F_Dest_Add	Sets the PROFIsafe destination address, that is, the address of the FENA adapter module in the safety communication network. **Note**: This address must be the same as is set in the F-Parameters for the PROFIsafe module properties (F_Dest_Add). For more information, see section *Configuring the safety PLC* on page *195*.	1
	1…65534		
PROFIsafe. 12	PROFIsafe telegram type	Shows the PROFIsafe telegram type.	*0x221*
	0x221	PROFIsafe telegram 0x221 (545). Corresponds to profile ABB_PS1 in the GSD file. See section *Downloading the GSD file* on page *196*.	
	0x222	PROFIsafe telegram 0x222 (546). Corresponds to profile ABB_PS2 in the GSD file. See section *Downloading the GSD file* on page *196*. **Note**: This profile requires that an encoder is used.	

Status and control words

This table lists the FSO module and drive status and control words. You can view these in the ACS880 window of Drive composer pro.

Index	Name/Value	Description		
Safety				
200.01	FSO speed ch1	Shows the motor speed estimate 1 of the FSO module. The FSO module reads the value from the drive via communication channel 1.		
	0.00 … rpm	Speed FbEq16: 1 = 1 rpm; FbEq32: 100 = 1 rpm		
200.02	FSO speed ch2	Shows the motor speed estimate 2 of the FSO module. The FSO module reads the source data from the drive via communication channel 2 and calculates the speed estimate 2 using the data.		
	0.00 … rpm	Speed FbEq16: 1 = 1 rpm; FbEq32: 100 = 1 rpm		
200.03	FSO DI status	Shows the states of the FSO digital inputs.		
		Bit	**Name**	**Values**
		0	Input X113:1	0 = Off, 1 = On
		1	Input X113:2	0 = Off, 1 = On
		2	Input X113:3	0 = Off, 1 = On
		3	Input X113:4	0 = Off, 1 = On
		4	Input X114:1	0 = Off, 1 = On
		5	Input X114:2	0 = Off, 1 = On
		6	Input X114:3	0 = Off, 1 = On
		7	Input X114:4	0 = Off, 1 = On
		8-15	Reserved	
200.04	FSO DO status	Shows the states of the FSO digital outputs.		
		Bit	**Name**	**Values**
		0	Output X113:7	0 = Off, 1 = On
		1	Output X113:8	0 = Off, 1 = On
		2	Output X113:9	0 = Off, 1 = On
		4	Output X114:7	0 = Off, 1 = On
		5	Output X114:8	0 = Off, 1 = On
		6	Output X114:9	0 = Off, 1 = On
		7-15	Reserved	

Index	Name/Value	Description		
200.05	FSO control word 1	Shows the states of the FSO commands.		
		Bit	**Name**	**Values**
		0	STO request	0 = Off, 1 = On
		1	SSE request	0 = Off, 1 = On
		2	SS1 request	0 = Off, 1 = On
		3	Reserved	
		4	SAR0 request	0 = Off, 1 = On
		5	SAR1 request	0 = Off, 1 = On
		6	Reserved	
		7	Reserved	
		8	Reserved	
		9	Reserved	
		10	SLS1 request	0 = Off, 1 = On
		11	SLS2 request	0 = Off, 1 = On
		12	SLS3 request	0 = Off, 1 = On
		13	SLS4 request	0 = Off, 1 = On
		14	Reserved	
		15	SDI positive request	0 = Off, 1 = On
200.06	FSO control word 2	Shows the states of the FSO commands.		
		Bit	**Name**	**Values**
		0	SDI negative request	0 = Off, 1 = On
		1	CRC request	0 = Off, 1 = On
		2	FSO brake	0 = Off, 1 = On
		3	Variable SLS request	0 = Off, 1 = On
		4	SS1 modoff allowed	0 = Off, 1 = On
		5	SSE modoff allowed	0 = Off, 1 = On
		6-15	Reserved	

Index	Name/Value	Description		
200.07	FSO status word 1	Shows the FSO status word 1.		
		Bit	**Name**	**Values**
		0	FSO mode bit 1	0 = Undefined 1 = Start-up mode 2 = Running mode 3 = Fail-safe mode 4 = Configuration mode
		1	FSO mode bit 2	
		2	FSO mode bit 3	
		3	FSO state bit 1	0 = Safe state 1 = Operational state
		4	FSO state bit 2	
		5	FSO STO active	0 = Off, 1 = On
		6	Brake state	0 = Off, 1 = On
		7	POUS monitoring	0 = Off, 1 = On
		8	SSE monitoring	0 = Off, 1 = On
		9	SS1 monitoring	0 = Off, 1 = On
		10	Reserved	
		11	SAR0 monitoring	0 = Off, 1 = On
		12	SAR1 monitoring	0 = Off, 1 = On
		13	Reserved	
		14	Reserved	
		15	Reserved	

Index	Name/Value	Description		
200.08	FSO status word 2	Shows the FSO status word 2.		
		Bit	**Name**	**Values**
		0	Reserved	
		1	SLS1 monitoring	0 = Off, 1 = On
		2	SLS2 monitoring	0 = Off, 1 = On
		3	SLS3 monitoring	0 = Off, 1 = On
		4	SLS4 monitoring	0 = Off, 1 = On
		5	Reserved	
		6	SDI positive monitoring active and rotation direction correct.	0 = Off, 1 = On
		7	SDI negative monitoring active and rotation direction correct	0 = Off, 1 = On
		8	SSM1 monitoring active and speed within limits	0 = Off, 1 = On
		9	SSM2 monitoring active and speed within limits	0 = Off, 1 = On
		10	SSM3 monitoring active and speed within limits	0 = Off, 1 = On
		11	SSM4 monitoring active and speed within limits	0 = Off, 1 = On
		12	SMS monitoring	0 = Off, 1 = On
		13	Reserved	
		14	var SLS monitoring	0 = Off, 1 = On
		15	Reserved	

Index	Name/Value	Description			
200.09	Drive status word 1	Shows the drive status word 1.			
		Bit	**Name**	**Description**	**Values**
		0	Drive status bit 1		0 = Disabled 1 = Readyon 2 = Readyrun 3 = Starting 4 = Readyref 5 = Stopping 6 = Faulted
		1	Drive status bit 2		
		2	Drive status bit 3		
		3	Drive status bit 4		
		4	Brake request	The drive requests the FSO to activate the brake.	0 = Off, 1 = On
		5	Encoder present	An encoder is present.	0 = Off, 1 = On
		6	Modulation	Drive modulation on or off.	0 = Off, 1 = On
		7	STO circuit 1	State of drive STO circuit 1.	0 = Off, 1 = On
		8	STO circuit 2	State of drive STO circuit 2.	0 = Off, 1 = On
		9	SS1 active	State on the drive side	0 = Off, 1 = On
		10	Reserved		
		11	SAR0 active		0 = Off, 1 = On
		12	SAR1 active		0 = Off, 1 = On
		13	Reserved		
		14	Reserved		
		15	Reserved		

Index	Name/Value	Description			
200.10	Drive status word 2	Shows the drive status word 2.			
		Bit	**Name**	**Description**	**Values**
		0	Reserved		
		1	SLS1 active	State on the drive side	0 = Off, 1 = On
		2	SLS2 active		0 = Off, 1 = On
		3	SLS3 active		0 = Off, 1 = On
		4	SLS4 active		0 = Off, 1 = On
		5	Reserved		
		6	SDI positive active		0 = Off, 1 = On
		7	SDI negative active		0 = Off, 1 = On
		8	Drive brake state	State of the drive operational brake.	0 = Off, 1 = On
		9	STO 1 diag	The drive has noticed an STO diagnostic pulse on circuit 1 or 2.	0, 1
		10	STO 2 diag		0, 1
		11-15	Reserved		

12

Start-up

Contents of this chapter

This chapter describes the general precautions to be taken before starting up the safety system for the first time.

Safety considerations

The start-up may only be carried out by a qualified electrician who has appropriate knowledge on functional, machine and process safety. The safety instructions must be followed during the start-up. See the drive and the safety component specific safety instructions in the individual product manuals.

WARNING! Until all the safety functionality is validated, the system must not be considered safe.

Checks

Before starting the system for the first time, make sure that

- the installation has been checked, according to the individual product checklists (drive, safety component) and the checklists provided in this document (see chapter *Installation checklists*).
- all necessary configuration steps have been completed
- all tools are cleared from the installation area to prevent short circuits and projectiles
- starting the system does not cause any danger.

13

Verification and validation

Contents of this chapter

This chapter describes verification and validation of the implemented safety functionality.

Verification and validation produce documented proof of the compliance of the implementation with specified safety requirements.

Further information can be found in *Technical guide No. 10 - Functional safety* (3AUA0000048753 [English]).

Verifying the achieved SIL/PL level

Verification of the functional safety system demonstrates and ensures that the implemented safety system meets the requirements specified for the system in the safety requirements specification phase.

The most convenient way to verify the required SIL/PL level reached with the implemented system is to use a specific safety calculator software.

Validation procedure

It is always the responsibility of the machine builder to ensure that the functionality of all the required safety functions has been appropriately verified and validated.

WARNING! Until all the safety functionality is validated, the system must not be considered safe.

The acceptance test must be performed to each safety function.

The acceptance test using the start-up checklists described below (see *Validation checklists for start-up*) must be performed:

- at initial start-up of the safety function
- after any changes related to the safety function (wiring, components, settings, etc.)
- after any maintenance work related to the safety function.

The acceptance test must include at least the following steps:

- having an acceptance test plan
- testing all commissioned functions for proper operation
- testing all used inputs for proper operation
- testing all used outputs for proper operation
- documenting all acceptance tests performed
- testing person signing and archiving the acceptance test report for further reference.

Acceptance test reports

You must store the signed acceptance test reports in the logbook of the machine. The report must include, as required by the referred standards:

- description of the safety application (including a figure)
- a description and revisions of safety components that are used in the safety application
- a list of all safety functions that are used in the safety application
- a list of all safety related parameters and their values (the drive STO has no safety-related parameters, but listing the non-safety related parameter *31.22 STO indication run/stop* and its setting is recommended)
- documentation of start-up activities, references to failure reports and resolution of failures
- the test results for each safety function, checksums, date of the tests and confirmation by the test personnel.

You must store any new acceptance test reports performed due to changes or maintenance in the logbook of the machine.

Competence

The acceptance test of the safety function must be carried out by a competent person with expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.

Tools

You need the Drive composer pro PC tool to perform the validation procedures.

Validation checklists for start-up

Validation of the PROFIsafe connection

Follow the steps below to validate the PROFIsafe connection:

1. Make sure that the PROFIsafe communication is enabled in FSO parameter *Safety bus type*.
2. Make sure that the FENA module is enabled in drive parameter *50.01* (*FBA A enable*) or *50.31* (*FBA B enable*).
3. Make sure that correct option slot is configured for PROFIsafe. The value of FSO parameter *Safety fieldbus adapter slot* must correspond to the FBA channel of the FENA module.
4. Make sure that the FENA module is configured correctly in drive parameter group 51 or 54 (depends on which FBA channel of the FENA module [FBA A or FBA B] is used). See *FENA-01/-11/-21 Ethernet adapter module user's manual* (3AUA0000093568 [English]) for details. Most importantly,
   - parameter *51.02/54.02 Protocol/Profile* must be set to configure one of the PROFINET profiles,
   - parameter *51.21* or *54.21* must be set to *Enabled* (0) to enable sending of the PROFIsafe diagnosis messages.
5. Make sure that the PROFIsafe watchdog time for the FENA module that is configured in the controller station is calculated as specified in section *Calculating the watchdog time* on page *192*.
6. Make sure that the PROFIsafe address (F_Dest_Add) of the FENA module is unique in the network and the same value is set in FSO parameter *PROFIsafe F_Dest_Add* and in the safety controller station.
7. Make sure that the PROFIsafe address (F_Source_Add) of the safety PLC is unique in the network.
8. Make sure that the PROFIsafe speed scaling value in FSO parameter *Safety fieldbus speed scaling* is calculated as specified in section *Configuring the safety fieldbus communication* on page *254*.
9. Make sure that the safety controller station is commissioned according to its instructions. See, for example, *AC500-S Safety User Manual* (3ADR025091M0202 [English]) for details.
10. Make sure that the functionality used in the project works correctly via PROFIsafe.
11. Make sure that the drive event log does not contain any unexpected entries. See chapter *Fault tracing* for details.

12. If possible, make sure that the FSO LEDs do not indicate any unexpected conditions. See chapter *Fault tracing* for details.
13. Make sure that the diagnostic messages at the safety controller station do not contain any unexpected entries.

Validation of the safety encoder interface

If an encoder or FSE module failure occurs, the reaction depends on the value of parameter *FSE diagnostic failure reaction* (*STO*, *No STO*, or *Est switch not active load*).

- **Case 1:** If you select *STO* or *No STO*, you have to configure and validate the STO function also without an encoder (see section *How to configure STO* on page *264*).
- **Case 2:** If you select *Est switch not active load,* you have to configure and validate all safety functions you use both with and without an encoder (see page *379*).

Case 1 and **Case 2**: Follow the steps below to validate the safety encoder interface:

1. Make sure that the correct installation instructions are followed when installing the safety encoder (see chapter *Installation checklists*).
2. Make sure that the safety encoder is configured according to the instructions given in section *Configuring the safety encoder interface* on page *252*).
3. Make sure that there are no configuration or sanity check errors present in the safety configuration.
4. Make sure that drive parameter *90.45 Motor feedback fault = Warning*.
5. Make sure that you can run and stop the motor freely.
6. Start the drive to the motor speed typical for the application.
7. Make sure that system is safe for coast stop (from the motor speed when the encoder cable is disconnected).
8. Activate the STO, SS1 or SSE safety function.
9. Cause an encoder failure by disconnecting the encoder cable from the FSE module while the drive is running and the safety function is active.
10. Make sure the FSO module activates the STO function and the drive trips, when the encoder failure occurs. The FSO module goes into the Fail-safe mode.

11. Make sure that there are no unwanted errors in the drive.
12. Reconnect the encoder cable.
13. To exit the Fail-safe mode, switch the power off and on, reboot the FSO module with drive parameter *96.09 FSO reboot* (see the drive firmware manual) or press the **Boot FSO** button in Drive composer pro.
14. Restart the drive and make sure that the motor runs normally.

Case 2: Follow these additional steps below to validate the safety encoder interface:

1. Make sure that you have configured all safety functions also for the encoderless mode (without the encoder).
2. Make sure that parameter *FSE diagnostic failure reaction* = *Est switch not active load*.
3. Cause an encoder failure by disconnecting the encoder cable from the FSE module.
4. Make sure that the correct warning is generated (*Encoder warning A7E1*).
5. Make sure that you can run and stop the motor freely.
6. Make sure that you have no active safety functions.
7. Start the drive to the motor speed typical for the application.
8. Activate a safety function (any other safety function except SDI).
9. Make sure that the correct warnings are generated (*FSO general warnings A7D0*, *FSE Ch1 diag event B793* and *FSE Ch12 diag event B794*).
10. Make sure the application runs and the safety function operates correctly with the estimated motor speed.
11. Repeat the procedure for all safety functions you use (expect SDI).
12. <u>If you use the SDI function</u>:
    - Repeat the procedure and activate the SDI function.
    - Make sure the FSO goes into the Fail-safe mode and activates the STO function.
    - Reconnect the encoder cable.
    - To exit the Fail-safe mode, reboot the FSO module with drive parameter *96.09 FSO reboot* (see the drive firmware manual) or press the **Boot FSO** button in Drive composer pro.
13. Reconnect the encoder cable.
14. Restart the drive and make sure that the motor runs normally.

Validation of safety functions

Once the system is fully configured and wired for the safety functions, and the start-up safety check has been done, you must do the following functional test procedure for each safety function:

1. Have the system at the Operational state when the safety function is requested.
2. Make sure that the acknowledgement method has been configured as suitable for the application (for example, manual or automatic acknowledgement).
3. Activate the safety function by requesting it with the designated trigger device.
4. Verify that the desired functionality takes place.
5. Document the test results to the acceptance test report.
6. Sign and file the acceptance test report.

Validation of the STO function

The STO function is the basic safety function and it has to be validated before other safety functions. Select the correct validation procedure based on how you use the SBC function together with the STO function.

Note: Always configure and validate the STO function. An internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal.

Validation of the STO function without SBC

Follow these steps to validate the STO function without SBC:

1. Check the cabling between the drive STO connector (XSTO) and the FSO module STO terminal (X111).
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the input for the STO function is configured correctly. **Note**: If you use the safety fieldbus to activate the STO function, configure and the validate the safety fieldbus interface first.
4. Make sure that the output to indicate the drive STO state (*STO output*) is configured correctly.
5. Make sure that the other STO function parameters are configured correctly (see section *How to configure STO* on page *264*):
   - parameter *STO SBC usage* is set to *None*.
   - parameter *Restart delay after STO* is set to the correct value.
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Make sure that you can run and stop the motor freely.
8. Activate the STO function (for example, disconnect the signal from the field device to the FSO input).
9. Make sure that the drive STO is activated immediately after the STO request.
10. Make sure that *STO output* shows the state of the drive STO correctly.
11. Make sure that you cannot acknowledge the STO function and restart the drive before the time defined by parameter *Restart delay after STO* has elapsed (or before the STO function is completed, see section *STO function* on page *58*).
12. Remove the STO function request.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
14. Check that there are no unwanted errors in the drive.
15. Restart the drive and make sure that the motor runs normally.

Validation of the STO function with SBC after or before STO

Follow these steps to validate the STO function with a time controlled brake (SBC):

1. Check the cabling between the drive STO connector (XSTO) and the FSO module STO terminal (X111).
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the input for the STO function is configured correctly.
   Note: If you use the safety fieldbus to activate the STO function, configure and the validate the safety fieldbus interface first.
4. Make sure that the output to indicate the drive STO state (*STO output*) is configured correctly.
5. Make sure that the other STO function parameters are configured correctly (see section *How to configure SBC after STO* on page *266* or *How to configure SBC before STO* on page *268*):
   - parameter *STO SBC usage* is set to *Delayed brake*
   - parameters *STO SBC delay* and *Restart delay after STO* are set to the correct values
   - parameter *SBC feedback action* is set correctly (*STO* or *No STO*).
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Make sure that you can ran and stop the motor freely.
8. Start the drive to the motor speed typical for the application.
9. Activate the STO function (for example, disconnect the signal from the field device to the FSO input).
10. When a positive *STO SBC delay* is used: Check that the STO is activated first and the SBC after the delay has elapsed.
    Note: When an encoder is used: If the zero speed limit *Zero speed with encoder* is reached before time *STO SBC delay* has elapsed, the FSO activates the SBC immediately when the motor speed is below the zero speed limit.
11. When a negative *STO SBC delay* is used: Check that the SBC is activated first and the STO after the delay has elapsed.
12. Check that *STO output* shows the state of the drive STO correctly.
13. Check that the SBC feedback input is activated after the activation of the SBC output.

14. Make sure that the correct failure reaction takes place if there is no SBC feedback signal (for example, disconnect the SBC feedback cable).
15. Make sure that you cannot acknowledge the STO function and restart the drive before the time defined by parameter *Restart delay after STO* has elapsed (or before the STO function is completed, see section *STO function* on page *58*).
16. Make sure that there are no unwanted errors in the drive.
17. Remove the STO function request.
18. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
19. Restart the drive. Make sure that the brake opens and the motor runs normally.

Validation of the STO function with speed limit activated SBC:

Note: This safety function requires that an encoder is used. Validate the safety encoder interface first according to the instructions in section *Validation of the safety encoder interface* on page *378*.

Follow these steps to validate the STO function with speed limit activated SBC:

1. Check the cabling between the drive STO connector (XSTO) and the FSO module STO terminal (X111).
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the input for the STO function is configured correctly. **Note**: If you use the safety fieldbus to activate the STO function, configure and the validate the safety fieldbus interface first.
4. Make sure that the output to indicate the drive STO state (*STO output*) is configured correctly.
5. Make sure that the other STO function parameters are configured correctly (see section *How to configure STO with speed limit activated SBC* on page *270*):
   - parameter *STO SBC usage* is set to *Speed limit*
   - parameters *STO SBC speed* and *Restart delay after STO* are set the correct values
   - parameter *SBC feedback action* is set correctly (*STO* or *No STO*).
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Make sure that you can ran and stop the motor freely.
8. Start the drive to the motor speed typical for the application.
9. Activate the STO function (for example, disconnect the signal from the field device to the FSO input).

10. Make sure that the drive STO is activated immediately after the STO request.
11. Check that the SBC is activated after the motor has reached the *STO SBC speed*, for example, using the monitoring feature of the Drive composer pro PC tool.
12. Make sure that *STO output* shows the state of the drive STO correctly.
13. Make sure that the SBC feedback input is activated after the activation of the SBC output.
14. Make sure that the correct failure reaction takes place if there is no SBC feedback signal (for example, disconnect the SBC feedback cable).
15. Make sure that you cannot acknowledge the STO function and restart the drive before the time defined by parameter *Restart delay after STO* has elapsed (or before the STO function is completed, see section *STO function* on page *58*).
16. Make sure that there are no unwanted errors in the drive.
17. Remove the STO function request.
18. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
19. Restart the drive. Make sure that the brake opens and the motor runs normally.

Validation of the SSE with immediate STO function

The SSE with immediate STO function is identical to the STO function with these differences:

- parameter *STO.13 Restart delay after STO* is not used (you can never acknowledge the SSE function and restart the drive before the motor has stopped)
- SSE input parameters (*SSE.11 SSE input A* and *SSE.12 SSE input B*) are used instead of STO input parameters
- SSE output parameters (*SSE.21 SSE output* and *SSE.22 SSE completed output*) are used instead of STO output parameters.

Validate the different SSE with immediate STO functions (with or without SBC) according to the procedures in section *Validation of the STO function* on page *380*.

Note: Always configure and validate the SSE function. An internal monitoring of the FSO module can trigger the SSE function even if you have not defined an external request signal. For example, the FSO module activates the SSE function if an I/O failure occurs.

Validation of the SSE with emergency ramp and SS1 functions

The SSE with emergency ramp and SS1 functions are identical with only minor differences. These functions are included in the same validation procedures below.

Validation of the SSE and SS1 functions with time monitoring

Follow these steps to validate the SSE and SS1 functions with time monitoring (each function separately):

1. Check the SSE (SS1) input connections from the field equipment to the FSO against the circuit diagrams.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the input for the SSE (SS1) function is configured correctly.
   Note: If you use the safety fieldbus to activate the SSE (SS1) function, configure and the validate the safety fieldbus interface first.
4. Make sure that the other SSE (SS1) function parameters are configured correctly (see section *How to configure SSE with time monitoring* on page *287* or section *How to configure SS1 with time monitoring (SS1-t)* on page *273*):
   - parameter *SSE monitoring method* is set to *Time* (parameter *SS1 type* is set to *SS1-t*)
   - parameter *SSE delay for STO* (*SS1-t delay for STO*) is set correctly.
5. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
6. Make sure that you can ran and stop the motor freely.
7. Start the drive to the motor speed typical for the application.
8. Activate the SSE (SS1) function (for example, disconnect the signal from the field device to the FSO input).
9. Make sure that the motor speed ramps down properly and the time monitoring delay is set correctly.
10. If the speed limit activated SBC is used:
    - Check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed*.
    - Check that the drive STO is activated at the same time or after a delay defined by parameter *STO SBC delay*.
    - Check that the SBC feedback input is activated after the activation of the SBC output.
11. Make sure that the drive STO is activated.

12. Remove the SSE (SS1) function request.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
14. Restart the drive and make sure that the motor runs normally.
15. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SSE and SS1 functions with ramp monitoring

Follow these steps to validate the SSE and SS1 functions with ramp monitoring (each function separately):

1. Check the SSE (SS1) input connections from the field equipment to the FSO against the circuit diagrams.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the input for the SSE (SS1) function is configured correctly.
   Note: If you use the safety fieldbus to activate the SSE (SS1) function, configure and the validate the safety fieldbus interface first.
4. Make sure that the other SSE (SS1) function parameters are configured correctly (see section *How to configure SSE with ramp monitoring* on page *288* or section *How to configure SS1 with ramp monitoring (SS1-r)* on page *275*):
   - parameter *SSE monitoring method* is set to *Ramp* (parameter *SS1 type* is set to *SS1-r*)
   - the SAR0 (SAR1) ramp times are set correctly. See section *How to configure SARn* on page *294*.
5. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
6. Make sure that you can ran and stop the motor freely.
7. Start the drive to the motor speed typical for the application.
8. Activate the SSE (SS1) function (for example, disconnect the signal from the field device to the FSO input).
9. Make sure that the motor speed ramps down properly and the SAR0 (SAR1) monitoring limits are set correctly.
10. If the speed limit activated SBC is used:
    - Check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed*.
    - Check that the drive STO is activated at the same time or after a delay defined by parameter *STO SBC delay*.
    - Check that the SBC feedback input is activated after the activation of the SBC output.
11. Make sure that the drive STO is activated.
12. Remove the SSE (SS1) function request.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).

14. Restart the drive and make sure that the motor runs normally.
15. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SLS functions

Note: The SLS validation procedures described in this section do not test the SLS trip limits. You can test the SLS trip limits by changing the SLS limit really close to the SLS trip limit (for example, 1 rpm below the trip limit).

Validation of the SLS function with time monitoring

Follow these steps to validate the SLS1...4 functions with time monitoring (SLS1 is used as an example):

1. Check the SLS1 input connections from the field equipment to the FSO against the circuit diagrams.
2. If the cascade connection is used: Check the cascade connections and this checklist in all cascaded drives. Only the SLS1 function can be cascaded.
3. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
4. Make sure that the input for the SLS1 function is configured correctly. **Note**: If you use the safety fieldbus to activate the SLS1 function, configure and the validate the safety fieldbus interface first.
5. Make sure that the other SLS1 function parameters are configured correctly (see section *How to configure SLSn with time monitoring* on page *295*):
   - parameters *SLS1 limit positive* and *SLS1 limit negative* are set to the correct values
   - parameters *SLS1 trip limit positive* and *SLS1 trip limit negative* are set to the correct values
     Note: If you also use the SMS function, the SLS1 trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.
   - parameter *SLS time delay* is set to the correct value
   - the correct SLS acknowledgement method is selected (parameter *SLS acknowledgement*).
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Start the drive to the motor speed higher than the speed defined by parameter *SLS1 limit positive*.

8. Activate the SLS1 function (for example, disconnect the signal from the field device to the FSO input).
9. Make sure that the motor speed ramps to below the speed defined by parameter *SLS1 limit positive* before *SLS time delay* has elapsed. The deceleration ramp is defined by drive parameters.
10. If cascading is used: Test the application so that the SLS1 time monitoring trips the drive and other cascaded drives during the deceleration ramp (that is, the FSO activates the SSE function and the motor either coasts or ramps to a stop).
    - Check that the drive STO is activated (immediately or after an emergency ramp).
    - If the SBC is used: Check that the SBC is activated as configured.
11. Make sure that the motor cannot run at a speed higher than the speed defined by parameter *SLS1 limit positive*.
12. Remove the SLS1 function request.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
14. Restart the drive and make sure that the motor runs normally.
15. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.
16. Repeat the test with the other used SLS functions.

Validation of the SLS function with ramp monitoring

Follow these steps to validate the SLS1...4 functions with ramp monitoring (SLS1 is used as an example):

1. Check the SLS1 input connections from the field equipment to the FSO against the circuit diagrams.
2. If the cascade connection is used: Check the cascade connections and this checklist in all cascaded drives. Only the SLS1 function can be cascaded.
3. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
4. Make sure that the input for the SLS1 function is configured correctly. **Note**: If you use the safety fieldbus to activate the SLS1 function, configure and the validate the safety fieldbus interface first.
5. Make sure that the other SLS1 function parameters are configured correctly (see section *How to configure SLSn with ramp monitoring* on page *297*):
   - parameters *SLS1 limit positive* and *SLS1 limit negative* are set to the correct values
   - parameters *SLS1 trip limit positive* and *SLS1 trip limit negative* are set to the correct values
     Note: If you also use the SMS function, the SLS1 trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.
   - the SAR1 ramp times are set correctly (see section *How to configure SARn* on page *294*)
   - the correct SLS acknowledgement method is selected (parameter *SLS acknowledgement*).
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Start the drive to the motor speed higher than the speed defined by parameter *SLS1 limit positive*.
8. Activate the SLS1 function (for example, disconnect the signal from the field device to the FSO input).

9. Make sure that the motor speed ramps to below the speed defined by parameter *SLS1 limit positive* within the ramp monitoring limits *SAR1 min ramp time to zero* and *SAR1 max ramp time to zero*).
10. If cascading is used: Test the application so that the SLS1 ramp monitoring trips the drive and other cascaded drives during the deceleration ramp (that is, the FSO activates the STO function and the motor coasts to a stop).
    - Check that the drive STO is activated.
    - If the SBC is used: Check that the SBC is activated as configured.
11. Make sure that the motor cannot run at a speed higher than the speed defined by parameter *SLS1 limit positive*.
12. Remove the SLS1 function request.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
14. Restart the drive and make sure that the motor runs normally.
15. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.
16. Repeat the test with the other used SLS functions.

Validation of the Variable SLS function with time monitoring

Note: This safety function requires that a safety PLC is connected to the FSO module via the PROFIsafe communication bus. Validate the PROFIsafe connection first according to the instructions in section *Validation of the PROFIsafe connection* on page *377*.

Follow these steps to validate the Variable SLS function with time monitoring:

1. Make a safety program that changes the scaling value of the SLS4 limits at desired situations. See section *Configuring Variable SLS* on page *299*.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the Variable SLS function is configured correctly (see section *How to configure Variable SLS with time monitoring* on page *299*):
   - parameter *SLS4 limit positive* and *SLS4 limit negative* are set to the correct values
   - parameters *SLS4 trip limit positive* and *SLS4 trip limit negative* are set to the correct values.
     Note: If you also use the SMS function, the SLS4 trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.
   - parameter *SLS time delay* is set to the correct value
   - the correct SLS acknowledgement method is selected (parameter *SLS acknowledgement*).
4. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
5. Start the drive to the motor speed higher than the speed defined by parameter *SLS4 limit positive*.
6. Activate the Variable SLS function from the safety PLC.
7. Make sure that the motor speed ramps to below the speed defined by parameter *SLS4 limit positive* and the desired scaling value before *SLS time delay* has elapsed.

8. If cascading is used: Test the application so that the time monitoring trips the drive and other cascaded drives during the deceleration ramp (that is, the FSO activates the SSE function and the motor either coasts or ramps to a stop).
9. Check that the drive STO is activated (immediately or after an emergency ramp).
10. If the SBC is used: Check that the SBC is activated as configured.
11. Make sure that the motor speed changes according to the scaling values sent from the safety PLC.
12. Make sure that the motor cannot run at a speed higher than the speed defined by parameter *SLS4 limit positive* and the scaling value.
13. Remove the Variable SLS function request from the safety PLC.
14. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
15. Restart the drive and make sure that the motor runs normally.
16. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the Variable SLS function with ramp monitoring

Note: This safety function requires that a safety PLC is connected to the FSO module via the PROFIsafe communication bus. Validate the PROFIsafe connection first according to the instructions in section *Validation of the PROFIsafe connection* on page *377*.

Follow the steps below to validate the Variable SLS function with ramp monitoring:

1. Make a safety program that changes the scaling value of the SLS4 limits at desired situations. See section *Configuring Variable SLS* on page *299*.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the Variable SLS function is configured correctly (see section *How to configure SLSn with ramp monitoring* on page *297*):
   - parameters *SLS4 limit positive* and *SLS4 limit negative* are set to the correct values
   - parameters *SLS4 trip limit positive* and *SLS4 trip limit negative* are set to the correct values
     Note: If you also use the SMS function, the SLS4 trip limits positive and negative must be below the speed defined by parameter *SMS trip limit positive* and above the speed defined by parameter *SMS trip limit negative*, respectively.
   - the SAR1 ramp times are set to the correct values (see section *How to configure SARn* on page *294*)
   - the correct SLS acknowledgement method is selected (parameter *SLS acknowledgement*).
4. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
5. Start the drive to the motor speed higher than the speed defined by parameter *SLS4 limit positive*.
6. Activate the Variable SLS function from the safety PLC (with a PROFIsafe profile bit).

7. Make sure that the motor speed ramps to below the speed defined by parameter *SLS4 limit positive* and the desired scaling value within the ramp monitoring limits *SAR1 min ramp time to zero* and *SAR1 max ramp time to zero*.
8. If cascading is used: Test the application so that the ramp monitoring trips the drive and other cascaded drives during the deceleration ramp (that is, the FSO activates the STO function and the motor coasts to a stop).
9. Check that the drive STO is activated.
10. If the SBC is used: Check that the SBC is activated as configured.
11. Make sure that the motor cannot run at a speed higher than the speed defined by parameter *SLS4 limit positive* and the scaling value.
12. Remove the Variable SLS function request from the safety PLC.
13. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
14. Restart the drive and make sure that the motor runs normally.
15. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SMS functions

Validation of the SMS function, version 1

Follow these steps to validate the SMS function, version 1:

1. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
2. Make sure that the SMS, version 1 function is active (*SMS activity and version* = *Version 1*).
3. Set parameter *SMS trip limit positive* to half of the value to be used in the application and parameter *SMS trip limit negative* to zero.
4. Download and validate the configuration with the Drive composer pro PC tool.
5. Make sure that you can ran and stop the motor freely.
6. Start the drive and accelerate in the forward direction to a speed higher than the *SMS trip limit positive*.
7. The FSO detects overspeed and activates the SSE function. The motor either coasts or ramps to a stop):
   - Make sure that the drive STO is activated (immediately or after an emergency ramp).
   - If the SBC is in use: Check that the SBC is activated as configured.
8. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
9. Restart the drive and check that the motor runs normally.
10. If the motor can rotate in the reverse direction, set parameter *SMS trip limit positive* to zero and parameter *SMS trip limit negative* to half of the value to be used in the application and repeat the test procedure for the reverse direction.
11. Set parameters *SMS trip limit positive* and *SMS trip limit negative* to their correct values to be used in the application. Download and validate the configuration with the Drive composer pro PC tool.
12. Repeat the test procedure as near as possible the maximum design speed of the machinery. This design speed must be the same or higher than the maximum speed of the drive.
13. Restart the drive and check that the motor can run at the maximum and minimum speeds.

⚠ **WARNING!** If the SMS validation is to be performed with the machinery coupled to the motor, make sure that the machinery is able to withstand the fast speed changes and the set maximum speed.

Validation of the SMS function, version 2

Note: The SMS validation procedure described in this section does not test the SMS trip limits. You can test the SMS trip limits by changing the SMS limit really close to the SMS trip limit (for example, 1 rpm below the trip limit).

Follow the steps below to validate the SMS function, version 2:

1. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
2. Make sure that the SMS, version 2 function is active (*SMS activity and version* = Version 2).
3. Make sure that the SMS, version 2 function is configured correctly (see section *How to configure SMS, version 2* on page *307*):
   - parameters *SMS limit positive* and *SMS limit negative* are set to the correct values
   - parameters *SMS trip limit positive* and *SMS trip limit negative* are set to the correct values.
4. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
5. Start the drive and make sure that the motor cannot run at a speed higher than the speed defined by parameter *SMS limit positive*.
6. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the POUS function

Follow the steps below to validate the POUS function:

1. Check the POUS input and output connections from the field equipment to the FSO against the circuit diagrams.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the POUS function is active (*POUS activity and version* = *Version 1*).
4. Make sure that the POUS function is configured correctly (see section *Configuring POUS* on page *308*):
   - parameter *POUS delay for completion* is set to the correct value
   - parameter *POUS input* and an output for the POUS indication lamp (*POUS completed output*) are set correctly
   - the correct POUS acknowledgement method is selected (for example, manual acknowledgement).
5. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
6. Make sure that you can ran and stop the motor freely.
7. Stop the motor.
8. Activate the POUS function (for example, disconnect the signal from the field device to the FSO input).
9. Make sure that the POUS indication lamp goes on after the delay defined by parameter *POUS delay for completion*.
10. Make sure that you cannot start the drive and motor.
11. Deactivate the POUS function (for example, connect the signal from the field device to the FSO input).
12. Make sure that the POUS indication lamp goes off.
13. Restart the drive and make sure that the motor runs normally.

Validation of the SSM functions

Follow these steps to validate the SSM1...4 functions (the SSM1 function is used as an example):

1. Check the SSM1 input and output connections from the field equipment to the FSO against the circuit diagrams.
2. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
3. Make sure that the SSM1 function is active (*SSM1 activity and version* = *Version 1*).
4. Make sure the SSM1 function is configured correctly (see section *Configuring SSM* on page *309*):
   - parameters *SSM1 limit positive* and *SSM1 limit negative* are set to correct values
   - an output to indicate the SSM1 status (*SSM1 output*) is configured.
5. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
6. Make sure that you can ran and stop the motor freely.
7. Start the drive and check that the motor can run at a higher speed than the speed defined by parameter *SSM1 limit positive*.
8. Activate the SSM1 monitoring (for example, disconnect the signal from the field device to the FSO input).
9. Check that the status of the SSM1 output changes (*SSM1 output*) when the motor speed goes above the speed defined by parameter *SSM1 limit positive*.
10. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SDI functions

Note: This safety function requires that an encoder is used. Validate the safety encoder interface first according to the instructions in section *Validation of the safety encoder interface* on page *378*.

The SDI positive function is used as an example. If you use the SDI negative function, you can validate it with the same procedure.

Note: The SDI validation procedures described in this section do not test the SDI trip limits.

Validation of the SDI positive function with time monitoring

Follow these steps to validate the SDI positive function with time monitoring:

1. Check the SDI input connections from the field equipment to the FSO against the circuit diagrams.
2. If the cascade connection is used, check the cascade connections and this checklist in all cascaded drives.
3. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
4. Make sure that the SDI positive function is active (*SDI version* = *Version 1*, *SDI positive activity* = *Enabled*).
5. Make sure that SDI positive function is configured correctly (see section *Configuring SDI* on page *311*):
   - parameter *SDI activation monitoring method* is set to *Time*
   - parameter *SDI delay* is set to the correct value
   - parameter *SDI tolerance limit degree* is set to the correct value
   - the SDI input and output parameters are set correctly
   - the correct SDI acknowledgement method (parameter *SDI acknowledgement*) is selected.
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Start the drive and make sure that the you can ran the motor in both directions.
8. Run the motor in the forbidden (negative) direction.
9. Activate the SDI positive function (for example, disconnect the signal from the field device to the FSO input).
10. Make sure that the motor stops before *SDI delay* has elapsed. The ramp is defined by drive parameters (*23.13* or *23.15*).
11. Make sure that the status of the SDI positive output changes (*SDI positive output A*) when the motor speed reaches zero.
12. Make sure that you can run the motor only into the correct (positive) direction.
13. Deactivate the SDI positive function.
14. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
15. Make sure that the status of the SDI positive output changes (*SDI positive output A*).
16. Make sure that you can run the motor in both directions.

Validation of the SDI positive function with ramp monitoring

Follow the steps below to validate the SDI positive function with time monitoring:

1. Check the SDI input connections from the field equipment to the FSO against the circuit diagrams.
2. If the cascade connection is used, check the cascade connections and this checklist in all cascaded drives.
3. Upload the parameters from the FSO with the Drive composer pro PC tool or open an existing safety file.
4. Make sure that the SDI positive function is active (*SDI version* = *Version 1*, *SDI positive activity* = *Enabled*).
5. Make sure that SDI positive function is configured correctly (see section *Configuring SDI* on page *311*):
   - parameter *SDI activation monitoring method* is set to *Ramp*
   - SAR1 ramp times are set correctly
   - parameter *SDI tolerance limit degree* is set to the correct value
   - the SDI input and output parameters are set correctly
   - the correct SDI acknowledgement method (parameter *SDI acknowledgement*) is selected.
6. If you made any changes, download and validate the configuration with the Drive composer pro PC tool.
7. Start the drive and check that the motor can run in both directions.
8. Run the motor in the forbidden (negative) direction.
9. Activate the SDI positive function (for example, disconnect the signal from the field device to the FSO input).
10. Make sure that the motor stops within the monitoring limits. The deceleration ramp and monitoring limits are defined by SAR1 parameters.
11. Make sure that the status of the SDI positive output changes (*SDI positive output A*) when the motor speed reaches zero.
12. Make sure that you can run the motor only into the correct (positive) direction.
13. Deactivate the SDI positive function.
14. If automatic acknowledgement is not used: Set an acknowledgement (for example, with an acknowledgement button).
15. Check that the status of the SDI positive output changes (*SDI positive output A*).
16. Check that you can run the motor in both directions.

Proof test intervals during operation

Proof tests are intended to ensure that the safety integrity of a safety system is maintained continuously and does not deteriorate over time. Proof tests are often required for mechanical brakes, for example. Proof tests are used mainly for parts of the system that cannot be automatically diagnosed.

The proof test interval is the interval between two proof tests. When the proof test interval has elapsed, the safety system has to be tested and restored to an "as new condition". The proof test must also be part of the regular maintenance plan.

For some of the components (electronics), the proof test interval is the same as the expected life time of the system.

A specific safety calculator software can assist in determining the requirements for the proof tests.

Residual risks

The safety functions are used to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. Therefore the warnings for the residual risks must be given to the operators.

14

Fault tracing

Contents of this chapter

This chapter describes the status LEDs and provides generic diagnostics and troubleshooting tips for FSO related faults generated by the drive.

Status LEDs

The status LEDs are situated on the front of the FSO module. The table below describes the status LED indications.

LED	LED off	LED lit and steady		LED blinking	
POWER	No power	Green	Power to the FSO is on.	-	-
RUN	FSO is in the Fail-safe mode and Safe state (STO activated).	Green	FSO is in the Operational or Safe state.	Green	FSO is in the Configuration or Start-up mode.
STATUS/FAULT	The drive is in normal operation, without active safety functions and no faults.	Green	A safety function is active.	Green	Request for a safety function has ended but it has not been acknowledged.
		Red	FSO is in the Fail-safe mode.	Red	FSO is in the Configuration mode (RUN LED is also blinking).
STO	The drive STO circuit is closed and the drive is in operation.	Green	The drive STO circuit is open.	-	-
FB	Safety communication to the fieldbus has stopped.	Green	FSO is ready to start safety communication to the fieldbus.	Green	Safety communication to the fieldbus is running.

Event types

The FSO module generates three types of events to the drive:

- Pure events, which are just informative data
- Warnings, which are shown to the user
- Faults, which stop the drive and are shown to the user.

The user can select the event type (warning, fault or event) for certain function requests, limit hits and special events:

- Parameter *FSOGEN.61 STO indication ext request* defines the event type for the STO, SS1 and SSE function external requests. The same parameter also defines the event type that the FSO module generates when the function is completed.
- Parameter *FSOGEN.62 STO indication safety limit* defines the event type for the limit hits of:
  - SLS1, …, SLS4, Variable SLS, SMS and SDI functions
  - ramp monitoring and time monitoring of the safety ramps SAR0 and SAR1.
- Parameter *SBUSGEN.10 STO indication passivation* defines the event type for the FSO module passivation due to safety fieldbus problems.

Faults, warnings and events

Code (hex)	Name	Cause	What to do	
Faults				
7A81	TUCSO fault	FSO subsystem fault	Contact your local ABB representative.	
7A8B	FSO general fault	FSO module is in the Configuration mode. FSO module also generates this fault after certain malfunctions which the FSO module indicates by warnings. First the FSO module generates a warning indication which allows the drive to control the system to a safe state. After this the drive trips.	See the warning log for more information on the actual cause.	3)
7A90	FSO stop completed	FSO module has completed the STO, SS1 or SSE function.	-	1)
7A91	FSO safe speed limit	Motor actual speed exceeded an SLS1...4 or SMS limit of the FSO module.	Check the drive.	2) 3)
7A92	FSO out of eme ramp	Motor speed was not inside the ramp window during the SSE function.	Make sure that the drive can decelerate the load using the ramp time (*200.102 SAR0 ramp time to zero*).	2)
7A93	FSO ramp coasted	Drive coasted the motor to stop instead of using the ramp.	Check that the FSO module speed limit for stopping the ramp deceleration is not excessive (*FSOGEN.51 Zero speed without encoder*).	2)
7A94	FSO out of safe ramp	Motor speed was not inside the ramp window during the SS1 function.	Make sure that the drive can decelerate the load using the ramp time (*200.112 SAR1 ramp time to zero*).	2)
7A96	FSO out of SDI	SDI positive or SDI negative exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)
7A97	FSO premature POUS	FSO received an external POUS request while the drive was still modulating.	It is recommended to activate the POUS function only when the drive is stopped.	

Code (hex)	Name	Cause	What to do	
7A98	FSO undefined fault	FSO new version, undefined fault in the dive event system.	Contact your local ABB representative.	
7A99	FSO passivated	FSO module was passivated due to safety fieldbus problems.	Check the fieldbus connection and fieldbus controller for passivation cause.	5)
Warnings				
A7D0	FSO general warnings	Warning from the FSO module, for example: • acknowledgement button not operated correctly • I/O redundancy fault • safety relay feedback fault • motor speed from the safety encoder lost	See the tips in the Drive Composer PC tool.	3)
A7D1	FSO internal fault	Internal fault in the FSO module	Reboot the FSO module. If the problem still exits, replace the FSO module. Contact your local ABB representative.	5) 3)
A7D2	FSO IO fault	Problems in the I/O cabling or safety relays	Check the FSO I/O cabling.	4) 3)
A7D3	FSO STO fault	Problems in the STO cabling or inside the drive	Check the FSO STO cabling.	4)
A7D4	FSO STO request	FSO module received an external STO request.	-	1)
A7D5	FSO communication fault	Fault in FSO communication	Check all connections.	4) 3)
A7D6	FSO safety fieldbus fault	Fault in FSO safety fieldbus communication	Check all connections.	4) 3)
A7D7	FSO configuration fault	Fault in FSO configuration	Check the FSO module parameter settings using Drive composer pro.	4)
A7D8	FSO safety encoder fault	Fault in the safety encoder connected to the FSE module	Check the safety encoder and the connections.	

Code (hex)	Name	Cause	What to do	
A7D9	FSO encoderless fault	Speed estimates differ too much.	• Check the behavior of the driven load compared with the drive control parameter settings. • Check that the drive is suitable for the drive train and the motor. • Adapt control parameters if gear play or torsional rigidity causes problems.	4)
A7DA	FSO temperature fault	FSO module temperature is too high.	• Check ambient conditions. Reboot the FSO module (switch the power off and on or use drive parameter *96.09 FSO reboot*, see the drive firmware manual). • Make sure that cooling is sufficient. Contact your local ABB representative.	4)
A7DB	FSO undefined warning	FSO new version, undefined warning in the drive event system.	Contact your local ABB representative.	
AA90	FSO stop completed	FSO module has completed the STO, SS1 or SSE function.	-	1)
AA91	FSO safe speed limit	Motor actual speed exceeded an SLS1...4 or SMS limit of the FSO module.	Check the drive.	2) 3)
AA92	FSO out of eme ramp	Motor speed was not inside the ramp window during the SSE function.	Make sure that the drive can decelerate the load using the ramp time (*200.102 SAR0 ramp time to zero*).	2)
AA93	FSO ramp coasted	Drive coasted the motor to stop instead of using the ramp.	Check that the FSO module zero speed limit for the deceleration ramp is not excessive (*FSOGEN.51 Zero speed without encoder* or *FSOGEN.52 Zero speed with encoder*).	2)
AA94	FSO out of safe ramp	Motor speed was not inside the ramp window during the SS1 function.	Make sure that the drive can decelerate the load using the ramp time (*200.112 SAR1 ramp time to zero*).	2)
AA96	FSO out of SDI	SDI positive or SDI negative exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)

Code (hex)	Name	Cause	What to do	
AA97	FSO POUS request	FSO module received an external POUS request and activated POUS.	-	
AA99	FSO passivated	FSO module was passivated due to safety fieldbus problems.	Check the fieldbus connection and fieldbus controller for passivation cause.	5)
AAA1	FSO STO request	FSO module received an external STO request.	-	1)
AAA2	FSO SSE request	FSO module received an external SSE request.	-	1)
AAA3	FSO SS1 request	FSO module received an external SS1 request.	-	1)
AAA4	FSO SLS1 hit	FSO module detected an SLS1 speed limit violation.	Check the drive.	2)
AAA5	FSO SLS2 hit	FSO module detected an SLS2 speed limit violation.	Check the drive.	2
AAA6	FSO SLS3 hit	FSO module detected an SLS3 speed limit violation.	Check the drive.	2)
AAA7	FSO SLS4 hit	FSO module detected an SLS4 speed limit violation.	Check the drive.	2)
AAA8	FSO SMS hit	FSO module detected an SMS speed limit violation.	Check the drive.	2)
AAA9	FSO SAR0 hit	FSO module detected an SAR0 limit violation.	Make sure that the drive can decelerate the load using the ramp time (*200.102 SAR0 ramp time to zero*).	2)
AAAA	FSO SAR1 hit	FSO module detected an SAR1 limit violation.	Make sure that the drive can decelerate the load using the ramp time (*200.112 SAR1 ramp time to zero*).	2)
AAB0	FSO SDI positive hit	SDI positive exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)
AAB1	FSO SDI negative hit	SDI negative exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)

Code (hex)	Name	Cause	What to do	
AAB2	FSO ramp time hit	FSO module detected a violation of a time monitored ramp.	Make sure that the drive can decelerate the load within the time defined for ramp time monitoring. • Check the drive ramp time settings. • Check that the drive can in fact accomplish the deceleration along the ramp defined. Make sure that the limit for ramp time monitoring of the FSO module exceeds the actual drive ramp time. The parameter varies depending on the safety function. For the SS1 function it is *SS1.14 SS1-t delay for STO*.	2)
AAB3	FSO zero spd hit	Drive speed rushed during zero speed delay (*SSE.16 SSE ramp zero speed delay for STO* or *SS1.15 SS1-r ramp zero speed delay for STO*).	Check the drive.	2)
AAB4	FSO speed sync fail	FSO module detected a difference between the two monitored motor speed values (*200.01 FSO speed ch1* and *200.02 FSO speed ch2*).	Restart the drive and FSO module.	2)
AAB5	FSO varSLS hit	FSO module detected a Variable SLS speed limit violation.	Check the drive.	2)
AAB6	FSO safebus passivation	FSO module was passivated due to communication problems.	Check the fieldbus connection and fieldbus controller for passivation cause.	5)
Events				
B790	FSO general event	FSO module generated an event other than a fault or a warning.	See the tips in the Drive Composer PC tool.	3)
B792	FSO undefined event	FSO new version, undefined event in the drive event system.	Contact your local ABB representative.	
B793	FSE Ch1 diag event	Encoder failure.	Check the encoder.	
B794	FSE Ch12 diag event	Encoder failure.	Check the encoder.	

Code (hex)	Name	Cause	What to do	
BA90	FSO stop completed	FSO module has completed the STO, SS1 or SSE function.	-	1)
BA91	FSO safe speed limit	Motor actual speed exceeded an SLS1...4 or SMS limit of the FSO module.	Check the drive.	2) 3)
BA92	FSO out of eme ramp	Motor speed was not inside the ramp window during the SSE function.	Make sure that the drive can decelerate the load using the ramp time (*200.102 SAR0 ramp time to zero*).	2)
BA93	FSO ramp coasted	Drive coasted the motor to stop instead of using the ramp.	Check that the FSO module zero speed limit for the deceleration ramp is not excessive (*FSOGEN.51 Zero speed without encoder* or *FSOGEN.52 Zero speed with encoder*).	2)
BA94	FSO out of safe ramp	Motor speed was not inside the ramp window during the SS1 function.	Make sure that the drive can decelerate the load using the ramp time (*200.112 SAR1 ramp time to zero*).	2)
BA96	FSO out of SDI	SDI positive or SDI negative exceeded the tolerance limit to the forbidden direction.	Check the drive.	
BA99	FSO passivated	FSO module was passivated due to safety fieldbus problems.	Check the fieldbus connection and fieldbus controller for passivation cause.	5)
BAA1	FSO STO request	FSO module received an external STO request.	-	1)
BAA2	FSO SSE request	FSO module received an external SSE request.	-	1)
BAA3	FSO SS1 request	FSO module received an external SS1 request.	-	1)
BAA4	FSO SLS1 hit	FSO module detected an SLS1 speed limit violation.	Check the drive.	2)
BAA5	FSO SLS2 hit	FSO module detected an SLS2 speed limit violation.	Check the drive.	2)
BAA6	FSO SLS3 hit	FSO module detected an SLS3 speed limit violation.	Check the drive.	2)

Code (hex)	Name	Cause	What to do	
BAA7	FSO SLS4 hit	FSO module detected an SLS4 speed limit violation.	Check the drive.	2)
BAA8	FSO SMS hit	FSO module detected an SMS speed limit violation.	Check the drive.	2)
BAA9	FSO SAR0 hit	FSO module detected an SAR0 limit violation.	Make sure that the drive can decelerate the load using the ramp time (*200.102 SAR0 ramp time to zero*).	2)
BAAA	FSO SAR1 hit	FSO module detected an SAR1 limit violation.	Make sure that the drive can decelerate the load using the ramp time (*200.112 SAR1 ramp time to zero*).	2)
BAB0	FSO SDI positive hit	SDI positive exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)
BAB1	FSO SDI negative hit	SDI negative exceeded the tolerance limit to the forbidden direction.	Check the drive.	2)
BAB2	FSO ramp time hit	FSO module detected a violation of a time monitored ramp.	Make sure that the drive can decelerate the load within the time defined for ramp time monitoring. • Check the drive ramp time settings. • Check that the drive can in fact accomplish the deceleration along the ramp defined. Make sure that the limit for ramp time monitoring of the FSO module exceeds the actual drive ramp time. The parameter varies depending on the safety function. For the SS1 function it is *SS1.14 SS1-t delay for STO*.	2)
BAB3	FSO zero spd hit	Drive speed rushed during zero speed delay (*SSE.16 SSE ramp zero speed delay for STO* or *SS1.15 SS1-r ramp zero speed delay for STO*).	Check the drive.	2)
BAB4	FSO speed sync fail	FSO module detected a difference between the two monitored motor speed values (*200.01 FSO speed ch1* and *200.02 FSO speed ch2*).	Restart the drive and FSO module.	2)

Code (hex)	Name	Cause	What to do	
BAB5	FSO varSLS hit	FSO module detected a Variable SLS speed limit violation.	Check the drive.	2)
BAB6	FSO safebus passivation	FSO module was passivated due to communication problems.	Check the fieldbus connection and fieldbus controller for passivation cause.	5)

1) This is a user-selectable event for a function request. See parameter *FSOGEN.61 STO indication ext request* and section *User-selectable events for function requests* on page *412*.

2) This is a user-selectable event for a limit hit or a special event. See parameter *FSOGEN.62 STO indication safety limit* and section *User-selectable events for limit hits and special events* on page *412*.

3) For more information, see the tips in the Drive Composer PC tool.

4) This warning indicates a fault actually. However, the FSO module generates a warning indication first to allow the drive to control the system to a safe state. When the system is in the safe state, the drive trips. Fault indication is *7A8B FSO general fault*.

5) This is a user-selectable event for a safety fieldbus failure. See parameter *SBUSGEN.10 STO indication passivation* and section *User-selectable events for safety fieldbus failures* on page *415*.

User-selectable events for function requests

The table below lists the user-selectable events related to function requests.

Function/ Incident	Events depending on the event type selection (parameter *FSOGEN.61*)		
	Fault	**Warning**	**Event**
STO function			
STO request	*AAA1 FSO STO request* (warning)[1]	*AAA1 FSO STO request*	*BAA1 FSO STO request*
STO completed	*7A90 FSO stop completed*	*AA90 FSO stop completed*	*BA90 FSO stop completed*
SS1 function			
SS1 request	*AAA3 FSO SS1 request* (warning)[1]	*AAA3 FSO SS1 request*	*BAA3 FSO SS1 request*
SS1 completed	*7A90 FSO stop completed*	*AA90 FSO stop completed*	*BA90 FSO stop completed*
SSE function			
SSE request	*AAA2 FSO SSE request* (warning)[1]	*AAA2 FSO SSE request*	*BAA2 FSO SSE request*
SSE completed	*7A90 FSO stop completed*	*AA90 FSO stop completed*	*BA90 FSO stop completed*

1) If you select Fault for parameter *FSOGEN.61 STO indication ext request*, the FSO module generates a warning at the function request, and a fault trip only after the function is completed. The fault trip is delayed because the drive must be able to control the system to the Safe state first.

Note: If you select None for parameter *FSOGEN.61 STO indication ext request*, the FSO module generates no event when it receives a function request or detects that the function is completed.

User-selectable events for limit hits and special events

The table below lists user-selectable events related to limit hits and special events.

Limit/Incident	Events depending on the event type selection (parameter *FSOGEN.62*)		
	Fault	**Warning**	**Event**
SLS1			
SLS1 limit hit	*AAA4 FSO SLS1 hit* (warning)[1)]	*AAA4 FSO SLS1 hit*	*BAA4 FSO SLS1 hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
SLS2			
SLS2 limit hit	*AAA5 FSO SLS2 hit* (warning)[1)]	*AAA5 FSO SLS2 hit*	*BAA5 FSO SLS2 hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
SLS3			
SLS2 limit hit	*AAA6 FSO SLS3 hit* (warning)[1)]	*AAA6 FSO SLS3 hit*	*BAA6 FSO SLS3 hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
SLS4			
SLS4 limit hit	*AAA7 FSO SLS4 hit* (warning)[1)]	*AAA7 FSO SLS4 hit*	*BAA7 FSO SLS4 hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
Variable SLS			
varSLS limit hit	*AAB5 FSO varSLS hit* (warning)[1)]	*AAB5 FSO varSLS hit*	*BAB5 FSO varSLS hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
SMS			
SMS limit hit	*AAA8 FSO SMS hit* (warning)[1)]	*AAA8 FSO SMS hit*	*BAA8 FSO SMS hit*
System at safe state	*7A91 FSO safe speed limit*	*AA91 FSO safe speed limit*	*BA91 FSO safe speed limit*
SDI positive			
SDI positive hit	*AAB0 FSO SDI positive hit* (warning)[1)]	*AAB0 FSO SDI positive hit*	*BAB0 FSO SDI positive hit*
System at safe state	*7A96 FSO out of SDI*	*AA96 FSO out of SDI*	*BA96 FSO out of SDI*

Limit/Incident	Events depending on the event type selection (parameter *FSOGEN.62*)		
	Fault	**Warning**	**Event**
SDI negative			
SDI negative hit	*AAB1 FSO SDI negative hit* (warning)[1)]	*AAB1 FSO SDI negative hit*	*BAB1 FSO SDI negative hit*
System at safe state	*7A96 FSO out of SDI*	*AA96 FSO out of SDI*	*BA96 FSO out of SDI*
SAR0			
SAR0 limit hit	*AAA9 FSO SAR0 hit* (warning)[1)]	*AAA9 FSO SAR0 hit*	*BAA9 FSO SAR0 hit*
System at safe state	*7A92 FSO out of eme ramp*	*AA92 FSO out of eme ramp*	*BA92 FSO out of eme ramp*
SAR1			
SAR1 limit hit	*AAAA FSO SAR1 hit* (warning)[1)]	*AAAA FSO SAR1 hit*	*BAAA FSO SAR1 hit*
System at safe state	*7A92 FSO out of eme ramp*	*AA92 FSO out of eme ramp*	*BA92 FSO out of eme ramp*
Ramp time hit			
Ramp time hit	*AAB2 FSO ramp time hit* (warning)[1)]	*AAB2 FSO ramp time hit*	*BAB2 FSO ramp time hit*
System at safe state	*7A92 FSO out of eme ramp*	*AA92 FSO out of eme ramp*	*BA92 FSO out of eme ramp*
Zero speed hit			
Zero speed hit	*AAB3 FSO zero spd hit* (warning)[1)]	*AAB3 FSO zero spd hit*	*BAB3 FSO zero spd hit*
System at safe state	*7A92 FSO out of eme ramp*	*AA92 FSO out of eme ramp*	*BA92 FSO out of eme ramp*
Speed values not in synchrony			
Speeds not in sync.	*AAB4 FSO speed sync fail* (warning)[1)]	*AAB4 FSO speed sync fail*	*BAB4 FSO speed sync fail*
System at safe state	*7A90 FSO stop completed*	*AA90 FSO stop completed*	*BA90 FSO stop completed*

[1)] If you select Fault for parameter *FSOGEN.62 STO indication safety limit*, the FSO module generates a warning at the limit hit, and a fault only after the system is at the Safe state.

Note: If you select None for parameter *FSOGEN.62 STO indication safety limit*, the FSO module generates no event when it detects a limit hit.

User-selectable events for safety fieldbus failures

The table below lists user-selectable events related to safety fieldbus failures.

Incident	Events depending on the event type selection (parameter *SBUSGEN.10*)		
	Fault	**Warning**	**Event**
Problem in the safety fieldbus communication	*AAB6 FSO safebus passivation* (warning)[1)]	*AAB6 FSO safebus passivation*	*BAB6 FSO safebus passivation*
System at safe state	*7A99 FSO passivated*	*AA99 FSO passivated*	*BA99 FSO passivated*

[1)] If you select Fault for parameter *SBUSGEN.10 STO indication passivation*, the FSO module generates a warning at the passivation, and a fault only after the system is at the Safe state.

Note: If you select None for parameter *SBUSGEN.10 STO indication passivation*, the FSO module generates no event when it detects a failure in the safety fieldbus communication.

Auxiliary codes

Faults, warnings and events have 32-bit auxiliary codes, which help in finding the problem. See the tips in the Drive Composer PC tool for more information on the auxiliary codes.

Reporting problems and failures

If you detect any failure in the safety module or safety functions, always contact your local ABB representative.

15

Maintenance

Contents of this chapter

This chapter explains replacement of the FSO and FSE modules in case of a module failure, reinstalling the FSO module to another drive, updating the firmware of the drive where the FSO is installed, factory reset, FSO update and decommissioning as well as proof tests.

WARNING! Read and obey the instructions in chapter *Safety* and chapter *Safety instructions* in the drive hardware manual. If you ignore them, injury or death, or damage to the equipment can occur.

Planning

All maintenance and the repair actions on a safety critical system are safety critical. You must plan and perform them accordingly.

Tools

You need the Drive composer pro PC tool to perform the maintenance procedures.

FSO module replacement

If the FSO module fails to operate, you have to replace it with a new one; the module is not repairable.

Note: When the FSO module is in the Fail-safe mode, it can be recovered by switching the power off and on, by rebooting the FSO with drive parameter *96.09 FSO reboot* (see the drive firmware manual) or by pressing the **Boot FSO** button in Drive composer pro.

WARNING! Read and obey the instructions in chapter *Safety* and chapter *Safety instructions* in the drive hardware manual. If you ignore them, injury or death, or damage to the equipment can occur.

Replacing the FSO module

1. Stop the driven machinery and prevent an unexpected start-up.
2. Upload the FSO parameters from the FSO to the Drive composer pro PC tool and save the safety file.
3. Disconnect the supply with the supply disconnecting device.
4. Disconnect the auxiliary voltage supply to the FSO.
5. Remove the wiring and the FSO module.
6. Mark clearly on the FSO module that it is decommissioned.
7. Install the new FSO module and wiring according to chapter *Installation*.
8. Download the FSO parameters from the Drive composer pro PC tool to the FSO according to chapter *Configuration*.
9. Perform the start-up procedure according to chapter *Start-up*.
10. Perform the validation procedure for each safety function according to chapter *Verification and validation*.

    Note: The STO function is the basic safety function and it has to be validated first.
11. Update the revision of the new FSO to the logbook of the driven machine.

Drive replacement

If you have to replace the drive where the FSO is installed, for example, because of a serious drive failure, follow the procedure below.

Reinstalling the FSO module to another drive

1. Stop the driven machinery and prevent an unexpected start-up.
2. Upload the FSO parameters from the FSO to the Drive composer pro PC tool and save the safety file.
3. Disconnect the supply with the supply disconnecting device.
4. Disconnect the auxiliary voltage supply to the FSO.
5. Remove the wiring and the FSO module.
6. Install the new drive. See the drive hardware manual.
7. Install the FSO module and wiring to the new drive according to chapter *Installation*.
12. Download the FSO parameters from the Drive composer pro PC tool to the FSO according to chapter *Configuration*.
8. Perform the start-up procedure according to chapter *Start-up*
9. Perform the validation procedure for each safety function according to chapter *Verification and validation*.

   Note: The STO function is the basic safety function and it has to be validated first.
10. Update the HW and SW versions of the new drive to the logbook of the driven machine.

Drive firmware update

If you have to update the firmware of the drive where the FSO module is installed, follow the procedure below.

Updating the firmware of the drive where the FSO module is installed

1. Stop the driven machinery and prevent an unexpected start-up.
2. Upload the FSO parameters from the FSO to the Drive composer pro PC tool and save the safety file.
3. Update the firmware of the drive.
4. Download the FSO parameters from the Drive composer pro PC tool to the FSO according to chapter *Configuration*.
5. Perform the start-up procedure according to chapter *Start-up*.
6. Perform the validation procedure for each safety function according to chapter *Verification and validation*.

   Note: The STO function is the basic safety function and it has to be validated first.
7. Update the HW and SW versions of the new drive to the logbook of the driven machine.

FENA module replacement

If you have to replace the FENA Ethernet adapter module, for example, because of a serious hardware failure, follow the procedure below.

Replacing the FENA module

1. Stop the driven machinery and prevent an unexpected start-up.
2. Disconnect the supply with the supply disconnecting device.
3. Replace the FENA module according to the instructions in *FENA-01/-11/-21 Ethernet adapter module user's manual* (3AUA0000093568 [English]).
4. Assign the device name for the FENA module from the safety PLC (see section *Configuring the ABB AC500-S Safety PLC* on page *196* or section *Configuring the Siemens SIMATIC Fail-safe S7 PLC* on page *208*.
5. Perform the start-up procedure according to chapter *Start-up*.
6. Perform the validation procedure for the PROFIsafe communication according to section *Validation of the PROFIsafe connection* on page *377*.
7. Update the HW and SW versions of the new FENA module to the logbook of the driven machine.

FSE module replacement

If you have to replace the FSE module, for example, because of a serious hardware failure, follow the procedure below.

Replacing the FSE module

1. Stop the driven machinery and prevent an unexpected start-up.
2. Disconnect the supply with the supply disconnecting device.
3. Replace the FSE module according to the instructions in *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).
4. Perform the start-up procedure according to chapter *Start-up*.
5. Perform the validation procedure for the safety encoder communication according to section *Validation of the safety encoder interface* on page *378*.
6. Update the revision of the new FSE module to the logbook of the driven machine.

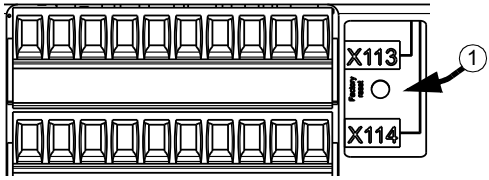
Factory reset

Do a factory reset if

- you forget the password
- you want to do the configuration again from scratch.

Note: The factory reset clears the configuration and takes the factory default values back in use. These factory default values are not the same as the pre-set values in a delivered FSO (ordered with a plus code). The factory default values are invalid for restart. The FSO needs a full reconfiguration before it can be restarted. You can also use the safety file that was saved at the first start-up (see page *249*).

1. Make sure that the motor is stopped.
2. Lift the Factory reset label to the right of the I/O terminals and push the button underneath with for example a pen until the LEDs start to blink (about 5 seconds). This returns the factory settings (parameters, including the password) to the FSO.



1. Reconfigure the safety functions with the Drive composer pro PC tool. To be able to restart the drive, make sure that at least these parameters are set to suitable values according to your application:

Parameter index	Name	Factory default value	Pre-set value (with option +Q972)
FSOGEN.21	Motor nominal speed	100.0 rpm	1500.0 rpm
FSOGEN.22	Motor nominal frequency	1 Hz	50 Hz
FSOGEN.41	Power-up acknowledgement	Manual	Automatic
STO.02	STO acknowledgement	Manual	Automatic
STO.13	Restart delay after STO	3,600,000 ms	2000 ms
STO.14	Time to zero speed with STO and modoff	3,600,000 ms	2000 ms
SBC.11	STO SBC usage	Delayed brake	None
SLSx.02	SLS acknowledgement	Manual	Automatic

2. Specify a new password with the tool.

Drive control board boot

If you reboot the drive control board (either by cycling the power or with parameter *96.08 Control board boot*), the FSO module goes into the Fail-safe mode. To exit the Fail-safe mode, switch the power off and on, reboot the FSO module with drive parameter *96.09 FSO reboot* or press the **Boot FSO** button in Drive composer pro.

Note: The STO function must be completed before you can reboot the FSO module with parameter *96.09 FSO reboot* or the **Boot FSO** button (see section *Safe torque off (STO)* on page *57*).

Updates

After any changes in the safety application or the safety system configuration, you must perform the acceptance tests to verify that the safety functionality is maintained. See chapter *Verification and validation*.

Proof tests

If periodic proof testing is necessary based on the safety calculations, you must include proof tests in the maintenance plan and perform them periodically. See also section *Proof test intervals during operation* on page *402*.

Note: The person responsible for the design of the complete safety function should also note the Recommendation of Use CNB/M/11.050 published by the European co-ordination of Notified Bodies for Machinery concerning dual-channel safety-related systems with electromechanical outputs:

- When the safety integrity requirement for the safety function is SIL 3 or PL e (cat. 3 or 4), the proof test for the function must be performed at least every month.
- When the safety integrity requirement for the safety function is SIL 2 (HFT = 1) or PL d (cat. 3), the proof test for the function must be performed at least every 12 months.

This is a recommendation and depends on the required (not achieved) SIL/PL. The FSO module does not contain any electromechanical components.

Decommissioning

WARNING! Read and obey the instructions in chapter *Safety* and chapter *Safety instructions* in the drive hardware manual. If you ignore them, injury or death, or damage to the equipment can occur.

When you decommission the FSO or FSE module, make sure that the safety of the machine is maintained until the decommissioning is complete. Mark clearly on the module that it is decommissioned.

If you use the SMS function, version 2, see the **Note** on page *144*.

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Technical data

Contents of this chapter

This chapter contains the technical specifications of the FSO-21 module.

Electrical data

Supply voltage	+24 ± 3 V DC (SELV/PELV)
Current consumption	Maximum 1000 mA (external power supply)
Inputs	4 redundant or 8 single, or combinations of redundant and single, 24 V DC NPN Maximum time delay between redundant input channels: 300 ms
Outputs	3 redundant or 6 single, or combinations of redundant and single, 24 V DC PNP

Control connection data

Logic levels	“0” < 5 V, “1” > 15 V
Digital input impedance	4 kohm
Digital output drive capability	150 mA each, 700 mA total
Max. allowed cable length between the drive and the activation switch	250 m (820 ft)

Terminal and lead-through data for the control cables

Conductor size						Tightening torque	
Solid or stranded		Stranded, ferrule without plastic sleeve		Stranded, ferrule with plastic sleeve			
Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max		
mm^2	AWG	mm^2	AWG	mm^2	AWG	N·m	lbf·in
0.14/1.5	26/16	0.25/1.5	23/16	0.25/0.5	23/21	0.24	2.1

Conductor size, two conductors with the same cross section								Tightening torque	
Solid		Stranded		Stranded, ferrules without plastic sleeve		Stranded, TWIN ferrules with plastic sleeve			
Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max		
mm^2	AWG	mm^2	AWG	mm^2	AWG	mm^2	AWG	N·m	lbf·in
0.08/0.5	28/21	0.08/0.75	28/19	0.25/0.34	23/22	0.5/0.5	21/21	0.24	2.1

Degrees of protection

Degree of protection	IP20

Size and weight

	mm	in	kg	lb
Length	100	3.94	-	-
Width	60	2.36	-	-
Depth (with wiring)	50	1.97	-	-
Weight	-	-	0.230	0.507

Cooling

Cooling method	Dry clean air (natural convection)

Speed estimation

Speed range	Allowed range depends on the used motor. Maximum range: (-30000…+30000 rpm)/(number of motor pole pairs).
Accuracy	The speed estimation error is ± motor slip. With synchronous motors, there can be small estimation ripples at the zero speed region (below 10 rpm).
Operational frequency	Drive output up to 500 Hz

Ambient conditions

	Operation installed for stationary use	**Storage** in the protective package	**Transportation** in the protective package
Altitude	0…1000 m (0…3300 ft) above sea level, no derating required 1000…2000 m (3300…6600 ft) above sea level, air outside the module derated to -15…+49 °C (+5…+120 °F) 2000…4000 m (6600…13200 ft) above sea level, air outside the module derated to -15…+40 °C (+5…+104 °F)	-	-
Air temperature	-15…+70 °C (+5…+158 °F)	-40…+70 °C (-40…+158 °F)	-40…+70 °C (-40…+158 °F)
Relative humidity	5…95%, no condensation allowed	5…95%, no condensation allowed	5…95%, no condensation allowed
Vibration	Frequency range: 2…9 Hz: Constant deflection = 7 mm 9…200 Hz: Constant acceleration = 20 m/s^2		

For the environmental limits for the drive, refer to the hardware manual of your drive.

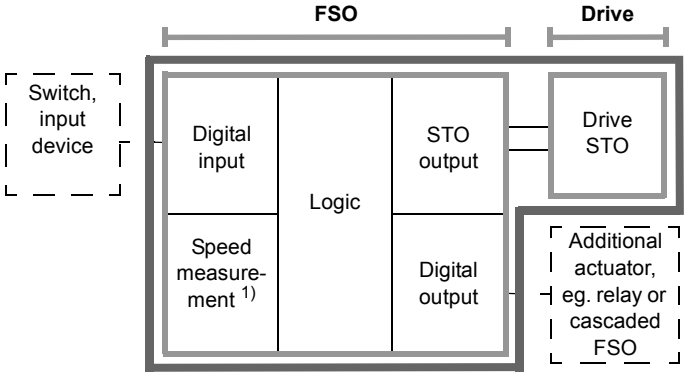
Safety functions

Stopping functions	
STO	Safe torque off
SBC	Safe brake control
SS1	Safe stop 1
SSE	Safe stop emergency
Speed-related functions	
SLS	Safely-limited speed
Variable SLS	Variable Safely-limited speed
SMS	Safe maximum speed
SSM	Safe speed monitor
SDI	Safe direction
SAR	Safe acceleration range - SAR is used only for deceleration with SS1, SSE, SDI and SLS and Variable SLS functions.
Other	
POUS	Prevention of unexpected start-up

Safety data

General

To determine the SIL/PL capability of the whole safety function where the FSO is included, the failure rates (PFD_{avg}/PFH) of all components implementing the safety function (see the figure below) must be added.



The safety data of the FSO and the drive is composed of the safety data of the subsystems used in the FSO and the safety data of the drive STO.

1) The Speed measurement subsystem of the FSO is only included in those safety functions that measure the speed of a motor. For example, the Prevention of unexpected start-up or the SSE with stop category 0 (drive coasts to a stop) do not use the speed measurement subsystem.

- **FSO module with its subsystems**. The FSO acts as the logic part in the safety function. Safety data for different subsystems is shown in section *Basic safety data* on page *433*. Safety data for some typical configurations of these subsystems is pre-calculated and shown in section *Safety data for some typical configurations* on page *435*.
- **Drive STO**. All safety functions implemented with the FSO utilize the drive STO as the actuator. For the safety data, see the drive hardware manual.
- **SLS function.** SLS always use the Speed measurement subsystem.
- **SMS function.** SMS function utilizes only FSO's subsystems Speed Measurement, Logic 2 and STO output. SMS function is not controlled by inputs, and it does not control any outputs.
- **Functions which monitor the ramp speed** (eg, Emergency stop function). These functions do not contain the Speed measurement subsystem, as the speed monitoring is implementing diagnostics, not the actual safety function.

- **Feedback.** Feedback circuit is not part of safety calculations. Thus the external feedback contacts that are connected to the digital inputs of the FSO module are not included in the calculations either.
- **Sensors, input devices and possible additional actuators**. For the safety data, see the manufacturer's documentation.

After calculating the total PFD_{avg}/PFH for the safety function, it must be verified that the PFD_{avg}/PFH of the safety function fulfills the requirement for the targeted SIL/PL.

Basic safety data

The FSO-21 module is a type B safety component as defined in IEC 61508-2.

The FSO-21 data related to safety standards IEC 61508, EN/IEC 61800-5-2, EN ISO 13849-1 and EN/IEC 62061 is listed below for the different subsystems within the FSO module.

The given safety data applies with proof test interval T1 = 20 years (high demand and continuous mode of operation) and T1 = 2 years or T1 = 5 years (low demand mode of operation). Make sure that the proof test is performed within this time (see also section *Proof tests* on page *424*).

EN 61508	
SIL	up to 3
SC	3

EN ISO 13849-1	
PL	up to e

EN/IEC 62061	
SILCL	3

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	PROFI-safe[1)]	1-ch. DI, pulses	2-ch. DI, pulses	1-ch. DI, no pulses	2-ch. DI, no pulses	Logic 1, 1-ch. DI or DO, no pulses[2)]	Logic 2, other cases[2)]
SIL/SILCL	3	3	3	2	3	1	3
PL	e	d	e	c	e	c	e
PFH (1/h)	1.0E-09	5.1E-10	1.8E-12	9.0E-09	2.3E-12	4.5E-09	4.4E-11
PFD_{avg} (T1 = 2 a)	8.8E-05	4.8E-06	2.4E-08	7.9E-05	2.8E-08	5.2E-05	4.1E-07
PFD_{avg} (T1 = 5 a)	8.8E-05	1.2-E5	4.8E-08	2.0E-04	5.8E-08	1.3E-04	9.9E-07
$MTTF_D$ (a)	114155	17844	12648	12648	12648	5048	5048
HFT	N/A	0	1	0	1	0	1
Cat.	N/A	2	3	1	3	1	3
SFF (%)	N/A	99.64	99.94	94.02	99.92	86.82	93.48
DC (%)	N/A	91.99	99.00	0.00	98.74	80.26	90.23

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[1)] We assume conservatively that PFH = λd = 1, FIT = 1e-9 1/h, $MTTF_D$ = 1/λd = 1/(1e-9 1/h) = 1e9 h = 114155 a. Based on the BGIA Report 2/2008e: Functional Safety of Machine Controls – Application of EN ISO 13849, ch. 6.2.17.

[2)] Either logic subsystem (Logic 1 or Logic 2) is included in each safety function implemented with the FSO. If the safety function contains any 1-channel digital input or output of the FSO with non-pulsed signals, the subsystem "Logic 1" must be used. Otherwise the subsystem "Logic 2" is used.

	1-ch. DO, pulses	2-ch. DO, pulses	1-ch. DO, no pulses [1]	2-ch. DO, no pulses	STO output	Speed meas.	Speed meas. with FSE-31
SIL/SILCL	3	3	1	3	3	3	3
PL	d	e	c	e	e	e	e
PFH (1/h)	3.1E-09	1.3E-11	6.2E-08	1.4E-11	1.8E-11	6.6E-09	3.8E-09
PFD_{avg} (T1 =2 a)	3.0E-05	1.7E-07	5.5E-04	1.8E-07	2.5E-07	4.9E-05	5.1E-05
PFD_{avg} (T1 =5 a)	7.1E-05	3.4E-07	1.4E-03	3.6E-07	4.8E-07	1.2E-04	1.0E-04
$MTTF_D$ (a)	1789	1789	1789	1789	1260	187	237
HFT	0	1	0	1	1	1	1
Cat.	2	3	1	3	3	4	3
SFF (%)	99.20	99.84	84.03	99.82	99.77	99.00	98.91
DC (%)	95.13	99.00	0.00	98.93	99.00	99.00	98.88

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[1] Hint: If you use a 1-channel digital output without the diagnostic pulses but you connect a status indication of the output back to an FSO module input, for example, by using an external auxiliary contact, you can use the safety data for *1-ch. DO, pulses* in the calculations instead of the data for *1-ch. DO, no pulses*. (You do not need to include the safety data of the feedback, in other words the data for the input to which the status indication is connected.)

FSE-31 pulse encoder interface module

The FSE-31 module is a type B safety component as defined in IEC 61508-2.

The FSE-31 data related to safety standards IEC 61508, EN/IEC 61800-5-2, EN ISO 13849-1 and EN/IEC 62061 is listed below. The given safety data applies with proof test interval T1 = 20 years (high demand and continuous mode of operation) and T1 = 2 years (low demand mode of operation). Make sure that the proof test is performed within this time (see also section *Proof tests* on page *424*).

SIL/ SILCL	PL	SFF [%]	PFH [1/h]	PFD_{avg} (T1 =2 a)	PFD_{avg} (T1 =5 a)	$MTTF_D$ (a)	DC [%]	SC	Cat.	HFT	CCF	Life-time [a]
3	e	>99	3.81E-09	5.12E-05	1.01E-04	237	≥90	3	3	1	80	20

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Safety data for some typical configurations

The table below shows FSO-21 safety data for some safety functions with typical combinations of the FSO module subsystems. See section *Basic safety data* on page *433* for more information on the subsystems.

Values without the FSE-31 module

Subsystems used in the safety function	PFH (1/h)	PFD_{avg} (T1 =2 a)	PFD_{avg} (T1 =5 a)	SFF (%)	HFT	SIL SILCL	$MTTF_D$ (a)	DC (%)	Cat.	PL
Prevention of unexpected start-up / Emergency stop, with a safe output (eg, releasing a mechanical brake)										
1-channel pulsed DI Logic 2 STO-output 1-channel pulsed output	3.7E-09	3.6E-05	8.4E-05	99.29	0	3	622.47	96.33	2	d
1-channel non-pulsed DI Logic 1 STO-output 1-channel non-pulsed output	7.6E-08	6.8E-04	1.7E-03	92.26	0	1	613.68	57.97	1	c
2-channel pulsed DI Logic 2 STO-output 2-channel pulsed output	7.7E-11	8.5E-07	1.9E-06	99.60	1	3	613.68	97.93	3	e
2-channel non-pulsed DI Logic 2 STO-output 2-channel non-pulsed output	7.8E-11	8.6E-07	1.9E-06	99.59	1	3	613.68	97.90	3	e
SLS, with a safe status output										
Speed measurement 1-channel pulsed DI Logic 2 STO-output 1-channel pulsed output	1.0E-08	8.5E-05	2.0E-04	99.03	0	3	143.67	98.38	2	d
Speed measurement 1-channel non-pulsed DI Logic 1 STO-output 1-channel non-pulsed output	8.2E-08	7.3E-04	1.8E-03	98.39	0	1	143.20	89.71	1	c
Speed measurement 2-channel pulsed DI Logic 2 STO-output 2-channel pulsed output	6.7E-09	5.0E-05	1.2E-04	99.05	1	3	143.20	98.75	3	e
Speed measurement 2-channel non-pulsed DI Logic 2 STO-output 2-channel non-pulsed output	6.7E-09	5.0E-05	1.2E-04	99.05	1	3	143.20	98.74	3	e

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Values with the FSE-31 module

Subsystems used in the safety function	PFH (1/h)	PFD_{avg} (T1 =2 a)	PFD_{avg} (T1 =5 a)	SFF (%)	HFT	SIL SILCL	$MTTF_D$ (a)	DC (%)	Cat.	PL
Prevention of unexpected start-up / Emergency stop, with a safe output (eg, releasing a mechanical brake)										
1-channel pulsed DI Logic 2 STO-output 1-channel pulsed output	3.7E-09	3.6E-05	8.4E-05	99.29	0	3	622.47	96.33	2	d
1-channel non-pulsed DI Logic 1 STO-output 1-channel non-pulsed output	7.6E-08	6.8E-04	1.7E-03	92.26	0	1	613.68	57.97	1	c
2-channel pulsed DI Logic 2 STO-output 2-channel pulsed output	7.7E-11	8.5E-07	1.9E-06	99.60	1	3	613.68	97.93	3	e
2-channel non-pulsed DI Logic 2 STO-output 2-channel non-pulsed output	7.8E-11	8.6E-07	1.9E-06	99.59	1	3	613.68	97.90	3	e
SLS, with a safe status output										
Speed measurement 1-channel pulsed DI Logic 2 STO-output 1-channel pulsed output	7.5E-09	8.7-05	1.9E-04	99.03	0	3	171.77	98.18	2	d
Speed measurement 1-channel non-pulsed DI Logic 1 STO-output 1-channel non-pulsed output	8.0E-08	7.3E-04	1.8E-03	98.39	0	1	171.10	87.81	1	c
Speed measurement 2-channel pulsed DI Logic 2 STO-output 2-channel pulsed output	3.9E-09	5.2E-05	1.0E-04	99.05	1	3	171.10	98.62	3	e
Speed measurement 2-channel non-pulsed DI Logic 2 STO-output 2-channel non-pulsed output	3.9E-09	5.2E-05	1.0E-04	99.05	1	3	171.10	98.61	3	e

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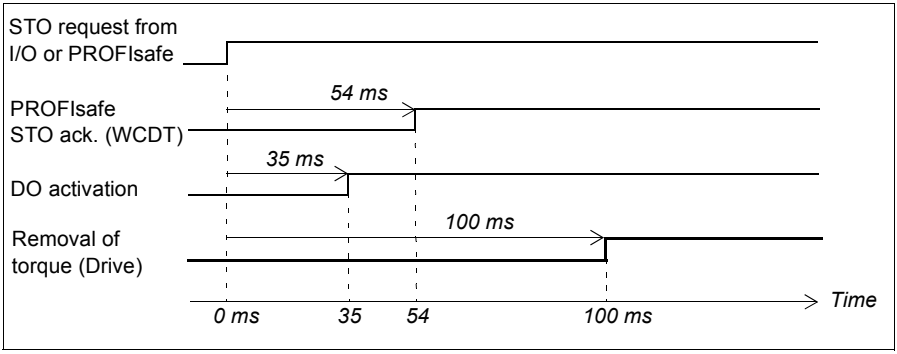
Life time

FSO-21 life time	20 years

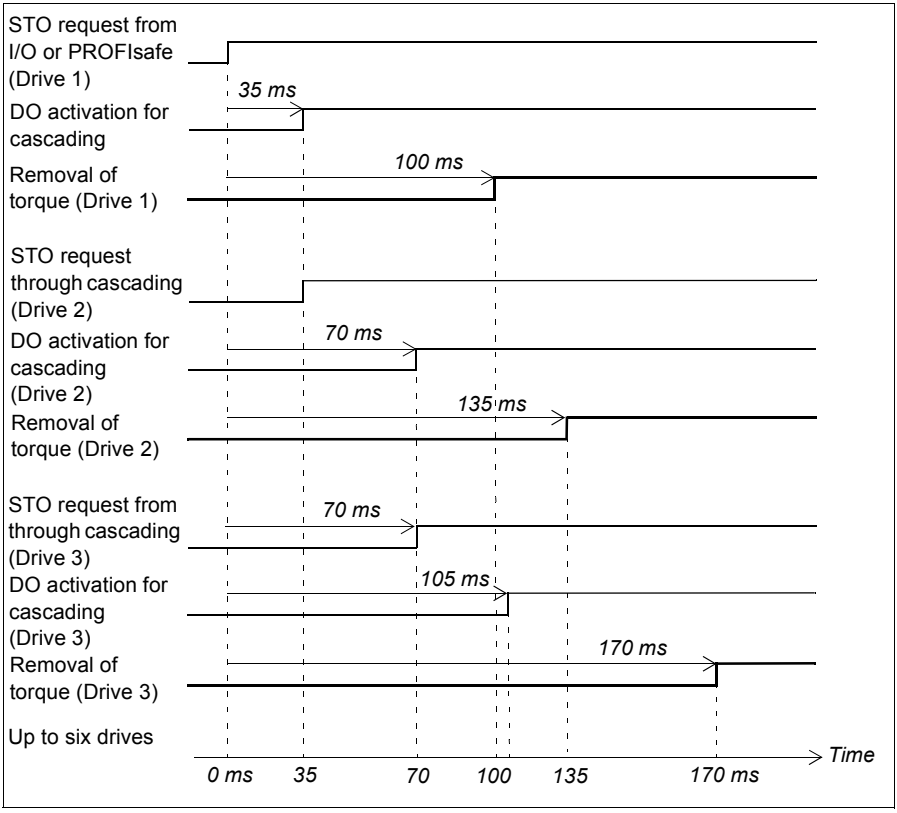
Response times

Safety function response time	Maximum response time of the FENA, FSO and drive combination is 100 ms. **Note:** Delays that depend on parameter settings can change the response time.
FSO-21 response time • from an FSO input to an FSO digital output activation	Maximum 35 ms
Cascade response time • from FSO's STO activation to the cascade output activation • from the cascade input to the cascade output activation	Maximum 35 ms Maximum 35 ms If the STO is cascaded, safety function response time for the cascaded units is (n-1) x 35 ms + 100 ms, where n is the number of cascaded FSO modules.
PROFIsafe • Worst case delay time (WCDT) • Device acknowledgement time (DAT)	54 ms (FSO and FENA combination) 54 ms

Example 1



Example 2


STO request from I/O or PROFIsafe (Drive 1)
35 ms
DO activation for cascading
100 ms
Removal of torque (Drive 1)
STO request through cascading (Drive 2)
70 ms
DO activation for cascading (Drive 2)
135 ms
Removal of torque (Drive 2)
STO request from through cascading (Drive 3)
70 ms
105 ms
DO activation for cascading (Drive 3)
170 ms
Removal of torque (Drive 3)
Up to six drives
Time
0 ms
35
70
100
135
170 ms

Related standards and directives

Referenced standards are listed in the table below.

Standard	Name
EN 60204-1:2006 + AC:2010 IEC 60204-1:2016	*Safety of machinery – Electrical equipment of machines – Part 1: General requirements*
IEC 61508 Parts 1-3, Ed. 2.0:2010	*Functional safety of electrical/electronic/programmable electronic safety-related systems*
IEC 61800-5-2:2016 EN 61800-5-2:2007	*Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*
IEC 62061:2015 Ed. 1.2 EN 62061:2005 +AC:2010+A1:2013+ A2:2015	*Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
EN ISO 12100:2010	*Safety of machinery – General principles for design – Risk assessment and risk reduction*
EN ISO 13849-1:2015	*Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*.
EN ISO 13849-2:2012	*Safety of machinery – Safety-related parts of control systems – Part 2: Validation*
IEC 61800-3:2004	*Adjustable Speed Electrical Power Drive Systems - Part 3: EMC requirements and specific test methods*
IEC 61326-3-2:2008	*Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - Industrial applications with specified electromagnetic environment*
IEC 60533:2015	*Electrical and electronic installations in ships - Electromagnetic compatibility (EMC) - Ships with a metallic hull*
2006/42/EC	*European Machinery Directive*
	PROFIsafe System Description – Safety Technology and Application. Version November 2010. Order Number 4.342.
	PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO, V2.4
Other	Sector-specific C-type standards

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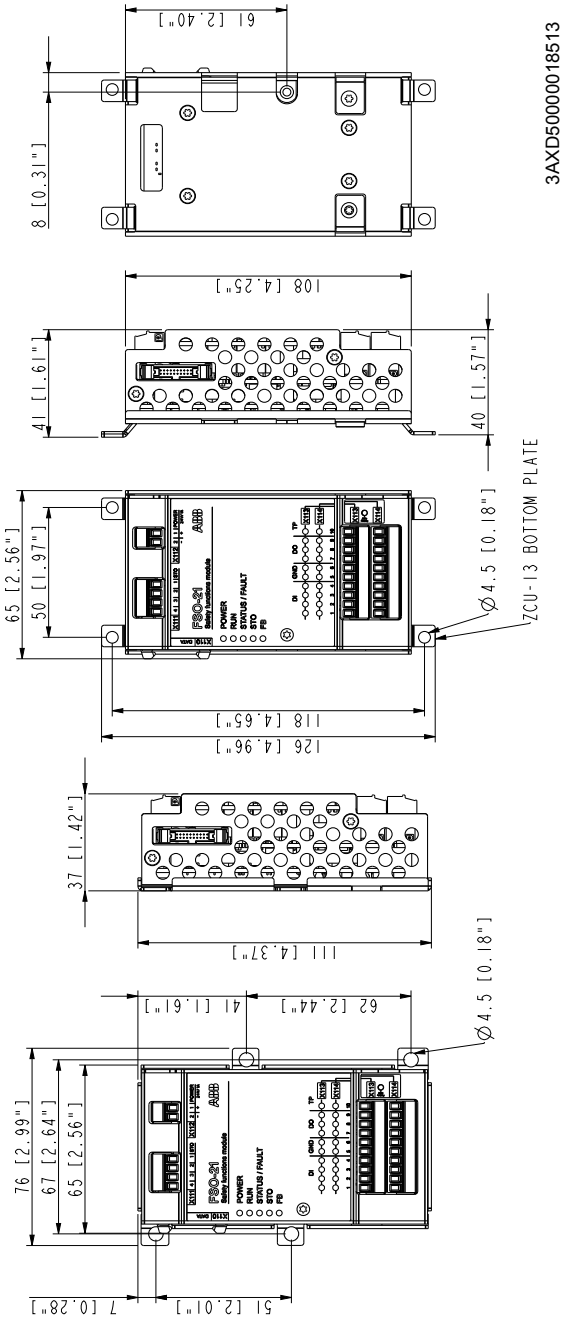
Dimension drawings

The dimension drawings of the FSO-21 module with two different bottom plates for different drive control unit types are shown below. The dimensions are given in millimeters and [inches].


3AXD50000018513
61 [2.40"]
8 [0.31"]
108 [4.25"]
41 [1.61"]
40 [1.57"]
65 [2.56"]
50 [1.97"]
118 [4.65"]
126 [4.96"]
Ø4.5 [0.18"]
ZCU-13 BOTTOM PLATE
37 [1.42"]
111 [4.37"]
Ø4.5 [0.18"]
62 [2.44"]
41 [1.61"]
76 [2.99"]
67 [2.64"]
65 [2.56"]
51 [2.01"]
7 [0.28"]
FSO-21
Safety functions module
POWER
RUN
STATUS / FAULT
STO
FB
ABB

Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/searchchannels.

Product training

For information on ABB product training, navigate to new.abb.com/service/training.

Providing feedback on ABB Drives manuals

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