OPTIONS FOR ABB DRIVES

Safely-limited speed with the encoder interface (option +Q965) for ACS880-07, -07LC, -17, -17LC, -37, and -37LC drives

User's manual

Safely-limited speed with the encoder interface (option +Q965) for ACS880-07, -07LC, -17, -17LC, -37, and -37LC drives

User's manual

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1

Safety instructions

Contents of this chapter

This chapter contains the safety instructions which you must obey when you install, operate and do maintenance on the safety functions of a drive.

Safety messages

These safety messages help to prevent personal injury and damage to the equipment. The hazard levels comply with standard ANSI Z535.6.

The manual uses these warning symbols:

⚠DANGER Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠WARNING Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE Is used to address practices not related to physical injury, but which can result in equipment damage.

Instructions for functional safety circuits

This manual does not contain the complete safety instructions of the drive. It only includes the instructions related to the scope of this manual.

⚠WARNING Obey these instructions and the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

- Only a qualified electrical professional who has sufficient knowledge about functional, machine, and process safety is permitted to install, start up and maintain the safety circuit. All user-made changes are on the user's responsibility.
- The safety function described in this manual does isolate the main or auxiliary circuits from the power supply. Before you do work on the drive, or its main or auxiliary circuits, do the steps in section Electrical safety precautions (page 11).
- (With permanent magnet or synchronous reluctance [SynRM] motors only)
  In case of a multiple IGBT power semiconductor failure, the drive system can produce an alignment torque which maximally rotates the motor shaft by $180/p$ (with permanent magnet motors) or $180/2p$ (with synchronous reluctance [SynRM] motors) degrees regardless of the activation of the Safe torque off function. p denotes the number of pole pairs.
- Do the validation test of the safety function at the start-up and also after you make changes to the safety circuit.
- Make sure that the functional safety of the machine is maintained in situations where the safety option does not provide protection, for example, during commissioning, system maintenance, fault tracing, or decommissioning.

Electrical safety precautions

These electrical safety precautions are for all persons who do work on the drive, motor cable or motor.

⚠WARNING Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do electrical installation or maintenance work. Do these steps before you do installation or maintenance work.

1. Prepare for the work.
   - Make sure that you have a work order.
   - Do an on-site risk assessment or job hazard analysis.
   - Make sure that you have the correct tools available.
   - Make sure that the workers are qualified.
   - Select the correct personal protective equipment (PPE).
   - Stop the drive and motor(s).
2. Clearly identify the work location and equipment.
3. Disconnect all possible voltage sources. Make sure that connection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - Open the charging switch if it is present.
   - Open the disconnector of the supply transformer. (The main disconnecting device in the drive cabinet does not disconnect the voltage from the AC input power busbars of the drive cabinet.)
   - Open the auxiliary voltage switch-disconnector (if it is present), and all other possible disconnecting devices that isolate the drive from dangerous voltage sources.
   - In the liquid cooling unit (if present), open the switch-disconnector of the cooling pumps.
   - If there is a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Open the main isolating device of the drive.
   - Disconnect all dangerous external voltages from the control circuits.
   - After you disconnect power from the drive, wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
4. Protect other energized parts in the work location against contact and take special precautions when close to bare conductors.
5. Measure that the installation is de-energized. Use a high-quality voltage tester. If the measurement requires that you remove shrouding or other cabinet structures, obey the local laws and regulations applicable to live electrical work. This includes, but is not limited to, electric shock and arc protection.
   - Before and after you measure the installation, verify the operation of the voltage tester on a known voltage source.
   - Make sure that the voltage between the input power terminals of the drive (L1, L2, L3) and the grounding (PE) busbar is zero.
   - Make sure that the voltage between the output power terminals of the drive (U, V, W) and the grounding (PE) busbar is zero.

     Important! Repeat the measurement with the DC voltage setting of the voltage tester. Measure between each phase and ground. There is a risk of dangerous DC voltage charging due to leakage capacitances of the motor circuit. This

voltage can remain charged for a long time after the drive power-off. The measurement discharges the voltage.

- Make sure that the voltage between the drive DC busbars and the grounding (PE) busbar is zero.

⚠WARNING The busbars inside the cabinet of liquid-cooled drives are partially coated. Measurements made through the coating are potentially unreliable, so only measure at uncoated portions. Note that the coating does not constitute a safe or touch-proof insulation.

6. Install temporary grounding as required by the local regulations.
7. Ask for a permit to work from the person that is responsible for the electrical installation work.

2

Introduction to the manual

Contents of this chapter

This chapter describes the manual in short and gives some general information for the reader. This chapter also contains a quick reference guide for implementing a safety system.

Applicability

This manual is applicable to ACS880-07/07LC/17/17LC/37/37LC drives which have the option +Q965: Safely-limited speed (SLS) with encoder, with FSO-21 and FSE-31.

Required versions when using the FSO-21 module with option +Q965:

- Drives with a UCU-22, -23, or -24 control unit: UCON-22 control board, revision K or later[1)]
- ACS880 primary control program (AINLX) version 2.2 or later, or
  ACS880 primary control program (YINLX) version 1.30 or later
- FSO-21 safety functions module: revision D or later
- FSE-31 pulse encoder interface module: revision D or later
- Drive Composer pro: 1.8 or later.

1) The control board revision is shown on a sticker on the control unit.

The FSO-21 module safety functionality described in this manual is valid for revision H. For earlier FSO module revisions, not all functionality related to the SLS function is supported.

This manual shows the default design of the safety circuit ordered with option code +Q965. The actual design can be different from the default design because of customer-defined modifications. Always refer to the documentation delivered with the drive.

Target audience

This manual is intended for people who install, commission, use and service the safety function. Read the manual before working on the unit. You are expected to know the fundamentals of electricity, wiring, electrical components, electrical schematic symbols, and functional safety.

Exclusion of liability

ABB is not responsible for the implementation, verification and validation of the overall safety system. It is the responsibility of the system integrator (or other party) who is responsible for the overall system and system safety.

The system integrator (or other responsible party) must make sure that the entire implementation complies with the instructions in this manual, all relevant standards, directives and local electrical code, and that the system is tested, verified and validated correctly.

Quick reference guide for taking a safety function into use

Task	☑
Connect the customer-defined wiring (if any). Refer to the wiring instructions in this manual and the circuit diagrams delivered with the drive.	☐
Check and/or set the safety function related parameters (as listed in this manual).	☐
Do the validation test to make sure that the implemented system meets the safety requirements. You can find the instructions for the validation test in this manual and in the FSO module user's manual.	☐
Document the validation test procedure. You can find the guidelines for the validation test report in this manual and in the FSO module user's manual.	☐

Related manuals

Manual	**Code**
Drive hardware	
ACS880-07 drives (560 to 2800 kW) hardware manual	3AUA0000143261
ACS880-07 drives (45 to 710 kW, 50 to 700 hp) hardware manual	3AUA0000105718
ACS880-07LC drives hardware manual	3AXD50000569786
ACS880-17 drives (160 to 3200 kW) hardware manual	3AXD50000020436
ACS880-17 drives (45 to 400 kW) hardware manual	3AXD50000035158
ACS880-17LC drives hardware manual	3AXD50000250295
ACS880-37 drives (160 to 3200 kW) hardware manual	3AXD50000020437
ACS880-37 drives (45 to 400 kW) hardware manual	3AXD50000035159
ACS880-37LC drives hardware manual	3AXD50000251407
Drive firmware	
ACS880 primary control program firmware manual (AINLX)	3AUA0000085967
ACS880 primary control program firmware manual (YINLX)	3AXD50001000998
ACS880 diode supply control program firmware manual	3AUA0000103295

Manual	Code
ACS880 diode supply control program (YDILX) firmware manual	3AXD50001096489
ACS880 IGBT supply control program firmware manual	3AUA0000131562
ACS880 IGBT supply control program (YISLX and YLHLX) firmware manual	3AXD50001019464
PC tools	
Drive Composer start-up and maintenance PC tool user's manual	3AUA0000094606
Functional safety design tool user's manual	3AXD10000102417
Safety	
Functional safety; Technical guide No. 10	3AUA0000048753
ABB Safety information and solutions	www.abb.com/safety
Options	
ACS-AP-I, -S, -W and ACH-AP-H, -W 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
Other documents	
Circuit diagrams	Delivered with the drive
Part lists	Delivered with the drive
Safety data report (if ordered with option code +P947)	

You can find manuals on the Internet. See below for the relevant code/link. For more documentation, go to www.abb.com/drives/documents.

ACS880-07 (45 to 710 kW) manuals

ACS880-07 (560 to 2800 kW) manuals

ACS880-07LC manuals

ACS880-17 (45 to 400 kW) manuals

ACS880-17 (160 to 3200 kW) manuals

ACS880-17LC manuals

ACS880-37 (45 to 400 kW) manuals

ACS880-37 (160 to 3200 kW) manuals

ACS880-37LC manuals

Terms and abbreviations

Term	Description
Cat.	Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. The categories are: B, 1, 2, 3 and 4. (EN ISO 13849-1)
CCF	Common cause failure (EN ISO 13849-1)
DC	Diagnostic coverage (EN ISO 13849-1)
Frame, frame size	Physical size of the drive or power module
FSE-31	Optional pulse encoder interface module for safety encoder
FSO-21	Safety functions module which supports the FSE-31 module and the use of safety encoders
HFT	Hardware fault tolerance (IEC 61508)
IGBT	Insulated gate bipolar transistor
PFD_{avg}	Average probability of dangerous failure on demand (IEC 61508)
PFH	Average frequency of dangerous failures per hour (IEC 61508)
PL	Performance level. Levels a...e correspond to SIL (EN ISO 13849-1)
PLC	Programmable logic controller
POUS	Prevention of unexpected start-up
Safety function response time	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.
SAR	Safe acceleration range
SBC	Safe brake control
SC	Systematic capability (IEC 61508)
SIL	Safety integrity level (1…3) (IEC 61508, IEC 62061, IEC 61800-5-2)
SLS	Safely-limited speed
SLS monitoring limit	The speed limit at which SLS monitoring is started, located in the middle of SLS trip limit and SLS limit.
SMS	Safe maximum speed
SS1	Safe stop 1 (IEC/EN 61800-5-2)
SSE	Safe stop emergency
SSM	Safe speed monitor
STO	Safe torque off (IEC/EN 61800-5-2)
T_1	Proof test interval. Defines the probabilistic failure rate (PFH or PFD_{avg}) for the safety function or subsystem. Performing a proof test at a maximum interval of T_1 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 T_1 values given cannot be regarded as a guarantee or warranty.
T_M	Mission time: the period of time covering the intended use of the safety function/device. After the mission time elapses, the safety device must be replaced. Note that any T_M values given cannot be regarded as a guarantee or warranty. (EN ISO 13849-1)
TP	Test pulse
Zero speed	For safety functions, the zero speed limit indicates the completion of the safe stopping function.

3

Option description

Contents of this chapter

This chapter describes the operation of the option +Q965, Safely-limited speed with the encoder interface, and its settings.

Overview

Option +Q965 uses the FSO-21 safety functions module (option +Q972) and the FSE-31 pulse encoder interface module (option +L521). ABB installs the FSO-21 and FSE-31 modules to the drive and sets the delivery configuration for the option at the factory.

With option +Q965, these safety functions are configured in the FSO module at the factory:

- Safely-limited speed (SLS). This function prevents the motor speed from exceeding the user-defined speed limits.
- Safe maximum speed (SMS). This function prevents the machine from exceeding the user-defined maximum speed of the machine or process.
- Safe speed monitor (SSM). This function provides a safe output signal to indicate when the motor speed is between user-defined limits.

The user defines the operation of the safety functions with the FSO module parameters at the start-up, for example, by setting the speed limits.

Note: If the Safe brake control (SBC) function is used, it is also activated according to the configuration (either before or after the drive STO function is activated, or at a specified speed limit). In this case, make sure that you have dimensioned the brake correctly for these situations. For more information, refer to the FSO module user's manual.

To maintain the SIL/PL capability, the motor must be equipped with a safety encoder.

Note: A safety function request to the FSO module must be active for a minimum of 20 ms.

Note: Motor thermal protection options (options +L513/+L514+Q971, +L536, or +L537+Q971) use the same digital input as the default design of option +Q965. If you have both options in the same drive, option +Q965 will use an alternative digital input. Refer to the delivery-specific circuit diagrams.

For more information on the FSO module, refer to the applicable FSO module user's manual.

The SLS and SSM functions comply with IEC/EN 61800-5-2. The SMS function is a special implementation of the SLS function. For a complete list of related standards and European directives, refer to section Related standards and directives (page 69).

Summary of wirings and settings

General information:

- The drive has a FSO-21 safety functions module (option +Q972). ABB installs the module at the factory.
- The drive has a FSE-31 pulse encoder interface module (option +L521). ABB installs the module at the factory.
- The motor must have a safety encoder. The customer installs the safety encoder and connects it to the FSE-31 module. The customer must make sure that the required safety integrity (SIL/PL) can be achieved with the used safety encoder.

The wirings and settings of the SLS function are:

- The customer connects the SLS activation signal (for example, a switch) to the FSO module.
- The customer connects the SLS indication signal (for example, an indication lamp or a gate opening signal) to the FSO module.
- The digital input of the FSO module to which the SLS activation signal is connected, is selected as the input for the SLS request. ABB sets the safety IO settings for SLS input and output at the factory to agree with the circuit diagrams.
- The digital output of the FSO module to which the SLS indication signal is connected, is selected as the SLS output. ABB sets the safety IO settings for SLS input and output at the factory to agree with the circuit diagrams.
- The speed limits must be set according to the application requirements.
- The SLS function is set to use either the time monitoring or ramp monitoring method to monitor the deceleration of the motor to the SLS speed limit.
- The deceleration time and limits for the deceleration ramp activated by the SLS function are set according to the application requirements.

The settings of the SMS function are:

- There are two different versions of the SMS function. Version 1 monitors the motor speed and trips the drive if the user-defined trip limit is exceeded. Version 2 of the SMS function is similar to the SLS function except that it can only be configured

to be continuously on or off. ABB activates the SMS function (Version 1) at the factory.

- The SMS positive and negative speed limits are FSO module parameters that the user must set at the start-up.

The wirings and settings of the SSM function are:

- ABB configures the SSM function at the factory to be permanently active. The user can change this setting with FSO module parameters.
- The customer connects the SSM indication signal (for example, an indication lamp) to the FSO module.
- ABB sets the safety IO settings for the SSM output at the factory to agree with the circuit diagrams.
- The SSM positive and negative speed limits are FSO module parameters that the user must set at the start-up.

Operation principle

SLS function

The Safely-limited speed (SLS) function limits the motor speed so that it does not exceed the user-defined speed limits when the function is active. The user defines the SLS limits and trip limits. When the user activates the SLS function, the FSO module sends a SLS request to the drive. The drive takes the SLS parameters into use and controlscontrol the motor speed accordingly until the user deactivates the SLS request.

If the motor speed is above the user-defined SLS trip limit when the SLS function is activated, the drive first decelerates the motor speed to the SLS limit. The FSO module monitors the deceleration to the required speed with the time or ramp monitoring method.

Note: It is a good practice to define the motor speed reference so that it stays between the SLS limits in the operating situations when the SLS function is active.

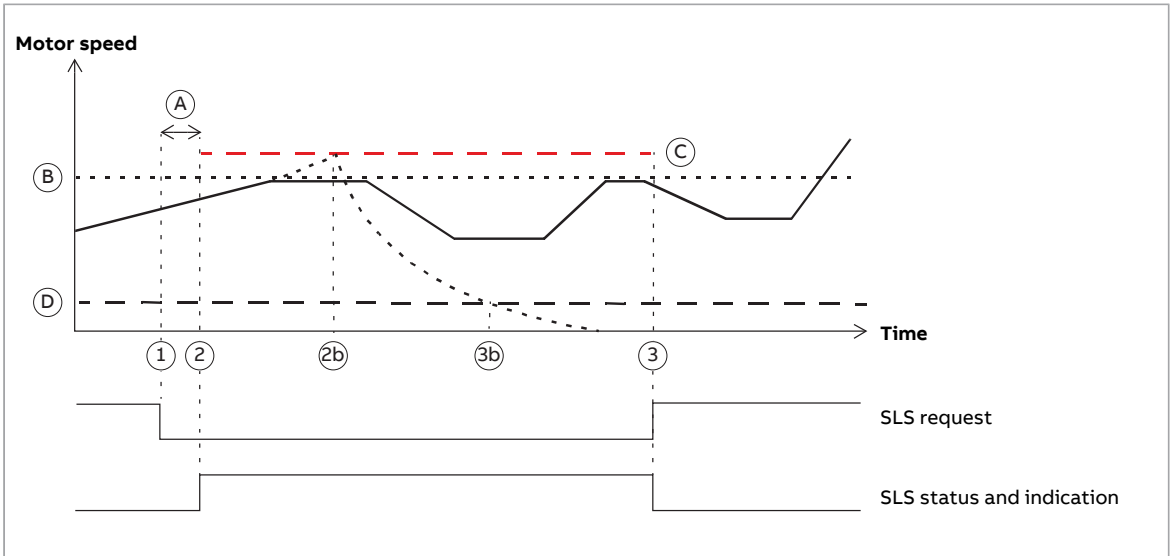
If the motor speed reaches the user-defined SLS trip limit, the FSO module activates the Safe stop emergency (SSE) function. Depending on parameter settings, the SSE function activates the drive Safe torque off (STO) immediately, or after a deceleration ramp. The motor coasts to a stop, or decelerates to zero speed.

There are four separate SLS functions in the FSO module with different parameter settings. In the examples below, and in the delivered default settings of the +Q965 option, the SLS1 function is used.

For more information, refer to chapter Parameter settings and the FSO module user's manual.

SLS with speed below the monitored speed

This time scheme diagram illustrates the operation of the SLS function. The motor speed is below the monitored speed when the user activates the SLS function.



A	Safety function response time
B	SLS1 limit positive (parameter 200.23)
C	SLS1 trip limit positive (parameter SLSx.14)
D	Zero speed with encoder (parameter FSOGEN.52). Relevant only if 2b occurs.

1. The user or a PLC de-energizes the applicable digital inputs of the FSO module. This activates the SLS request.
2. After the safety function response time (A), the FSO module starts to monitor the motor speed. The FSO module energizes the digital output that indicates the SLS status.
   While the monitoring is active, the drive limits the motor speed so that it stays at or below the SLS1 limit positive. The FSO module monitors the actual motor speed.
   (2b) If the motor speed goes above the SLS1 trip limit positive (C), the FSO module activates the SSE function and the motor coasts to a stop (in this case, the SSE function is configured as Immediate STO, refer to section Parameters for the SSE function (page 40)).

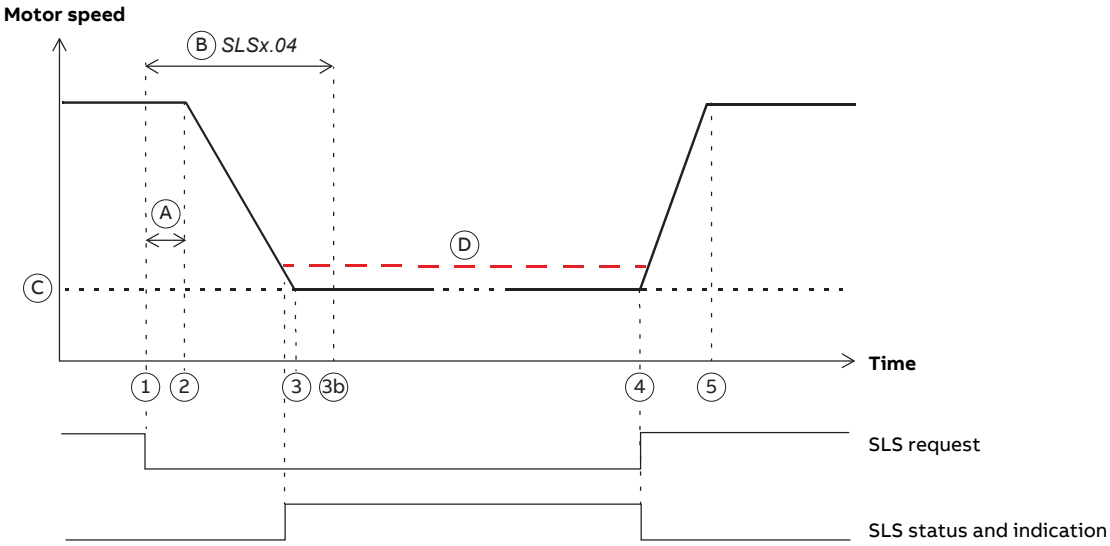
   Note: In this case, the FSO activates the SLS indication when the motor speed goes below the SLS1 limit positive (B).

   Note: In option +Q978, the SBC function is used to control the main contactor/breaker. If the drive has this option and a trip limit hit occurs, STO activation causes the main contactor/breaker to open.
3. The user or a PLC energizes the applicable digital inputs of the FSO module. This deactivates the SLS request. The FSO module acknowledges the SLS1 function automatically. This is set by an FSO parameter (SLSx.02), and no external acknowledgement input is used. The FSO module stops SLS monitoring and de-energizes the SLS indication signal.
   (3b) The motor speed goes below the zero speed limit (D). If the FSO module activated the SSE function at 2b, the STO acknowledgement is now permitted.

The user must reset the drive if the STO indication parameter (FSOGEN.62 or 31.22) is set so that a fault is generated.

SLS with speed above the monitored speed - time monitoring

This time scheme diagram illustrates the operation of the SLS function with time monitoring. The motor speed is above the monitored speed when the SLS function is activated.



A	Safety function response time
B	SLS time delay (parameter SLSx.04): When time B has elapsed from the start of the counter (step 1 below), the FSO module starts SLS monitoring (if not already started).
C	SLS1 limit positive (parameter 200.23)
D	SLS1 trip limit positive (parameter SLSx.14)

1. The user or a PLC de-energizes the applicable digital inputs of the FSO module. This activates the SLS request. The FSO module starts a counter for time (B).
2. After the safety function response time (A), the drive starts to decelerate the motor according to the user-defined deceleration ramp. The FSO module starts SLS monitoring and energizes the digital output that indicates the SLS status when the motor speed is in the middle of the SLS1 trip limit and the SLS1 limit.
3. The actual motor speed reaches the SLS1 limit positive. The drive limits the motor speed reference so that the motor speed stays at or below the SLS1 limit positive. The FSO module monitors the actual motor speed. If the motor speed goes above the SLS1 trip limit positive (D), the FSO module activates the SSE function (refer to section SLS with speed below the monitored speed (page 20)).
   (3b) Time (B) has elapsed. The FSO module starts SLS monitoring (if not already started).

   Note: If the motor speed is not below the SLS monitoring limit after time B has elapsed, the FSO module activates the SSE function. Depending on SSE function parameter settings, the motor either coasts to a stop (“Immediate STO”) or ramps down to zero speed (“Emergency ramp”). For more information, refer to section Parameters for the SSE function (page 40) and the FSO module user’s manual.

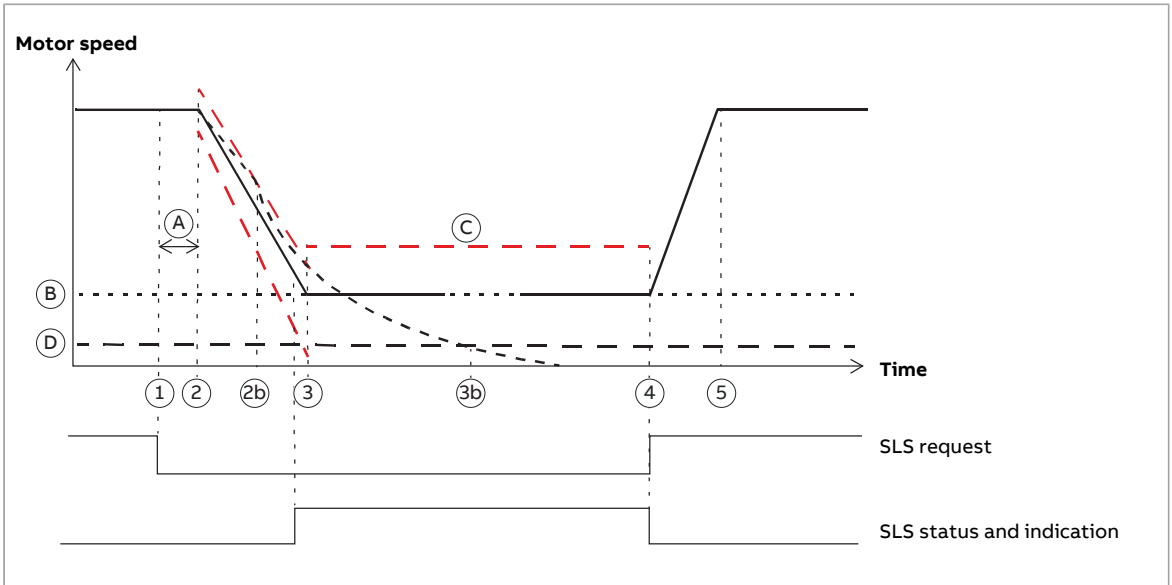
Note: In this case, the FSO activates the SLS indication when the motor speed goes below the SLS limit positive (C).

Note: In option +Q978, the SBC function is used to control the main contactor/breaker. If the drive has this option and a trip limit hit occurs, STO activation causes the main contactor/breaker to open.

4. The user or a PLC energizes the applicable digital inputs of the FSO module. This deactivates the SLS request.
   The FSO module acknowledges the SLS function automatically. This is set to be automatic by an FSO parameter (SLSx.02), and no external acknowledgement input is used. The FSO module stops SLS monitoring and de-energizes the digital output that indicates the SLS status. The drive returns to normal operation and starts to follow its ordinary speed reference. The drive accelerates the motor to the desired speed along its acceleration ramp (drive parameter).
5. Normal operation continues.

SLS with speed above the monitored speed - ramp monitoring

This time scheme diagram illustrates the operation of the SLS function with ramp monitoring. The motor speed is above the monitored speed when the SLS function is activated.



A	Safety function response time
B	SLS1 limit positive (parameter 200.23)
C	SLS1 trip limit positive (parameter SLSx.14)
D	Zero speed with encoder (parameter FSOGEN.52). Relevant only if (2b) occurs.

1. The user or a PLC de-energizes the applicable digital inputs of the FSO module. This activates the SLS request.
2. After the safety function response time (A), the drive starts to decelerate the motor speed. The ramp is defined and monitored using the SAR1 parameters of the FSO module. The FSO module monitors the actual deceleration rate of the motor against the ramp monitoring settings. The FSO module starts SLS

monitoring and energizes the digital output that indicates the SLS status when the motor speed is in the middle of the SLS1 trip limit and the SLS1 limit.
(2b) If the motor speed does not follow the ramp monitoring limits, the FSO module activates the STO function. The motor coasts to a stop.

Note: In option +Q978, the SBC function is used to control the main contactor/breaker. If the drive has this option and a trip limit hit occurs, STO activation causes the main contactor/breaker to open.

Note: In this case, the FSO activates the SLS indication when the motor speed goes below the SLS1 limit positive (B).

3. The actual motor speed reaches the SLS1 limit positive. The drive limits the motor speed reference so that the motor speed stays below the SLS1 limit positive. The FSO module monitors the actual motor speed. If the motor speed goes above the SLS1 trip limit positive (C), the FSO module activates the SSE function (refer to section SLS with speed below the monitored speed (page 20)).
(3b) The motor speed goes below the zero speed limit (D). If the motor speed did not follow the ramp at 2b, the STO acknowledgement is now permitted. The user must reset the drive if the STO indication parameter (FSOGEN.62 or 31.22) is set so that a fault is generated.
4. The user or a PLC energizes the applicable digital inputs of the FSO module. This deactivates the SLS request. The FSO module acknowledges the SLS function automatically. This is set to be automatic by an FSO parameter (SLSx.02), and no external acknowledgement input is used. The FSO module stops SLS monitoring and de-energizes the digital output that indicates the SLS status. Thedrive returns to normal operation and starts to follow its ordinary speed reference. The drive accelerates the motor to the desired speed along its acceleration ramp (drive parameter).
5. Normal operation continues.

SLS reaction when modulation is lost during deceleration ramp

This section describes the functionality of the FSO module when drive modulation is lost during the SLS deceleration ramp and safe speed estimate is used. Safe speed estimate is used only when there is an encoder failure and parameter S_ENCGEN.11 is set to Est switch not active load. For functionality with encoder feedback, refer to section Drive modulation loss when encoder feedback is used (page 31).

If the SLS function is activated when motor speed is above the SLS trip limit, FSO causes the drive to decelerate to the SLS limit. The user can select how the FSO reacts if the drive stops modulating during this deceleration ramp. The table that follows gives the possible values of parameter SLSx.05.

Value of parameter SLSx.05 SLS ramp modoff reaction	**FSO reaction if drive modulation is lost during SLS deceleration ramp**
Modoff delay time	STO is activated after the delay defined by parameter SLSx.06. If modulation returns before SLSx.06 delay has elapsed, monitoring and deceleration towards SLS monitoring limit starts again. See Example 1: Modoff delay time – modulation returns before modoff delay (page 24).
Monitoring active	SLS ramp or time monitoring remains on. The monitoring limit hits are generated based on the last valid speed estimate. See Example 2: SAR1 ramp monitoring active (page 26) and Example 4: Time monitoring active (page 28).

Value of parameter SLSx.05 SLS ramp modoff reaction	FSO reaction if drive modulation is lost during SLS deceleration ramp
Monitoring active and modoff delay time	Modoff delay time and Monitoring active are used: FSO generates the monitoring limit hit based on which condition is met first and activates the STO. See Example 3: SAR1 ramp monitoring and SLS modoff delay time active (page 27).
Monitoring and modoff delay time disabled	Monitoring is stopped and SLS indication is given after STO.14 delay. If modulation returns during deceleration ramp, monitoring and deceleration towards SLS monitoring limit start again. **Note:** No tripping fault is given due to loss of drive modulation. See Example 5: Monitoring and modoff delay time disabled (page 29).

Value of parameter SLSx.05 SLS ramp modoff reaction	When modulation is lost	When modulation comes back
Modoff delay time	Ramp monitoring (SAR1) is disabled, Time monitoring is suspended. [1)]	Ramp monitoring (SAR1) is restarted, Time monitoring is continued. [1)]
Monitoring active	Last valid speed frozen and used.	New speed taken into use.
Monitoring active and modoff delay time	Last valid speed frozen and used.	New speed taken into use.
Monitoring and modoff delay time disabled	Ramp monitoring (SAR1) is disabled, Time monitoring is suspended. [1)]	Ramp monitoring (SAR1) is restarted, Time monitoring is continued. [1)]

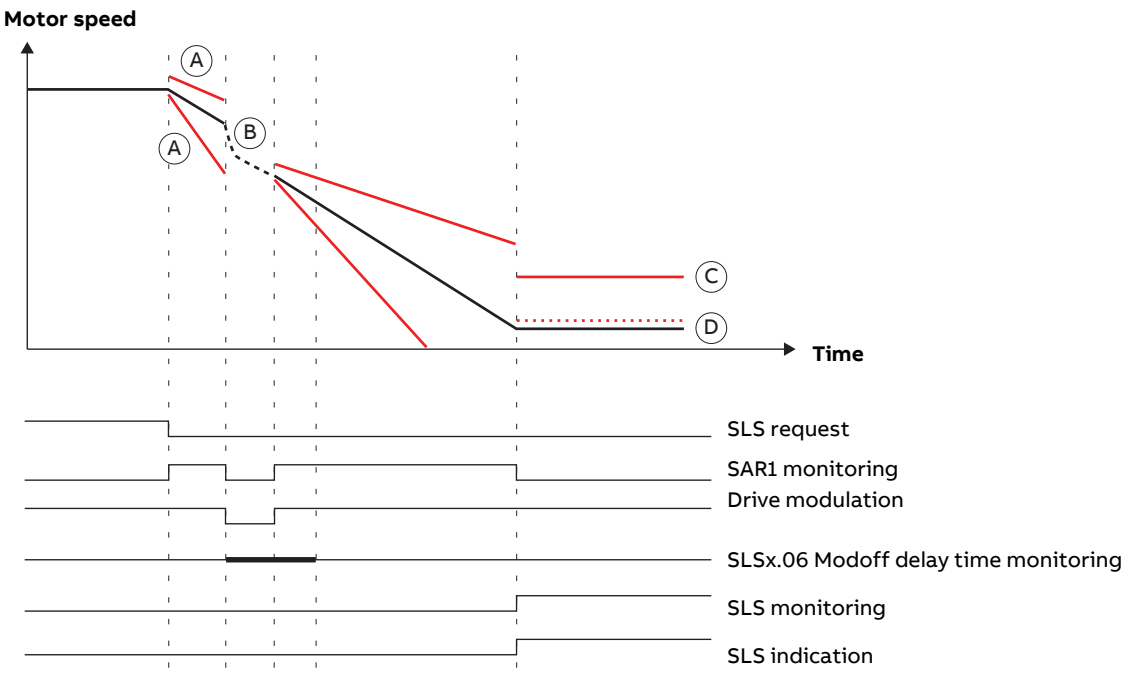
1) Time monitoring: The time monitoring counter does not increase when the drive is not modulating. If modulation does not return, SLS indicates safe state after coast time (defined by parameter STO.14) has elapsed. If modulation returns within the specified time:
- with the motor speed below the SLS trip limit at that time, SLS monitoring starts and the SLS output indicates a safe state
- with the motor speed above the SLS trip limit at that time, the drive trips because of a SLS trip limit hit.

Note: When encoder feedback is used, parameters SLSx.05 and SLSx.06 have no effect.

Example 1: Modoff delay time – modulation returns before modoff delay

In this example, parameter SLSx.05 is set to Modoff delay time. The time diagram below describes the operation of the SLS function when modulation is lost during the

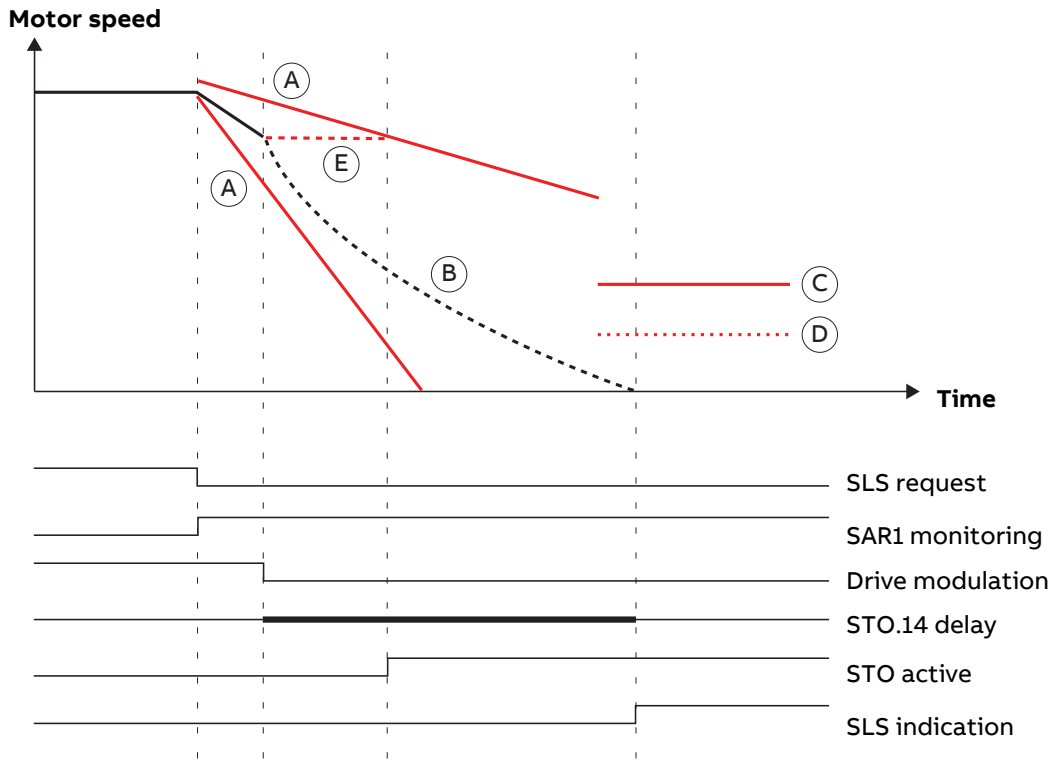
deceleration ramp, and the modulation returns before the modoff delay time has run out.



A	SAR1 ramp monitoring
B	Actual motor speed (coasting after modoff)
C	SLS trip limit
D	SLS limit

Example 2: SAR1 ramp monitoring active

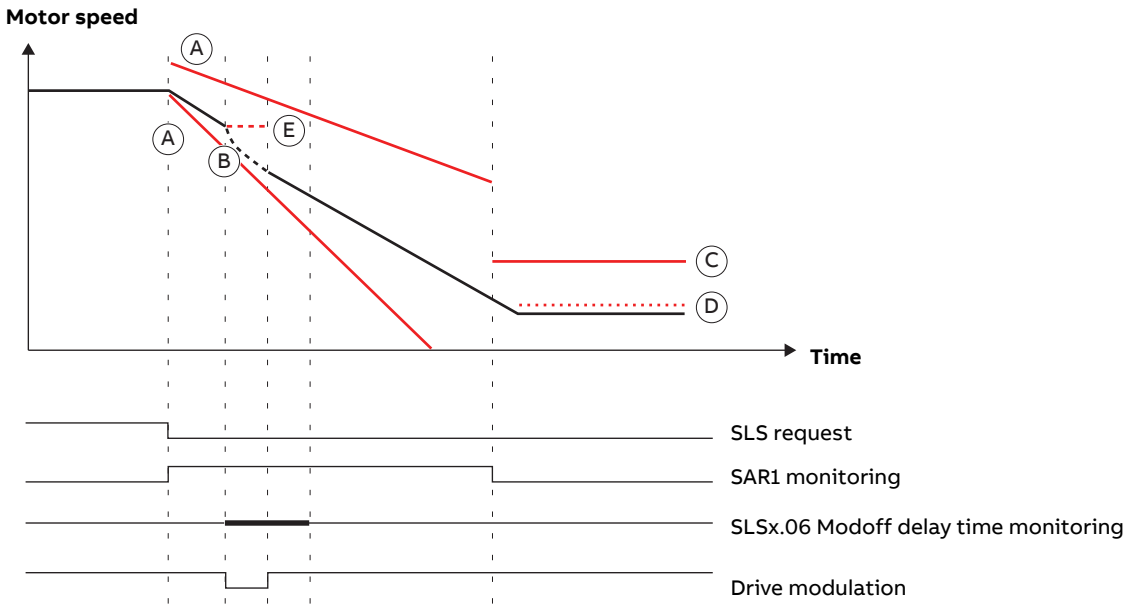
In this example, parameter SLSx.05 is set to Monitoring active. The time diagram below describes the operation of the SLS function when modulation is lost during the deceleration ramp.



A	SAR1 ramp monitoring
B	Actual motor speed (coasting after modoff)
C	SLS trip limit
D	SLS limit
E	Last valid speed estimate of FSO

Example 3: SAR1 ramp monitoring and SLS modoff delay time active

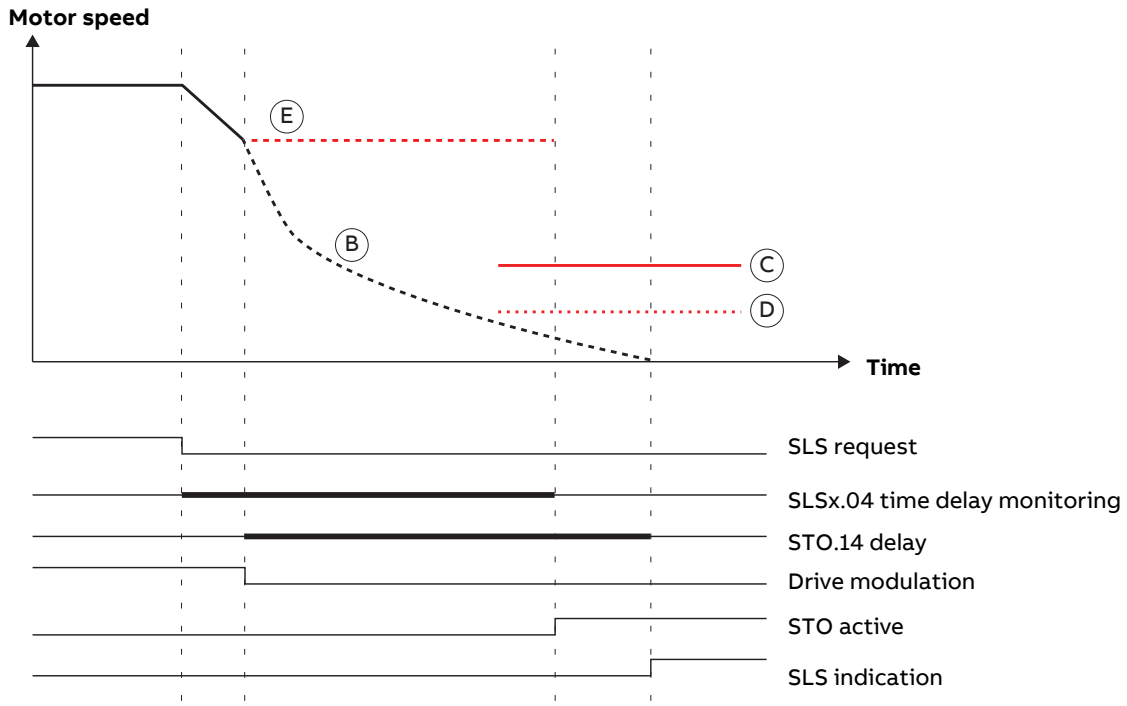
In this example, parameter SLSx.05 is set to Monitoring active and modoff delay time. The time diagram below describes the operation of the SLS function when modulation is lost during the deceleration ramp.



A	SAR1 ramp monitoring
B	Actual motor speed (coasting after modoff)
C	SLS trip limit
D	SLS limit
E	Last valid speed estimate of FSO

Example 4: Time monitoring active

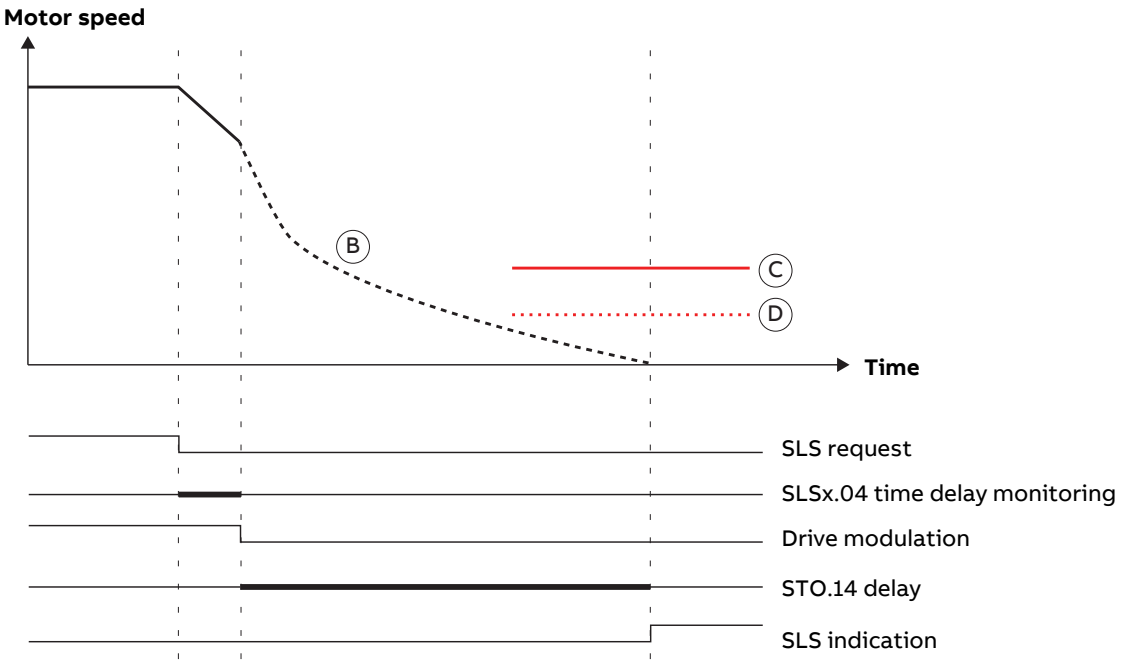
In this example, parameter SLSx.05 is set to Monitoring active. The time diagram below describes the operation of the SLS function when modulation is lost during the deceleration ramp.



B	Actual motor speed (coasting after modoff)
C	SLS trip limit
D	SLS limit
E	Last valid speed estimate of FSO

Example 5: Monitoring and modoff delay time disabled

In this example, parameter SLSx.05 is set to Monitoring and modoff delay time disabled. The time diagram below describes the operation of the SLS function when modulation is lost during the deceleration ramp.



B	Actual motor speed (coasting after modoff)
C	SLS trip limit
D	SLS limit

SMS function

Safe maximum speed (SMS) is used to protect the machine from speeds or frequencies that are too high.

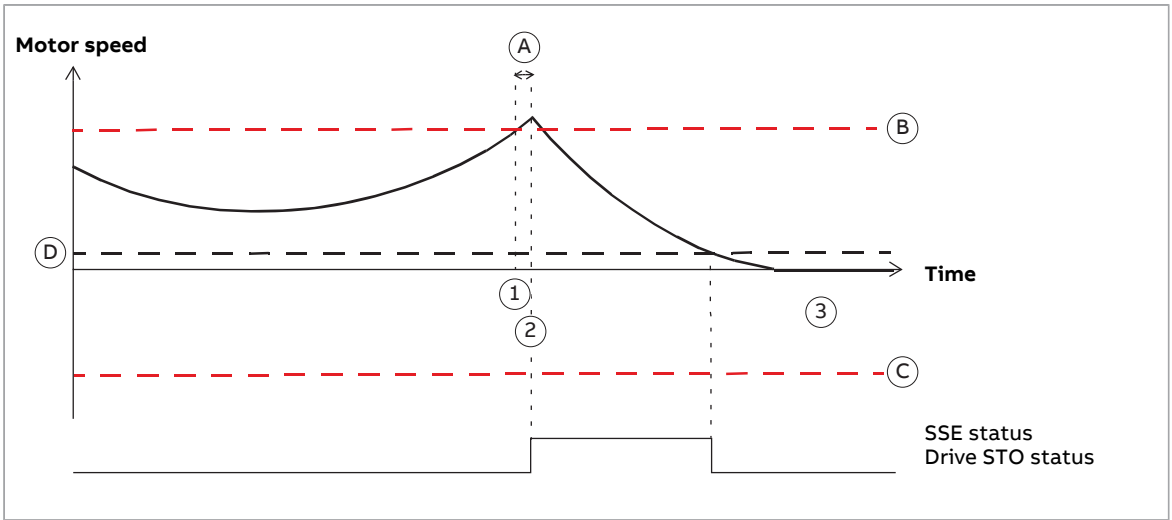
The FSO module includes two versions of the SMS function:

- **Version 1:** If the motor speed reaches the minimum or the maximum SMS trip limit, the FSO module activates the Safe stop emergency (SSE) function. Depending on parameter settings, the FSO module activates the drive STO immediately or after a deceleration ramp. The motor coasts to a stop, or decelerates to zero speed.
- **Version 2:** The minimum and maximum SMS limits limit the motor speed. This version of the SMS function is similar to the SLS function, but it can only be configured to be permanently on or off.

This manual describes version 1.

The user selects the version of the SMS function and sets the SMS maximum and minimum speed limits. For more information, refer to chapter Parameter settings and the FSO module user's manual.

This time scheme diagram illustrates the operation of the SMS function (version 1).



A	Safety function response time
B	SMS trip limit positive (parameter SMS.14)
C	SMS trip limit negative (parameter SMS.13)
D	Zero speed with encoder (parameter FSOGEN.52)

1. The motor speed reaches the SMS trip limit positive.
2. After the safety function response time (A), the FSO module activates the SSE function, which activates the drive STO. The motor coasts to a stop. In this case, the SSE function is configured as Immediate STO (parameter SSE.13).

   Note: In option +Q978, the SBC function is used to control the main contactor/breaker. If the drive has this option and a trip limit hit occurs, STO activation causes the main contactor/breaker to open.
3. When the motor speed reaches the zero speed limit (D), the FSO module automatically acknowledges the SSE function (parameter STO.02 is set to Automatic) and deactivates the drive STO. The user must reset the drive if the STO indication parameter (FSOGEN.62 or 31.22) is set so that a fault is generated.

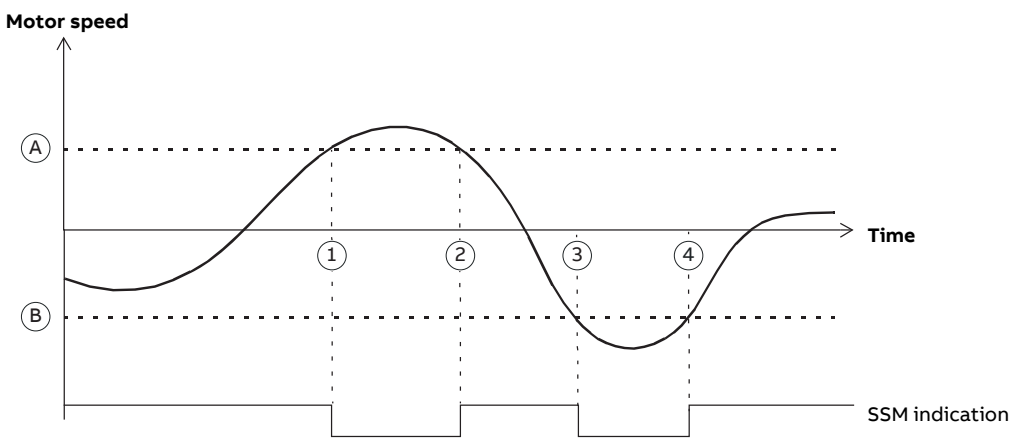
   Note: Drives with option +Q978 or +Q979: An external acknowledgement input is used (Parameter STO.02 is set to Manual).

SSM function

Safe speed monitoring (SSM) provides a safe output signal to indicate whether the motor speed is between user-defined limits. When the motor speed is within the SSM limits, the SSM indication signal in the FSO module is on.

There are four separate SSM functions in the FSO module with different parameter settings. The SSM1 function is used as an example and in the delivered default settings of the +Q965 option. ABB activates the SSM1 function at the factory. The user sets the SSM positive and negative speed limits at the start-up. For more information, refer to chapter Parameter settings and the FSO module user's manual.

This time scheme diagram illustrates the operation of the SSM1 function.



A	SSM1 limit positive (parameter SSMx.13)
B	SSM1 limit negative (parameter SSMx.12)

1. The motor speed goes above the SSM limit positive. The SSM indication goes off.
2. The motor speed goes below the SSM limit positive. The SSM indication goes on.
3. The motor speed goes below the SSM limit negative. The SSM indication goes off.
4. The motor speed goes above the SSM limit negative. The SSM indication goes on.

Drive modulation loss when encoder feedback is used

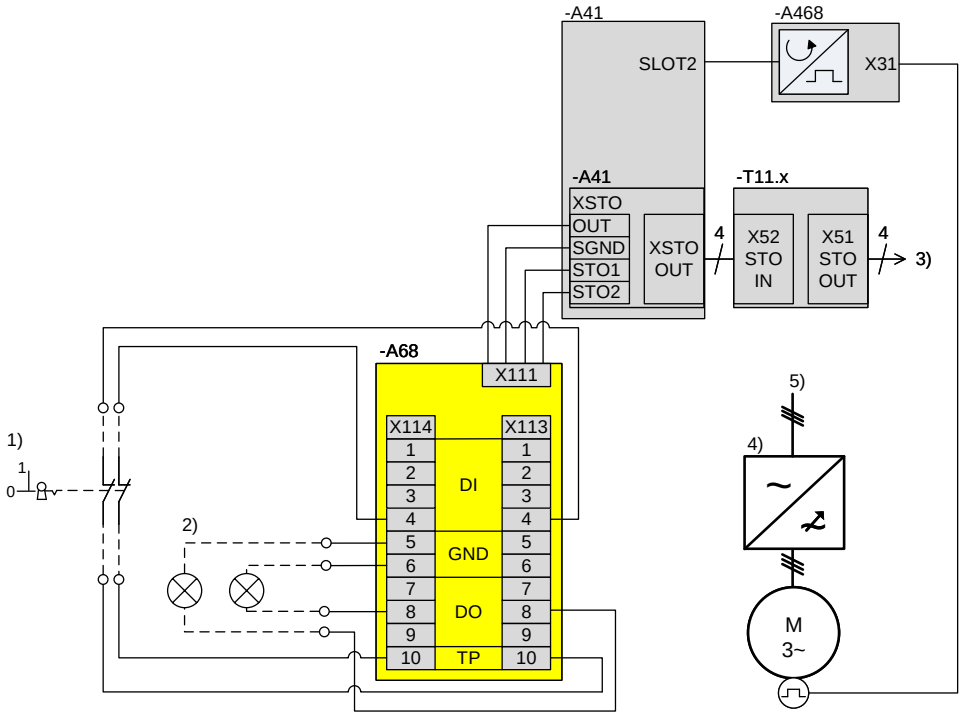
When using encoder feedback: If drive modulation is lost during the safe deceleration ramp, and the motor speed does not stay inside the monitoring limits, FSO generates a monitoring limit hit indication and activates STO based on measured motor speed in these conditions:

- SAR1 ramp monitoring with SS1, SLS or SDI functions
- SAR0 ramp monitoring with SSE function as Emergency ramp
- time monitored ramp with SS1, SLS, SDI or SSE functions.

Note: Parameters SLSx.05 and SLSx.06 are used only with safe speed estimate. With encoder feedback, they have no effect. However, if an encoder failure occurs, and parameter S_ENCGEN.11 is set to Est switch not active load, FSO switches from encoder feedback to safe speed estimate.

Operation principle diagram

This diagram shows the connections of the FSO module. The figure shows a simplified operation principle. For a more detailed description, refer to the circuit diagrams delivered with the drive.



- - -	The dashed line in the figure indicates a customer-defined installation.
A68	FSO-21 safety functions module
A468	FSE-31 pulse encoder interface module
X113, X114	Terminal block in the FSO module
X111	STO connections to inverter control unit
A41	Inverter control unit
T11.x	Inverter module(s) under inverter unit T11 (only for R8i)
TP	Test pulse(s) for digital input
1)	SLS request (DI X113:4 & X114:4)
2)	SSM indication (DO X113:8) / SLS indication (DO X114:8)
3)	To parallel inverter modules (if any)
4)	Drive module
5)	Main circuit

Fault reaction function

Definition: A safety function requires a “fault reaction function” that tries to initiate a safe state if it detects a failure in the safety system.

This section gives information on the fault reaction functions in the FSO and FSE-31 modules, the safety encoder, and the drive STO.

Examples of different failures:

- a short or open circuit or redundancy failure of the SLS activation switch wiring chain
- an internal failure in the FSO module
- an internal failure in the FSE-31 module or the safety encoder
- an internal failure in the drive STO.

FSO module

The fault reaction function of the FSO module trips the drive if it detects a failure. The FSO module activates the STO function or the Safe stop emergency (SSE) function. This activates the drive STO function. The drive STO function is active until the fault is repaired.

The FSO module goes into Fail-safe mode. The STATUS/FAULT LED of the FSO module is red until the fault is repaired. To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module.

For more information, refer to the firmware manual and the FSO module user’s manual.

Resetting the FSO module

To reset the FSO module:

- switch the power off and on, or
- click the **Reboot FSO** button on the Safety view of the Drive Composer pro PC tool, or
- use parameter 96.09 FSO reboot.

FSE-31 module and safety encoder

The fault reaction function depends on the value of FSO parameter S_ENCGEN.11 FSE diagnostic failure reaction.

If there is a fault in the FSE-31 module or safety encoder, and parameter S_ENCGEN.11 is set to the value STO, the FSO-21 module goes into Fail-safe mode and activates the drive STO function. To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module.

In FSE-31 module faults, the STATUS/FAULT LED of the FSO-21 module is red and the STATUS LED of the FSE-31 module is off. The drive also indicates some FSE-31 module faults.

In safety encoder faults, the STATUS/FAULT LED of the FSO-21 module is red and the ENC STATUS LED of the FSE-31 module is off. The drive also indicates a safety encoder fault. The safety encoder goes into the Safe state. To exit the Safe state, remove the cause of the fault and reboot the safety encoder (for example, switch the power off and on).

For more information, refer to the firmware manual, FSO-21 safety functions module user's manual (3AXD50000015614 [English]) and FSE-31 pulse encoder interface module user's manual (3AXD50000016597 [English]).

Drive STO function

The drive STO function has internal fault diagnostics and a fault reaction function, which causes a fault trip if it detects a redundancy fault of STO control signals or an internal failure. Refer to the hardware and firmware manuals of the drive.

4

Electrical installation

Contents of this chapter

This chapter gives information on the electrical installation of the safety option.

Wiring

⚠WARNING Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

There is an extension terminal block [X68] inside the drive cabinet. The tables that follow show the connections between the extension terminal block [X68] and the FSO module connectors [X113] and [X114].

FSO X113	1	2	3	4	5	6	7	8	9	10
X68	3	4	5	6	7	8, 9	10	11	12	13, 14, 15, 16

FSO X114	1	2	3	4	5	6	7	8	9	10
X68	17	18	19	20	21	22, 23	24	25	26	27, 28, 29, 30

There is a separate terminal block [X965] inside the drive cabinet for customer connections. The terminal block [X965] is connected to the extension terminal block [X68].

ABB installs the FSO and FSE-31 modules and the wiring between the FSO module and the drive at the factory.

Connect the safety encoder to the FSE-31 module on site. Obey the instructions of the encoder manufacturer and these rules:

- Use a double-shielded, twisted pair cable.
- The maximum permitted cable length between the safety encoder and the FSE-31 module is 300 m (980 ft).

For more information, refer to FSE-31 pulse encoder interface module user's manual (3AXD50000016597 [English]).

SLS function

You must connect the SLS request signal to the FSO module on site. You can also connect the SLS indication signal of the FSO module to the control system on site. Connect the SLS signals to terminal block [X965] according to the circuit diagrams of the delivery.

For the terminal designations, refer to the circuit diagrams delivered with the drive. If you use a switch for SLS activation, obey these general rules:

1. Connect the SLS request switch with two conductors (two-channel connection). Keep the channels separate.

   Note: If you use only one channel in a two-channel implementation, or if the channels are connected together, the cross fault detection of the FSO module detects a redundancy fault and activates the fault reaction function.

   Note: If you change the input and the parameter settings in the FSO module into a one-channel implementation, it has an effect on the safety integrity of the safety function. In this case, the safety data that ABB has calculated for the function is not valid.

2. Use a shielded, twisted pair cable. ABB recommends double-shielded cable.
3. Make sure that the sum resistance for one channel (loop resistance) from the field to the FSO module is not more than 1 kohm.
4. The maximum permitted cable length between the drive and the activation switch (for the whole loop) is 250 m (820 ft).
5. Obey the general control cable installation instructions given in the drive hardware manual.
6. Use test pulses in the FSO inputs.

SMS function

It is not necessary to make connections for the SMS function.

SSM function

If necessary, connect the SSM indication signal output of the FSO module. You can use terminal block [X965]. Refer to the circuit diagrams of the delivery.

5

Parameter settings

Contents of this chapter

This chapter gives the parameters that you must set in the FSO module and the drive.

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 expertise and knowledge of functional safety, the safety functions and the configuration of the FSO module. ABB has training courses on the FSO module.

FSO module parameter settings

The default parameter values shown below are example values for the safety functions described in this manual. Actual parameter values of the delivery can be different. Always make sure that:

- the parameter settings agree with the circuit diagrams, and
- the design agrees with the safety requirements of the application.

You must use the Drive Composer pro PC tool to set the FSO module parameters. You also need a password to download the configuration to the FSO module from Drive Composer pro. For the default password of the FSO module, refer to the FSO module user's manual. For more information on Drive Composer pro, refer to Drive Composer start-up and maintenance PC tool user's manual (3AUA0000094606 [English]).

Note: When the motor is running, you cannot change the password, adjust parameter values, or upload or download the FSO configuration file.

Note: The FSO module has a factory reset button. The factory reset button clears the configuration and sets the parameters to the factory default values. These values are not the same as the preset values in an FSO module that was ordered as an option (with a plus code). You cannot restart the drive with the factory default values. If you do a factory reset of the FSO module, you must reconfigure the FSO module and set all applicable parameters. For more information on the factory reset, refer to the FSO module user's manual.

When using SS1, SLS or SMS safety functions: The FSO module activates the STO function if the motor speed hits a ramp monitoring limit during the deceleration ramp. The FSO module activates the SSE function if the motor speed hits a trip limit during SLS or SMS monitoring. Thus, you must also configure the STO and SSE functions.

Follow the configuration steps described in the FSO module user's manual, chapter **Configuration**.

There are parameters that you must always set and parameters that are related to some safety functions only. These tables list all the parameters that you must check and set for option +Q965. The example values are applicable only to option +Q965.

General parameters

These parameters are common to all safety functions.

Index	Name	Example value	Description
FSOGEN.21	Motor nominal speed	1500 rpm	Sets the synchronous motor speed.
FSOGEN.22	Motor nominal frequency	50 Hz	Sets the nominal motor frequency. Must be equal to the value on the motor rating plate.
FSOGEN.41	Power-up acknowledgement	Automatic	Sets the power-up acknowledgement method of the FSO module. **Automatic:** It is not necessary to push a reset button after energizing the FSO module. The FSO module generates the acknowledgement signal automatically after the power-up. **Manual:** The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42 Acknowledgement button input. Make sure that the value is Automatic.
FSOGEN.42	Acknowledgement button input	None	Selects the digital input for the acknowledgement signal when parameter FSOGEN.41 Power-up acknowledgement or STO.02 STO acknowledgement is set to Manual. In the safety functions described in this manual, parameters FSOGEN.41 Power-up acknowledgement and STO.02 STO acknowledgement are set to Automatic, and this digital input is not used. The safety functions are configured not to require a reset/acknowledgement of the safety function after power-up or the removal of the safety function request.

Index	Name	Example value	Description
FSOGEN.52	Zero speed with encoder	10 rpm	Sets the general zero speed limit for safety functions when a safety encoder is used. This parameter is relevant when the SSE function is activated and if parameter SSE.13 SSE function is set to Emergency ramp. Refer to section Parameters for the SSE function (page 40). **Note:** You cannot set trip limits below this value.
FSOGEN.62	STO indication safety limit	Fault	Sets the type of the indication that the FSO module generates for the limit hits of the SLS1…SLS4 and SMS functions and for limit hits during ramp and time monitoring of safety ramps SAR0 and SAR1. SLS: When the motor speed does not follow the deceleration ramp, the FSO module activates the STO function and generates this user-defined indication. When the motor speed reaches the SLS trip limit, the FSO module activates the SSE function and generates this user-defined indication. SMS: When the motor speed reaches the SMS trip limit positive or below the SMS trip limit negative, the FSO module activates the SSE function and generates this user-defined indication. SSM: This value has no effect in the operation. If necessary, adjust the default setting. If you select Fault, you must reset the drive before you can restart it.

Parameters for the STO function

These parameters are related to the STO function of the FSO module. The FSO module can activate the STO function in internal fault situations. The SLS function also activates the STO function if a ramp monitoring limit is reached during deceleration.

Index	Name	Example value	Description
STO.02	STO acknowledgement	Automatic	Sets the acknowledgement method used in the STO, SSE and SS1 functions. **Automatic:** The FSO module generates the STO acknowledgement signal automatically, and the user does not have to press a reset button (see parameter FSOGEN.42 Acknowledgement button input).
STO.11	STO input A	None	Sets the digital input that is connected to the primary input of the STO function. The safety option described in this manual does not use this function and the value must be None.

Index	Name	Example value	Description
STO.14	Time to zero speed with STO and mod-off	2000 ms	The time it takes for the motor to coast to a standstill from maximum process speed. This must be measured with the Drive Composer pro PC tool when an encoder is used for motor control (otherwise you have to make sure that the motor shaft has stopped rotating by other means, eg, visually.). Acknowledgement is permitted after coast stop in the STO, SSE and SS1 functions (when SBC is not used). 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 permitted. If the drive STO is activated or modulation stopped while a monitoring safety function is indicating “unsafe”, after this time acknowledgement is permitted. For example, if the drive modulation is lost during SLS deceleration ramp, SLS OK will be indicated after this time has elapsed. When an encoder is used: This parameter is relevant only if there is an encoder failure and the FSO module activates the STO function.
SBC usage			
SBC.11	STO SBC usage	None	Activates/deactivates the control of a mechanical brake of the motor. None: This feature is not in use. In this manual, it is assumed that you do not use a brake. If you do, you must take care of its on/off control by the FSO module and change this and other settings. Refer to the FSO module user’s manual. **Note:** In option +Q978, the SBC function is used to control the main contactor/breaker. Do not change this setting.

Parameters for the SSE function

These parameters are related to the Safe stop emergency (SSE) function of the FSO module. The SLS and SMS functions activate the SSE function if the motor speed

reaches a trip limit during monitoring. The FSO module can activate the SSE function in internal fault situations.

Index	Name	Example value	Description
SSE.13	SSE function	Immediate STO or Emergency ramp	Sets the type of the SSE function. **Immediate STO:** The FSO module activates the drive STO function immediately after the SSE request. **Emergency ramp:** The FSO module decelerates the motor to zero speed, and then activates the drive STO function. SAR0 parameters define the deceleration ramp. For more information, refer to the FSO module user's manual. Zero speed is defined by parameter FSOGEN.51 Zero speed without encoder or FSOGEN.52 Zero speed with encoder. For option +Q965, ABB sets this parameter to value Immediate STO at the factory. Adjust the default value when necessary.
SSE.14	SSE monitoring method	Ramp or Time	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:** SAR0 parameters define the emergency ramp and monitoring limits. Refer to SAR0 ramp settings (page 42). **Time:** Parameter 200.102 SAR0 ramp time to zero defines the emergency ramp and it is monitored with parameter SSE.15 SSE delay for STO. For option +Q965, ABB sets this parameter to value Ramp at the factory. Adjust the default value when necessary.
SSE.15	SSE delay for STO	20000 ms	Sets the SSE monitoring time after which the FSO module activates the drive STO function 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 is set to Time), and the motor speed does not follow the ramp. **Note:** This delay must be considered when the total response time for the safety function is defined.

Index	Name	Example value	Description
SSE.16	SSE ramp zero speed delay for STO	0 ms	Sets an extra delay time for the drive STO activation at the zero speed in the SSE function. With this parameter, the FSO module delays the STO activation so that the drive is able to reach the shaft 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.52). After this delay has elapsed, the FSO module activates the drive STO. You can use this parameter when the motor rotates a high inertia load. **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). This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp.
SBC usage			
SBC.15	SSE/SS1 SBC speed	0 rpm	Sets the absolute speed below which the mechanical brake of the motor is activated while ramping. **0 rpm:** The feature is not in use. In this manual, it is assumed that you do not use a brake. If you do, you must take care of its on/off control by the FSO module and change this and other settings. Refer to the FSO module user's manual.
SAR0 ramp settings			
200.102	SAR0 ramp time to zero	1000 ms	Sets the target time for the reference emergency stop ramp SAR0 (used in the SSE function). Target time = Time in which the drive decelerates the motor from speed 200.202 SAR speed scaling to zero. This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp. Adjust the default value when necessary.
200.202	SAR speed scaling	1500 rpm	Sets a speed value that the FSO module uses as a reference point in ramp parameter calculations (both SAR0 and SAR1 ramps). Adjust the default value when necessary.

Index	Name	Example value	Description
SARx.02	SAR initial allowed range	100 ms	Sets the initial allowed range for the SAR0/SAR1 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, refer to the FSO module user's manual.
SARx.11	SAR0 min ramp time to zero	500 ms	Sets the minimum ramp time for the SAR0 ramp monitoring. This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp. Adjust the default value when necessary.
SARx.12	SAR0 max ramp time to zero	1500 ms	Sets the maximum ramp time for the SAR0 ramp monitoring. This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp. Adjust the default value when necessary.

Parameters for the SLS function

There are four separate SLS functions (SLS1…4) in the FSO module. The SLS functions are identical and the configuration is done similarly, only the parameter numbers differ. The SLS1 function is shown as an example. ABB has activated the SLS1 function at the factory. For more information, see FSO module user's manual.

Index	Name	Example value	Description
200.21	SLS1 activity and version	Version 1	Activates or deactivates the SLS1 function and shows the version of the SLS1 function. Disabled: Deactivates the SLS1 function. Version 1: Activates the SLS1 function.
200.22	SLS1 limit negative	-200 rpm	Sets the SLS1 negative speed limit for the drive. Adjust the default value to agree with the motor. **Note:** The difference between the SLS limit and the corresponding SLS trip limit (SLSx.13 SLS1 trip limit negative) must be at least 0.1 rpm.
200.23	SLS1 limit positive	200 rpm	Sets the SLS1 positive speed limit for the drive. Adjust the default value to agree with the motor. **Note:** The difference between the SLS limit and the corresponding SLS trip limit (SLSx.14 SLS1 trip limit positive) must be at least 0.1 rpm.

Index	Name	Example value	Description
SLSx.02	SLS acknowledgement	Automatic	Sets the acknowledgement method used in the SLS1…4 functions. Automatic: The FSO module generates the SLS acknowledgement signal automatically after the SLS request is removed and the SLS limit is achieved. The user does not have to press a reset button (see parameter FSOGEN.42 Acknowledgement button input).
SLSx.03	SLS activation monitoring method	Time or Ramp	Sets the monitoring method that is used in SLS activation. Time monitoring: The drive (parameter 23.13 Deceleration time 1 or 23.15 Deceleration time 2) defines the deceleration ramp and it is monitored with parameter SLSx.04 SLS time delay. Ramp monitoring: SAR1 parameters define the deceleration ramp and monitoring limits. See parameters 200.112, SARx.21, SARx.22 and SARx.02. For option +Q965, ABB sets this parameter to value Ramp at the factory. Adjust the default value when necessary.
SLSx.04	SLS time delay	4000 ms	Sets the SLS monitoring time after which the FSO module activates the SLS monitoring after the SLS request. This parameter is relevant only if time monitoring is used (parameter SLSx.03 SLS activation monitoring method is set to Time). **Note:** With time monitoring, when parameter SLSx.05 is set to Monitoring active and Modoff delay time, parameters SLSx.04 and SLSx.06 must be set to a shorter time than parameter STO.14. If they are not set to a shorter time than STO.14, STO is not activated due to a limit hit when drive modulation is lost with SLS function.
SLSx.05	SLS ramp modoff reaction	Modoff delay time	Selects the fault reaction in case the drive modulation is lost during the SLS deceleration ramp, when SLS is activated from speed which is higher than SLS limit speed. For more information, see FSO module user's manual. **Note:** If encoder feedback is used, parameter SLSx.05 has no effect.
SLSx.06	SLS ramp modoff delay time	0 ms	Time to trip when modulation is lost. **Note:** SLSx.06 time must be set to a shorter time than STO.14. If it is not set to a shorter time than STO.14, STO is not activated due to limit hit when drive modulation is lost with SLS function. **Note:** If encoder feedback is used, parameter SLSx.06 has no effect.

Index	Name	Example value	Description
SLSx.11	SLS1 input A	DI X113:4 & X114:4	Sets the digital input that is connected to the primary input of the SLS function with limits 1. For option +Q965, ABB has configured the SLS request signal to these digital inputs at the factory.
SLSx.13	SLS1 trip limit negative	-250 rpm	Sets the SLS1 negative speed limit that trips the drive. Adjust the default value to agree with the motor. **Note:** The difference between the SLS trip limit and the corresponding SLS limit (200.22 SLS1 limit negative) must be at least 0.1 rpm.
SLSx.14	SLS1 trip limit positive	250 rpm	Sets the SLS1 positive speed limit that trips the drive. Adjust the default value to agree with the motor. **Note:** The difference between the SLS trip limit and the corresponding SLS limit (200.23 SLS1 limit positive) must be at least 0.1 rpm.
SLSx.15	SLS1 output A	DO X114:8	Sets the digital output that is connected to the primary output of the SLS1 function. Active when the SLS monitoring is on. For option +Q965, ABB has configured the SLS indication signal to this digital output at the factory.
SAR1 ramp settings			
200.112	SAR1 ramp time to zero	2000 ms	Sets the target time for the stop ramp SAR1 that is used in the SLS function. Adjust the default value when necessary. Target time = The time in which the drive decelerates the motor(s) from speed 200.202 SAR speed scaling to zero. **Note:** With value 0 ms, the drive uses the emergency stop ramp set by drive parameter 23.23. In this case, the FSO module also monitors the actual ramp (ramp monitoring or time monitoring). Time monitoring: This value has no effect in the operation. The drive (parameter 23.13 Deceleration time 1 or 23.15 Deceleration time 2) defines the deceleration ramp. Ramp monitoring: Adjust the default value when necessary.
200.202	SAR speed scaling	1500 rpm	The same value is used for SAR0 and SAR1 ramps. Refer to SAR0 ramp settings (page 42).
SARx.02	SAR initial allowed range	100 ms	The same value is used for SAR0 and SAR1 ramps. Refer to SAR0 ramp settings (page 42).

Index	Name	Example value	Description
SARx.21	SAR1 min ramp time to zero	1000 ms	Sets the minimum ramp time for the SAR1 ramp monitoring. Time monitoring: This value has no effect in the operation. Ramp monitoring: Sets the minimum deceleration time for the emergency stop. Adjust the default value when necessary. **Note:** With value 0 ms, the ramp is not monitored.
SARx.22	SAR1 max ramp time to zero	3000 ms	Sets the maximum ramp time for the SAR1 ramp monitoring. Time monitoring: This value has no effect in the operation. Ramp monitoring: Sets the maximum deceleration time for the emergency stop. Adjust the default value when necessary.
I/O settings			
SAFEIO.36	DI X113:4 diag pulse on/ off	On	Sets the diagnostic pulse of digital input X113:4 on or off. On: The input monitors that it receives test pulses.
SAFEIO.40	DI X114:4 diag pulse on/ off	On	Sets the diagnostic pulse of digital input X114:4 on or off. On: The input monitors that it receives test pulses.
SAFEIO.57	DO X114:8 diag pulse on/off	On	Sets the diagnostic pulse of digital output X114:8 on or off. On: The output monitors that it receives test pulses.
SAFEIO.75	DO X114:8 logic state	Active high	Sets the logic state of digital output X114:8. Active high: The digital output is on when the indicated signal is active. For option +Q965, ABB has configured the SLS indication signal to this digital output at the factory. Make sure that this value corresponds to the actual wiring. Refer to the circuit diagrams of the delivery.

Parameters for the SMS function

These parameters are related to the SMS function (version 1) of the FSO module.

Index	Name	Example value	Description
200.71	SMS activity and version	Version 1	Activates or deactivates the SMS function and shows the version of the SMS function. Disabled: Deactivates the SMS function (default). Version 1: Activates version 1 of the SMS function. Version 2: Activates version 2 of the SMS function (for more information, refer to the FSO module user's manual). For option +Q965, ABB has configured the SMS function (Version 1) at the factory. Adjust the value if necessary.
SMS.13	SMS trip limit negative	-2000 rpm	Sets the negative speed limit that trips the drive for the SMS function. **Note:** You cannot set this limit above the general zero speed limit (parameter FSOGEN.52).
SMS.14	SMS trip limit positive	2000 rpm	Sets the positive speed limit that trips the drive for the SMS function. **Note:** You cannot set this limit below the general zero speed limit (parameter FSOGEN.52).

Parameters for the SSM function

There are four separate SSM functions (SSM1…4) in the FSO-21 module. The SSM functions are identical and the configuration is done similarly, only the parameter numbers are different. The SSM1 function is shown as an example. ABB has activated the SSM1 function at the factory. For more information, refer to the FSO-21 module user's manual.

Index	Name	Example value	Description
SSMx.01	SSM1 activity and version	Version 1	Activates or deactivates the SSM1 function and shows the version of the SSM1 function. Disabled: Deactivates the SSM1 function. Version 1: Activates the SSM1 function. For option +Q965, ABB has activated the SSM1 function at the factory. Adjust the value if necessary.
SSMx.11	SSM1 input	Always on	Sets the digital input connected to the SSM1 function. Always on: The SSM1 function is always on. No external request signal is needed to activate the SSM1 function. For option +Q965, ABB has configured the SSM1 function to be "Always on" at the factory.
SSMx.12	SSM1 limit negative	-100 rpm	Sets the negative speed limit for the SSM1 function.

Index	Name	Example value	Description
SSMx.13	SSM1 limit positive	100 rpm	Sets the positive speed limit for the SSM1 function.
SSMx.14	SSM1 output	DO X113:8	Sets the digital output connected to the SSM1 function. Active when the motor speed is within the SSM1 speed limits. For option +Q965, ABB has configured the SSM1 indication signal to this digital output at the factory.
SAFEIO.55	DO X113:8 diag pulse on/ off	On	Sets the diagnostic pulse of digital output X113:8 on or off. On: The output monitors that it receives test pulses.
SAFEIO.72	DO X113:8 logic state	Active high	Sets the logic state of digital output X113:8. Active high: The digital output is on when the indicated signal is active. For option +Q965, ABB has configured the SSM1 indication signal to this digital output at the factory. Make sure that this value corresponds to the actual wiring. Refer to the circuit diagrams of the delivery.

FSE-31 module and safety encoder related parameters

Set these parameters when you use a safety encoder in the safety application.

Index	Name	Example value	Description
200.231	FSE 3X act and par version	Version 1	Activates the FSE-31 encoder interface and shows the version of the encoder parameter groups (91 and 92).
200.232	Number of encoders	Single encoder CH1	Shows the number of safety encoders connected to the FSE-31 module.
S_ENCGEN.01	Safe pulse encoder version	Version 1	Activates the safety encoder and shows the version parameter group S_ENCGEN.

Index	Name	Example value	Description
S_ENCGEN.11	FSE diagnostic failure reaction	STO	Sets the action taken when there is a problem with the FSE-31 module or the safety encoder. STO: The FSO module goes into 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 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 (safe speed estimate). If you select this value, you must also set the parameters related to safe speed estimate. Refer to the FSO-21 module user's manual. Do not select this value in applications with an active load.
S_ENCGEN.14	Enc speed cross comp tolerance	1 rpm	Sets the encoder speed cross comparison tolerance. This defines how much the axle speed of the motor can change within 1 ms. Adjust the default value to agree with the motor. This parameter is used for the encoder diagnostic. It defines how large the difference between the speed information from channel A and B of the encoder can be. If the difference between the speed information channels is larger than the value of this parameter, FSO will safely stop the system (STO). The correct value depends on the configuration (motor and load). Typically this value is 2 … 10 rpm. A value that is too small will cause an encoder fault (A7D8) and a value that is too large will prevent encoder diagnostic related to this parameter. For more information, refer to the FSO-21 module user's manual.
S_ENCGEN.41	Gear numerator encoder 1	1	Sets the rotation direction for the safety encoder. With this parameter, you can change the rotation direction of the motor. If necessary, adjust the default value.
91.11	Module 1 type	FSE-31	Sets the type of the safety encoder interface module 1.
91.12	Module 1 location	2	Sets the slot in which the safety encoder interface module 1 is located.
92.01	Encoder 1 type	HTL1	Activates or deactivates the communication with the safety encoder interface module 1 and sets the type for the safety encoder.

Index	Name	Example value	Description
92.02	Encoder 1 source	Module 1	Sets the safety encoder interface module that the safety encoder 1 is connected to.
92.10	Pulses/revolution	2048	Sets the number of HTL pulses per revolution for safety encoder 1. Adjust the default value to agree with the safety encoder. Make sure that the value is the same that is shown on the encoder nameplate.
92.17	Accepted pulse freq of encoder 1	300 kHz	Sets the maximum pulse frequency range of encoder 1. Adjust the default value to agree with the motor and safety encoder. You can use this formula to define the value: r_max · ppr_enc + 10%, where • r_max = the maximum motor speed used in the application (or the motor nominal speed) • ppr_enc = Pulses/revolution of the safety encoder (parameter 92.10).

Drive parameter settings

The table that follows gives the parameters related to the safety function in the ACS880 primary control program. The parameters are set at the factory.

No.	Name	Default value[1)]	Description
31.22	STO indication run/stop	Warning/Warning	Selects which indications are given when the Safe torque off (STO) function is activated. Warning/Warning is the recommended setting. **Note:** ABB recommends that you do not set this parameter to Fault/Fault, Fault/Warning, or Fault/Event. These values will cause the drive to trip on a fault each time that the FSO module activates the drive STO function.

1) Value set by ABB at the factory for the default design.

The table that follows gives the parameters that you must set when you use a safety encoder.

No.	Name	Value	Description
90.41	Motor feedback selection	Encoder 1	Selects the motor speed feedback value used during motor control.
90.45	Motor feedback fault	Warning	Selects how the drive reacts to loss of measured motor feedback. To configure the drive to trip on encoder faults, set this parameter to value *Fault*. For more information, refer to the firmware manual.
92.21	Encoder cable fault mode	A+, A-, B+, B-, Z+, Z-	Selects which encoder cable channels and wires are monitored for wiring faults.

Ramp parameters

Set these parameters only for the SLS function.

When the SLS function is activated and the motor speed is above the SLS limit positive, the drive decelerates the motor speed to the SLS limit.

In SLS with time monitoring, the drive (parameter 23.13 Deceleration time 1 or 23.15 Deceleration time 2) always defines the deceleration ramp.

In SLS with ramp monitoring, the drive uses the ramp settings in the FSO module or in the drive. If FSO parameter 200.112 SAR1 ramp time to zero is set to 0, the drive parameter 23.23 Emergency stop time defines the deceleration ramp. In this case, the FSO module monitors the actual deceleration ramp using SAR1 parameters.

After the SLS function is deactivated, the drive returns to normal operation and starts to follow its ordinary speed reference. The drive accelerates the motor to the wanted speed along its acceleration ramp. Drive parameters define the acceleration ramp and it is not monitored.

For the parameter settings in the drive, refer to the firmware manual.

6

Use of the safety function

Contents of this chapter

This chapter describes the use of the safety function with factory default settings.

Activating and deactivating the SLS function

To activate the SLS function, de-energize the SLS inputs of the FSO module.

When the SLS monitoring is on and the motor speed is below the SLS limit:

- the FSO module energizes a digital output and the indication connected to this output (for example, a lamp) is on.

When the drive trips after an SLS trip limit hit:

- the FSO module generates an indication, defined by parameter FSOGEN.62
- the drive generates an indication, defined by parameter 31.22.

To deactivate the SLS function, energize the SLS inputs of the FSO module.

If a trip limit hit occurs and the FSO module or drive is configured to trip on a fault, you must reset the faults from the drive.

For the terminal designations, refer to the circuit diagrams delivered with the drive.

The indications that the FSO module generates are configurable. For more information, refer to chapter Parameter settings in this manual and chapter **Fault tracing** in the FSO module user's manual.

Activating and deactivating the SMS function

If the SMS function is activated at the start-up, it monitors the motor speed continuously. The SMS function is activated and deactivated with FSO module

parameter 200.71. To change this parameter value, a password is necessary. Refer to chapter Parameter settings.

When the drive trips after an SMS trip limit hit:

- the FSO module generates an indication, defined by parameter FSOGEN.62
- the drive generates an indication, defined by parameter 31.22.

If a trip limit hit occurs and the FSO module or drive is configured to trip on a fault, you must reset the faults from the drive.

The indications that the FSO module generates are configurable. For more information, see chapter Parameter settings in this manual and chapter **Fault tracing** in the FSO module user's manual.

Activating and deactivating the SSM function

If the SSM function is activated at the start-up, it monitors the motor speed continuously. The SSM function is activated and deactivated with FSO module parameters (for example, SSMx.01 and SSMx.11 for the SSM1 function). To change these parameter values, a password is necessary. See chapter Parameter settings.

Note: This manual describes the SSM function when it is set to Always on at the start-up. You can also configure the SSM function to activate through an external request signal (from the FSO I/O or a PLC). Obey the wiring instructions given for the SLS function. For more information, refer to the FSO module user's manual.

When the motor speed is between the SSM speed limits, the FSO module energizes a digital output and the indication signal connected to this output is on. For the terminal designations, refer to the circuit diagrams delivered with the drive.

7

Start-up and validation test

Contents of this chapter

This chapter describes the start-up, validation test procedure, and validation of the safety function.

Validation of the safety functions

You must do a validation test to make sure that the safety function operates correctly and according to the safety requirements.

Competence

The person who does the validation test of the safety function must be a competent person with expertise and knowledge of the safety function and functional safety, as required by IEC 61508-1 clause 6. This person must document and sign the test procedures and report.

Validation procedure

You must validate the general settings of the FSO module and the safety encoder before you validate the safety function. Refer to the FSO module user's manual, chapter **Verification and validation**.

You must do the validation test using the checklist given in this manual and the validation test plan of the complete safety system:

- at the initial start-up of the safety function
- after changes related to the safety function (wiring, components, safety function -related parameter settings, etc.)
- after changes related to the power unit or its circuit boards

- at the proof test of the safety function
- after maintenance work related to the safety function.

The validation test must include at least the following steps:

- you must have a validation test plan
- you must test all commissioned functions for correct operation, from each operation location
- you must document all validation tests
- you must sign and store the validation test report for further reference.

Validation test reports

You must store the signed validation test reports in the logbook of the machine. The report must include, as required by the referred standards:

- a 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
- 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 validation test reports done due to changes or maintenance in the logbook of the machine.

Start-up and validation test

You must use the Drive Composer pro PC tool to do the start-up and validation test. Do the test in both operation directions of the motor.

If you use SMS function, version 2: Do the validation test as given in the FSO module user's manual.

Note: The SLS validation test procedure described in this chapter does not test the trip limits, because the SLS function limits the motor reference speed to the SLS limit. ABB has validated the functionality of trip limits in the verification tests.

Action	☑
⚠**WARNING** Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.	☐
Initial status	
Safety encoder interface: If you use a safety encoder in the safety application, validate the safety encoder interface as described in FSO-21 safety functions module user's manual (3AXD50000015614 [English]), chapter **Verification and validation**.	☐

Action	☑
Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. Refer to the hardware manual. Before you do the motor ID run, you must deactivate the SLS and SMS functions: • SLS function: Make sure that the SLS request is not active (for example, from a switch). • SMS function: Set parameter 200.71 SMS activity and version to value Disabled. After the motor ID run, activate the SLS and SMS functions.	☐
Make sure that the FSO STO function is configured and validated. Refer to the FSO module user's manual. Internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal. The STO function must be validated before other safety functions. **Note:** If parameter S_ENCGEN.11 is set to Est switch not active load, both STO function with speed estimate and STO function with encoder feedback must be tested - most importantly, the value of parameter STO.14 must be set according to the application requirements.	☐
For the SLS and SMS functions: Make sure that SSE parameters are set and SSE function is validated for trip limit situations as described in the FSO module user's manual.	☐
Checks and settings with no voltage connected	
Stop the drive and do the steps in section Electrical safety precautions (page 11) before you start the work.	☐
After you connect the SLS activation signal or an indication system to the drive, do a check of the connections against the applicable circuit diagrams. Do the check also if you made other connections to the safety circuit on site (for example, connected shipping splits of large drives).	☐
Inverter units with parallel R8i inverter modules: Make sure that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules.	☐
Settings with voltage connected	
Close the cabinet doors and power up the drive. Refer to the hardware manual.	☐
Make sure that the parameter settings related to the safety functions are correct. Refer to chapter Parameter settings. For the SMS function: • Make sure that the SMS function is active (parameter 200.71 SMS activity and version is set to value Version 1). • Set parameter SMS.14 SMS trip limit positive to half of the value that will be used in the application. • Set parameter SMS.13 SMS trip limit negative to zero. For more information, refer to section Parameters for the SMS function (page 47). For the SSM function: For more information, refer to section Parameters for the SSM function (page 47).	☐
Save the FSO safety file (button **Save safety file** in the Drive Composer pro PC tool). **Note:** The FSO safety file is not included in the drive backup process.	☐

Action	☑
Validation test	
ABB recommends that you monitor at least these signals with the Drive Composer PC tool: • 01.01 Motor speed used (rpm) • 01.02 Motor speed estimated (rpm) • 01.07 Motor current (A) • 01.10 Motor torque (%) • 06.18 Start inhibit status word • 23.01 Speed ref ramp input (rpm) • 23.02 Speed ref ramp output (rpm) • 90.01 Motor speed for control (rpm) • 90.10 Encoder 1 speed (rpm) • 200.01 FSO speed ch1 (rpm) • 200.02 FSO speed ch2 (rpm) • 200.03 FSO DI status • 200.04 FSO DO status • 200.05 FSO control word 1 • 200.06 FSO control word 2 • 200.07 FSO status word 1 • 200.08 FSO status word 2 • 200.09 Drive status word 1 • 200.10 Drive status word 2	☐
Make sure that it is safe to start, run and stop the motor during the test.	☐
For the SLS function: If it is necessary to activate STO function when drive modulation is lost during SLS deceleration ramps, follow the test procedure for the SLS function described in the FSO module user's manual.	☐
Start the drive and make sure that the motor is running. For the SLS function: Increase the motor speed close to the maximum speed of the application (above the SLS limit). For the SMS function: Increase the motor speed above the speed defined in parameter SMS trip limit positive. For the SSM function: Make sure that the SSM1 indication is on.	☐
For the SLS function: Activate the SLS request of the FSO module. For the SMS function: Make sure that the drive trips. For the SSM function: Increase the motor speed above the speed defined in parameter SSMx.13 SSM1 limit positive.	☐
For the SLS function: Make sure that the drive decelerates the motor speed to the SLS limit, stays under the SLS limit, and indicates the SLS function. For information on cascade connection, see FSO module user's manual. For the SMS function: Reset the drive if the STO indication parameter (FSOGEN.62 or 31.22) is set so that a fault is generated. For the SSM function: Make sure that the SSM1 indication goes off.	☐
Make sure that the drive generates none of these faults: • STO hardware failure (5090) • Safe torque off 1 loss (FA81) • Safe torque off 2 loss (FA82) If the drive generates these faults, refer to the fault tracing instructions in this manual. If the FSO module generates a fault, refer to the FSO module user's manual, chapter **Fault tracing**.	☐

Action	☑
For the SLS function: When the SLS request signal is on, make sure that you cannot increase the reference speed above the SLS limit: • with the panel in the local control mode • with an external speed reference signal in the external control mode. The LOC and REM buttons of the control panel or the Drive composer PC tool switch between the local and external controls. For the SMS function: Restart the drive. Make sure that the drive continues normal operation. For the SSM function: Decrease the motor speed below the speed defined in parameter SSMx.13 SSM1 limit positive.	☐
For the SLS function: Deactivate the SLS request of the FSO module. Make sure that the drive continues normal operation. For the SSM function: Make sure that the SSM1 indication goes on.	☐
For the SLS and SMS functions: Stop and restart the drive and motor. Make sure that they operate normally.	☐
Do the test again in the reverse direction.	☐
Do the test again from each operating location.	☐
For the SMS function: Set the SMS parameters to suitable values to be used in the application.	☐
Create a backup file of the drive parameters with the Drive Composer pro PC tool.	☐
Save the FSO safety file with the button **Save safety file** in the Drive Composer pro PC tool.	☐
Fill in and sign the validation test report. Store the report in the logbook of the machine.	☐

8

Fault tracing

Contents of this chapter

This chapter provides general diagnostics and troubleshooting tips.

Fault tracing

STO circuit connections

Use a voltage tester or multimeter to measure the continuity of the STO circuit connections, if the drive generates one or more of these faults:

- STO hardware failure (5090)
- Safe torque off 1 loss (FA81)
- Safe torque off 2 loss (FA82)

Refer to the circuit diagrams delivered with the drive.

Stop the drive and do the steps in section Electrical safety precautions (page 11) before you start the work.

Other

For more fault tracing possibilities, refer to the hardware and firmware manuals of the drive.

Reporting problems and failures related to safety functions

Contact ABB.

9

Maintenance

Contents of this chapter

This chapter contains information for the maintenance and decommissioning of the safety function.

Safety circuit maintenance

After the safety function is validated, it must be maintained by periodic proof testing.

If you change the wiring or a component after the start-up, replace a power unit or its circuit boards, replace the FSO or FSE-31 module, modify FSO module parameters, or restore parameters to their factory default values:

- Use only ABB-approved spare parts.
- Register the change to the change log for the safety circuit.
- If parameters were restored to the factory default values: Set the parameters related to the safety function.
- Do the validation test of the safety function.
- Document the tests and store the report into the logbook of the machine.

Proof test interval

Proof tests are used to detect failures in the safety function. To do a proof test, use the validation test procedure given in this manual.

Periodic proof testing of the safety function is necessary to maintain the required SIL/PL-level. In high demand mode of operation, the maximum proof test interval is 20 years. In low demand mode of operation, the maximum proof test interval is 2 or 5 years (high or low demand as defined in IEC 61508, IEC/EN 62061 and EN ISO 13849-1). Regardless of the mode of operation, it is a good practice to do the proof test for the

safety function at least once a year. It is also a good practice to include the proof test for the safety function in the routine maintenance program of the machinery.

The person responsible for the design of the complete safety system 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 done 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 done at least every 12 months.

This is a recommendation and depends on the required (not achieved) SIL/PL. For example, contactors, breakers, safety relays, contactor relays, emergency stop buttons, switches, etc. are typically safety devices which have electromechanical outputs. The STO circuit of the drive does not have electromechanical outputs. Also, the FSO and FSE-31 modules do not have electromechanical outputs.

Functional safety components

The mission time of functional safety components is 20 years which equals the time during which failure rates of electronic components remain constant. This applies to the components of the standard Safe torque off circuit as well as any modules, relays and, typically, any other components that are part of functional safety circuits.

The expiry of mission time terminates the certification and SIL/PL classification of the safety function. The following options exist:

- Renewal of the whole drive and all optional functional safety module(s) and components.
- Renewal of the components in the safety function circuit. In practice, this is economical only with larger drives that have replaceable circuit boards and other components such as relays.

Note that some of the components may already have been renewed earlier, restarting their mission time. The remaining mission time of the whole circuit is however determined by its oldest component.

Contact your local ABB service representative for more information.

Competence

The person who does the maintenance and proof test activities of the safety function must be a competent person with expertise and knowledge of the safety function and functional safety, as required by IEC 61508-1 clause 6.

Residual risk

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. Thus, the warnings for the residual risks must be given to the operators.

Intentional misuse

The safety circuit is not designed to protect a machine against intentional misuse.

Decommissioning

When you decommission a drive, make sure that the functional safety of the machine is maintained by other means until the decommissioning is completed.

10

Technical data

Contents of this chapter

This chapter gives the safety data, ambient conditions, and list of standards related to the product.

Safety data

Safety performance with different safety pulse encoders

Refer to FSE-31 pulse encoder interface module user's manual (3AXD50000016597 [English]).

This table gives the maximum PFH values for the safety encoder to fulfill the requirements for each safety integrity level.

Frame size	SIL 3 / PL e	SIL 2 / PL d	SIL 1 / PL c
R6…R8	7.8E-08	9.8E-07	1.0E-05
R9	7.8E-08	9.8E-07	1.0E-05
R10…R11	7.7E-08	9.8E-07	1.0E-05
R6i…R7i	7.7E-08	9.8E-07	1.0E-05
1×R8i	8.0E-08	9.8E-07	1.0E-05
2×R8i	8.0E-08	9.8E-07	1.0E-05
3×R8i	8.0E-08	9.8E-07	1.0E-05
4×R8i	8.0E-08	9.8E-07	1.0E-05
5×R8i	8.0E-08	9.8E-07	1.0E-05
6×R8i	8.0E-08	9.8E-07	1.0E-05
7×R8i	8.0E-08	9.8E-07	1.0E-05

Frame size	SIL 3 / PL e	SIL 2 / PL d	SIL 1 / PL c
8×R8i	8.0E-08	9.8E-07	1.0E-05
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Safety data values

The safety data is valid for the default design of the safety circuit shown in this manual. If the final design is different from the default design, and the customer has ordered safety data calculations (option +P947), ABB calculates the new safety data and delivers it separately to the customer.

The safety data calculations are based on the assumption that the emergency stop is used once a month.

The SLS switch, the safety encoder and other possible safety devices are not included in the calculations. The FSE-31 module is included in the calculations. The same safety data values apply to the SLS, SMS and SSM functions.

Frame size	SIL	SC	PL	PFH [1/h] [1]	PFD_{avg} (T_1=2a)	PFD_{avg} (T_1=5a)	DC [%] [2]	Cat.	HFT	CCF	T_M [a]	T_1 [a] [3] [4]
R6…R8	3	3	e	2.2E-08	3.6E-05	1.5E-04	≥90	3	1	80	20	20/5/2
R9	3	3	e	2.2E-08	3.5E-05	1.5E-04	≥90	3	1	80	20	20/5/2
R10…R11	3	3	e	2.3E-08	4.1E-05	1.7E-04	≥90	3	1	80	20	20/5/2
R6i…R7i	3	3	e	2.3E-08	4.3E-05	1.7E-04	≥90	3	1	80	20	20/5/2
1×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
2×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
3×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
4×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
5×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
6×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
7×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
8×R8i	3	3	e	2.0E-08	1.4E-05	1.0E-04	≥90	3	1	80	20	20/5/2
												3AXD10000097591 M

1) PFH values are according to EN ISO 13849.
2) DC for low demand mode is 90% (determined by the DC of the worst component in the subsystem).
3) See the Recommendation of Use CNB/M/11.050 published by the European coordination of notified bodies for lower T_1 requirement.
4) T_1 = 20a is used with high demand mode of operation. T_1= 2a/5a is used with low demand mode of operation.

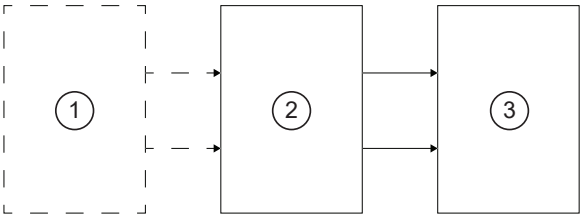
Safety component types

Safety component types as defined in IEC 61508-2:

- FSO module: type B
- FSE module: type B
- drive STO circuit:
  - frame sizes R1…R9 and drives with R6i…R7i inverter modules: type A
  - drives with R6i…R7i inverter modules and UCU-22, -23 or -24 control unit: type B
  - frame sizes R10 and R11 and drives with R8i inverter modules: type B.

Safety block diagrams

The components that are included in the safety data calculations are shown in the safety block diagram(s). The components not included in the drive delivery are not included in the safety data calculations.



1	SLS switch (not included in the drive delivery)
2	FSO module, and FSE module
3	Drive STO

Relevant failure modes

Relevant failure modes are:

- internal failures of the FSO module, the FSE module, and the drive STO.

These failures are included in the failure rate value of the function.

Fault exclusions

Fault exclusions (not considered in the calculations):

- short and open circuits in the cables of the safety circuit
- short and open circuits in the cabinet terminal blocks of the safety circuits.

Operation delays

Total delay: (less than) 500 ms (includes the response time of the drive STO).

Note: When using a safety encoder, you must add the delays of the encoder when defining the total response time for the safety function and the fault reaction function.

Ambient conditions

For the environmental limits for the safety functions and the drive, refer to the drive hardware manual and the FSO module user's manual.

Related standards and directives

Standard	Name
IEC 61800-5-2:2016 EN 61800-5-2:2007	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements – Functional
IEC 62061:2021 + AMD1:2024 EN IEC 62061:2021	Safety of machinery – Functional safety of safety-related control systems
EN ISO 13849-1:2023	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design

Standard	Name
EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems - Part 2: Validation
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronics safety related systems – Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronics safety related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61511-1:2016 + AMD1:2017	Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements
IEC 61000-6-7:2014	Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
IEC 61326-3-1:2017	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications
2006/42/EC	European Machinery Directive
	Supply of Machinery (Safety) Regulations 2008 (UK)
Other	Machine-specific C-type standards

Compliance with the European Machinery Directive

The drive is an electronic product which is covered by the European Low Voltage Directive. However, the drive internal safety function of this manual is in the scope of the Machinery Directive as a safety component. This function complies with European harmonized standards such as IEC/EN 61800-5-2.

Declaration of conformity according to EU Machinery Directive 2006/42/EU (3AXD10000105027)

Compliance with the Supply of Machinery (Safety) Regulations (UK)

The drive is an electronic product which is covered by the Electrical Equipment (Safety) Regulations. However, the drive internal safety function of this manual is in the scope of the Supply of Machinery (Safety) Regulations as a safety component. This function complies with designated standards such as EN 61800-5-2.

Declaration of conformity according to UK Supply of Machinery (Safety) Regulations 2008 (3AXD10001326695)

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/contact-centers.

Product training

For information on ABB product training, navigate to new.abb.com/service/training.

Providing feedback on ABB manuals

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