
OPTIONS FOR ABB DRIVES

Emergency stop, configurable stop category 0 or 1 (option +Q979) for ACS880-07/07LC/17/17LC/37/37LC drives

User's manual



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Table of contents



1. Safety instructions



4. Electrical installation



7. Start-up and validation test



Table of contents

1 Safety instructions

Contents of this chapter	7
Use of warnings and notes	7
Instructions for functional safety circuits	8
Electrical safety precautions	9

2 Introduction to the manual

Contents of this chapter	11
Applicability	11
Target audience	11
Exclusion of liability	12
Quick reference guide for taking a safety function into use	12
Related manuals	12
Terms and abbreviations	14

3 Option description

Contents of this chapter	15
Overview	15
Summary of wirings and settings	16
Operation principle	17
Time schemes with a speed estimate (no safety encoder)	18
Emergency stop, stop category 0	18
Emergency stop, stop category 1 with time monitoring	19
Emergency stop, stop category 1 with ramp monitoring	21
Time schemes with a safety encoder	23
Emergency stop, stop category 0	23
Emergency stop, stop category 1 with time monitoring	24
Emergency stop, stop category 1 with ramp monitoring	26
Operation principle diagrams	28
Fault reaction function	29
FSO module	29
Resetting the FSO module	30
FSE-31 module and safety encoder	30
Drive STO function	30

4 Electrical installation

Contents of this chapter	31
Wiring	31

5 Parameter settings

Contents of this chapter	33
Competence	33
FSO module parameter settings	33
General parameters	34



Parameters for the STO function	36
Parameters for the SSE function	38
I/O parameters	38
Parameters for Emergency stop, stop category 0	39
Parameters for Emergency stop, stop category 1	39
Changing the stop category from 0 to 1	41
FSE-31 module and safety pulse encoder related parameters	42
Drive parameter settings	44

6 Use of the safety function

Contents of this chapter	45
Activating the safety function	45
Resetting the safety function	46

7 Start-up and validation test

Contents of this chapter	47
Validation of the safety functions	47
Competence	47
Validation procedure	47
Validation test reports	48
Start-up and validation test	48

8 Maintenance

Contents of this chapter	51
Safety circuit maintenance	51
Proof test interval	51
Competence	52
Residual risk	52
Intentional misuse	52
Decommissioning	52

9 Technical data

Contents of this chapter	53
Safety data	53
Safety data values	53
ACS880-07/07LC/17/17LC/37/37LC drives without the FSE-31 module	53
ACS880-07/07LC/17/17LC/37/37LC drives with the FSE-31 module	54
Safety component types	54
Safety block diagrams	55
Relevant failure modes	55
Fault exclusions	55
Operation delays	55
Ambient conditions	56
Related standards and directives	56
Compliance with the European Machinery Directive	56

Further information



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.

Use of warnings and notes

Warnings tell you about conditions which can cause injury or death, or damage to the equipment. They also tell you how to prevent the danger. Notes draw attention to a particular condition or fact, or give information on a subject.

The manual uses these warning symbols:

**WARNING!**

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

**WARNING!**

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

**WARNING!**

Electrostatic sensitive devices warning tells you about the risk of electrostatic discharge which can cause damage to the equipment.

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.

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.



WARNING!

The safety function described in this manual does not isolate the main circuit or auxiliary circuit from the power supply. Do not do work on the drive, motor cable or motor before you have isolated the drive system from all power supplies and measured that there are no dangerous voltages. Before you start the work, do the steps in section *Electrical safety precautions (page 9)*.



WARNING!

(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.



WARNING!

Do the validation test of the safety function at the start-up and also after you make changes to the safety circuit.



WARNING!

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.



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 or maintenance work.



Electrical safety precautions

These electrical safety precautions are for all personnel 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 installation or maintenance work.

Go through these steps before you begin any installation or maintenance work.

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Make sure that re-connection is not possible. Lock out and tag out.
 - Open the main disconnecting device of the drive.
 - If you have a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
 - Disconnect all dangerous external voltages from the control circuits.
 - After you disconnect power from the drive, always wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
3. Protect any other energized parts in the work location against contact.
4. Take special precautions when close to bare conductors.
5. Measure that the installation is de-energized.
 - Before and after measuring the installation, verify the operation of the voltage tester on a known voltage source.
 - Make sure that the voltage between the drive input power terminals (L1, L2, L3) and the grounding (PE) busbar is zero.
 - Make sure that the voltage between the drive output terminals (T1/U, T2/V, T3/W) and the grounding (PE) busbar is zero.
 - Make sure that the voltage between the drive DC terminals (UDC+ and UDC-) and the grounding (PE) terminal is zero. In cabinet-built drives, measure between the drive DC busbars (+ and -) and the grounding (PE) busbar.
6. Install temporary grounding as required by the local regulations.
7. Ask the person in control of the electrical installation work for a permit to 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 +Q979: Emergency stop, configurable stop category 0 or 1 with STO, with FSO.

Required versions with the FSO-12 module:

- ACS880 primary control program: 1.80 or later
- FSO-12 safety functions module: revision C or later
- Drive composer pro: 1.6 or later.

Required versions with the FSO-21 module:

- ACS880 primary control program: 2.2 or later
- FSO-21 safety functions module: revision D or later
- FSE-31 pulse encoder interface module: revision D or later (if used)
- Drive composer pro: 1.8 or later.

This manual shows the default design of the safety circuit ordered with option code +Q979. 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	<input checked="" type="checkbox"/>
Connect the user-defined wiring (if any). See the wiring instructions in this manual and the circuit diagrams delivered with the drive.	<input type="checkbox"/>
Check and/or set the safety function related parameters (as listed in this manual).	<input type="checkbox"/>
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.	<input type="checkbox"/>
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.	<input type="checkbox"/>

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	3AUA0000085967
ACS880 primary control program quick start-up guide	3AUA0000098062
ACS880 diode supply control program firmware manual	3AUA0000103295
ACS880 IGBT supply control program firmware manual	3AUA0000131562
PC tools	
Drive composer start-up and maintenance PC tool user's manual	3AUA0000094606
Functional safety design tool user's manual	TT201312111015
Safety	
Functional safety; Technical guide No. 10	3AUA0000048753

Manual	Code
ABB Safety information and solutions	www.abb.com/safety
Options	
ACX-AP-x assistant control panels user's manual	3AUA0000085685
FSO-12 safety functions module user's manual	3AXD50000015612
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 the safety circuit is different from the default design)	

See www.abb.com/drives/documents for all manuals on the Internet.



[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)
E-stop	Emergency stop
Frame, frame size	Physical size of the drive or power module
FSE-31	Optional pulse encoder interface module for safety encoder
FSO-12, FSO-21	Optional functional safety modules
HFT	Hardware fault tolerance (IEC 61508)
IGBT	Insulated gate bipolar transistor
modoff	No modulation
NC	Normally closed
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)
POUS	Prevention of unexpected start-up
SAR	Safe acceleration range
SC	Systematic capability (IEC 61508)
SIL	Safety integrity level (1...3) (IEC 61508)
SILCL	Maximum SIL (level 1...3) that can be claimed for a safety function or subsystem (IEC/EN 62061)
SS1	Safe stop 1 (IEC/EN 61800-5-2)
SSE	Safe stop emergency
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.
TP	Test pulse
Zero speed	For safety functions, the zero speed limit indicates the completion of the safe stopping function.



Option description

Contents of this chapter

This chapter describes the operation and settings of the option +Q979: Emergency stop, configurable stop category 0 or 1 with STO, with FSO.

Overview

Option +Q979 uses the FSO-12 safety functions module (option +Q973) or the FSO-21 safety functions module (option +Q972) for the emergency stop safety function. In this emergency stop option, the drive STO function is activated. The main contactor/breaker of the drive is not opened.

ABB installs the FSO module, and the emergency stop circuit to the drive. ABB sets default parameter values for the option at the factory. The user adjusts the operation of the emergency stop function with the safety parameters at the start-up, for example, sets the stop category (0 or 1). ABB sets stop category 0 at the factory.

If option +L521 is selected, ABB installs the FSO-21 safety functions module and FSE-31 pulse encoder interface module to the drive. With this option, you can use a safety encoder in the application.

Note: The FSO-12 module is not compatible with the FSE-31 module or safety encoders.

The option +Q979 supports the following emergency stop functions:

- Emergency stop, stop category 0
This is an uncontrolled stop (IEC/EN 60204-1). When the user pushes the emergency stop button, the Safe torque off (STO) function of the FSO module is activated. This activates the drive STO function. The motor coasts to a stop.
- Emergency stop, stop category 1
This is a controlled stop (IEC/EN 60204-1). When the user pushes the emergency stop button, the Safe stop 1 function (SS1) of the FSO module is activated. After the drive decelerates the motor speed to a user-defined zero speed limit, the FSO module activates the drive STO function.
The SS1 function can operate in time monitoring or in ramp monitoring mode. In time monitoring mode, the FSO module monitors that a user-defined deceleration time limit is not exceeded. In ramp monitoring mode, the FSO module monitors that the motor decelerates along a user-defined stop ramp.

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

To start the drive, the user must release the emergency stop button and then push the emergency stop reset button for 0.3 ... 3 s. This resets the emergency stop circuit and deactivates the drive STO.

Note: ACS880-07/07LC drives, frames n×DXT + n×R8i with a main contactor/breaker (option +F250/+F255), ACS880-17/17LC/37/37LC drives, frames n×R8i + n×R8i, and ACS880-17/37 drives, frames R8 and R11: When the inverter unit STO is activated, the main contactor/breaker is opened after a user-defined delay (defined with parameter 94.11, the default value is 600 s). See the hardware and firmware manuals for more information.

For a detailed description of the drive Safe torque off function, see the hardware manual of your drive. For more information on the safety functions of the FSO module, see *FSO-12 safety functions module user's manual* (3AXD50000015612 [English]) or *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]). For more information on the FSE-31 module, see *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

The design principles of the option +Q979 comply with EN ISO 13850.

The STO and SS1 functions comply with IEC/EN 61800-5-2. For a complete list of related standards and European directives, see section [Related standards and directives \(page 56\)](#).

■ Summary of wirings and settings

The wirings and settings of the emergency stop function are:

- The drive is equipped with the FSO safety functions module (option +Q973 or +Q972). ABB installs the module at the factory.
 - One emergency stop button is installed on the cabinet door and wired to the FSO module. ABB wires the button at the factory. The user can add buttons to the emergency stop circuit.
-

- One emergency stop reset button is installed on the cabinet door and wired to the FSO module. The reset button also includes an emergency stop indication lamp. ABB wires the button and the indication lamp at the factory. The user can add reset buttons to the reset circuit.
- The digital output of the FSO module to which the emergency stop indication lamp is connected, is selected as the output for the Stop completed signal. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.

Emergency stop, stop category 0:

- The digital inputs of the FSO module to which the emergency stop button is connected, are selected as the inputs for the STO request. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.

Emergency stop, stop category 1:

The user must set these FSO module parameters at start-up:

- The digital inputs of the FSO module to which the emergency stop button is connected, are selected as the inputs for the SS1 request.
- The SS1 function is set to use either the time monitoring or ramp monitoring mode.
- The stop ramp that is used to decelerate the motor(s) and the monitoring limits (stop ramp time or ramp monitoring limits) are set according to the application requirements.

Additional requirements when a safety encoder is used:

- The drive is equipped with a FSO-21 safety functions module and FSE-31 pulse encoder interface module. If option +L521 is selected, ABB installs the modules at the factory.
- The motor must be equipped with a safety encoder. The user installs and connects the safety encoder to the FSE-31 module. The user must make sure that the required safety integrity (SIL/PL) can be achieved with the used safety encoder.

Operation principle

The operation and configuration of the emergency stop function is slightly different with and without a safety encoder. Only the FSO-21 module supports the safety encoder interface, and you can also use it without a safety encoder.

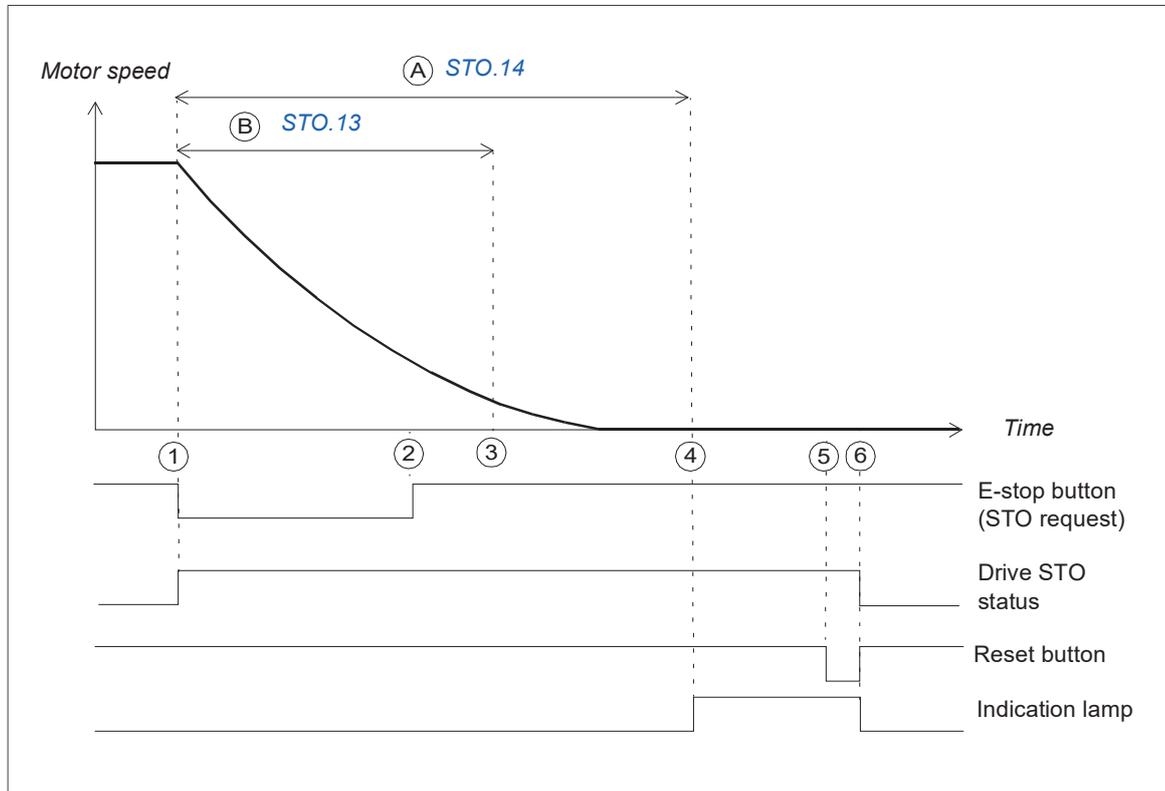
Note: The Emergency stop, stop category 1 function uses the SS1 function of the FSO module. The SS1 function uses SAR1 parameters to define the stop ramp. In some situations (for example, in internal fault situations or due to another safety function) the FSO module can activate the Safe stop emergency (SSE) function. The SSE function uses SAR0 parameters to define the stop ramp.

Note: If the FSO module activates the SSE function while the SS1 function is active, the SSE function overrides the SS1 function. Therefore, SAR0 parameters are used instead of SAR1 parameters to define the stop ramp. You must take this into account when you use the SS1 function to implement an emergency stop (stop category 1).

■ Time schemes with a speed estimate (no safety encoder)

Emergency stop, stop category 0

This time scheme diagram illustrates the operation of the Emergency stop, stop category 0 safety function. This option uses the Safe torque off (STO) function of the FSO module.



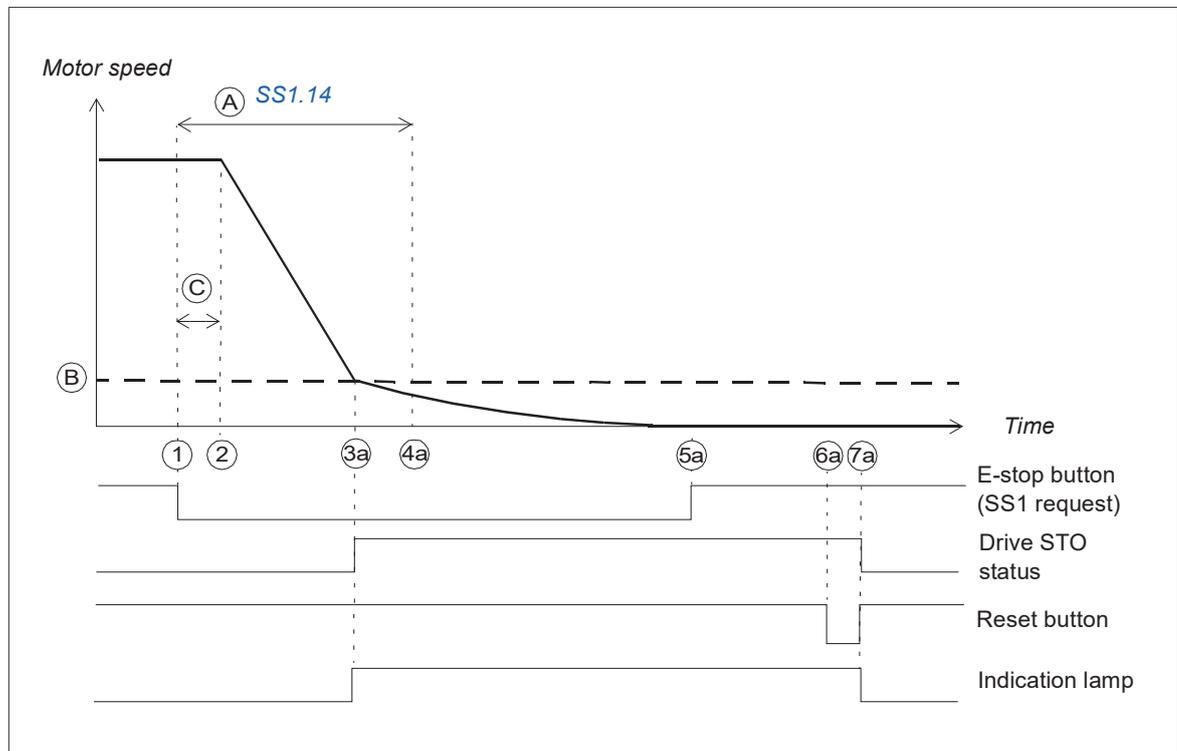
- A Time to zero speed: Time from the activation of the STO function to the moment when the STO function is completed. The indication lamp comes on. The user must set this to the time that it takes for the motor to coast from the maximum speed to zero speed (parameter *STO.14 Time to zero speed with STO and modoff*).
- B Restart delay: Delay from pushing the emergency stop button (and activation of the STO function) to the moment when acknowledgement of the safety function is permitted at the earliest. With this parameter, it is possible to let the drive restart while the motor is still running (fly-start) (parameter *STO.13 Restart delay after STO*).

1. The user pushes the emergency stop button. The FSO module activates the FSO and drive STO functions. The FSO module starts timers for delays A and B.
2. The user releases the emergency stop button.
3. Time B has elapsed. Acknowledgement of the STO function is possible even though the motor is still running. (In this example, the user pushes the reset button in step 5.)
4. Time A has elapsed. The motor has stopped and the emergency stop indication lamp comes on.
5. The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Emergency stop, stop category 1 with time monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with time monitoring. This option uses the Safe stop 1 (SS1) function of the FSO module.

Case A: The motor speed reaches the zero speed limit within the user-defined time

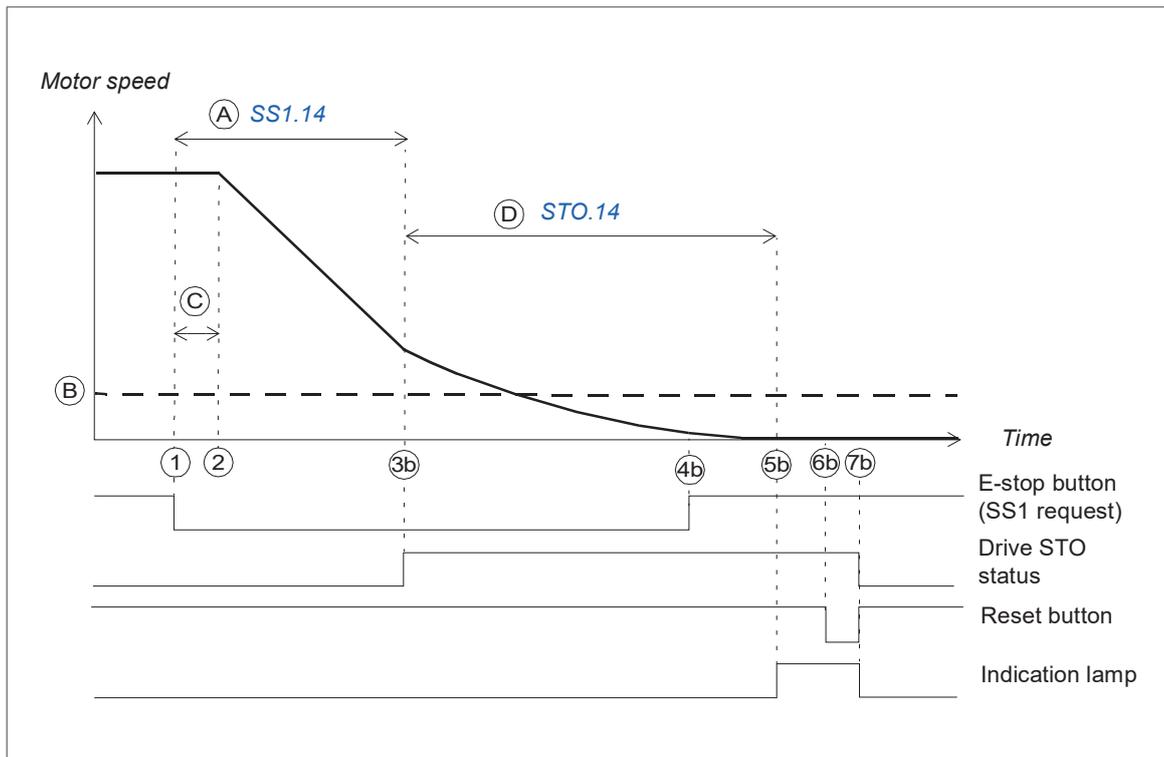


- A SS1-t monitoring time: When time A has elapsed, the FSO module activates STO function.
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).
- C Safety function response time.

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. a) The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO function. The emergency stop indication lamp comes on.
Note: You can set an additional delay for the STO activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).
4. a) Time A has elapsed. The STO function is already active. In this case, this time has no effect.
5. a) The user releases the emergency stop button.
6. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. a) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not reach the zero speed limit within the user-defined time

Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.



- A SS1-t monitoring time: When time A has elapsed from the start of the counter (step 1), the FSO module activates FSO and the drive STO functions (case B). In case A, the FSO module has already activated the STO function. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *FSGEN.51 Zero speed without encoder*).
- C Safety function response time.
- D Time to zero speed: When time D has elapsed from the start of the counter (step 3b, activation of the STO function), acknowledgement of the STO function is possible. The user must set this to the time it takes for the motor to coast from the maximum speed to zero speed (parameter *STO.14 Time to zero speed with STO and modoff*).

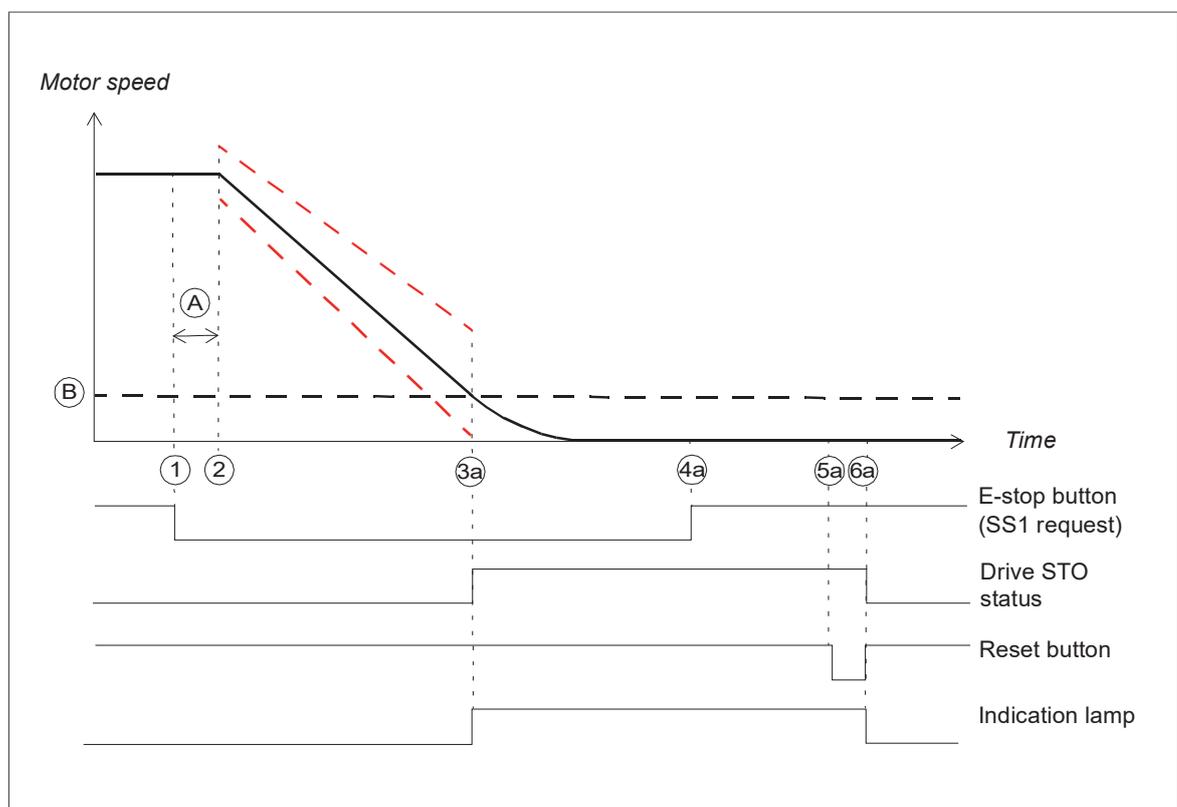
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. b) The FSO module activates the FSO and drive STO functions (case B) and starts a counter for time D. The motor coasts to a stop.
4. b) The user releases the emergency stop button.
5. b) Time D has elapsed. The motor has stopped and the emergency stop indication lamp comes on. Acknowledgement of the STO function is possible.

6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Emergency stop, stop category 1 with ramp monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with ramp monitoring. This option uses the Safe stop 1 (SS1) function of the FSO module.

Case A: The motor speed reaches the zero speed limit within the user-defined stop ramp monitoring window



- A Safety function response time.
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).

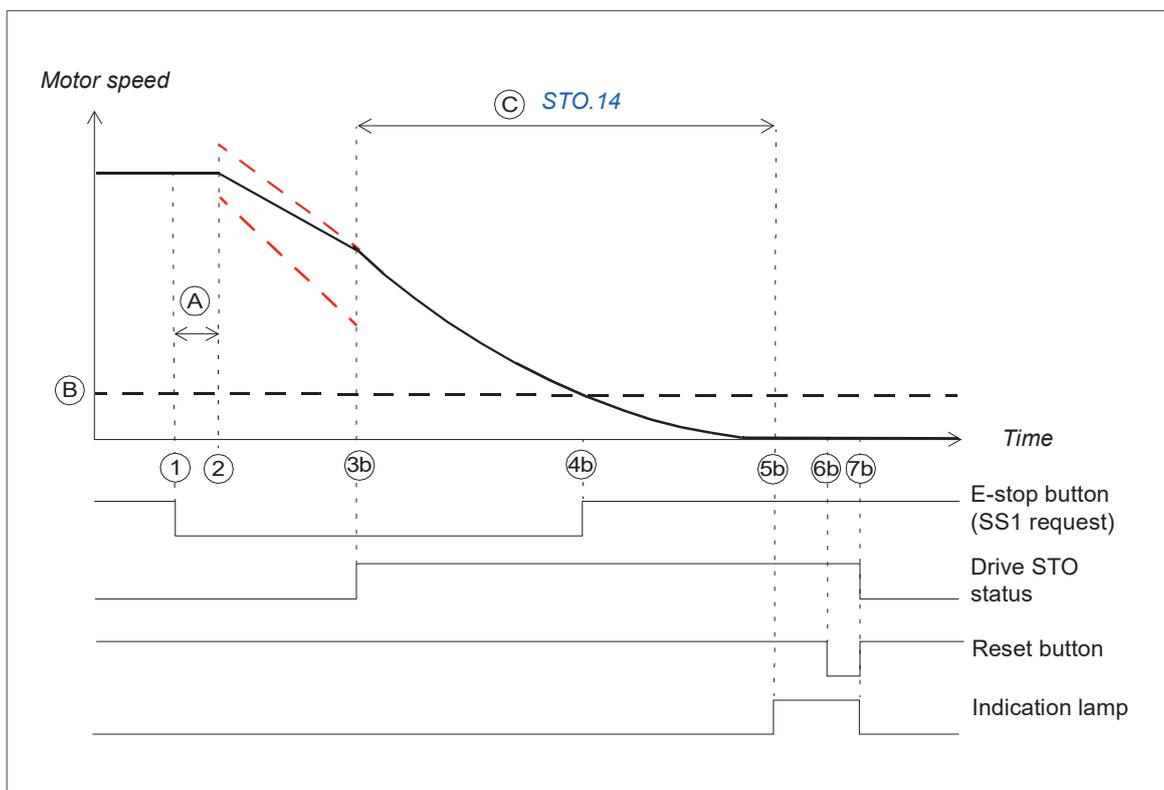
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).

3. a) The motor speed reaches the zero speed limit. The FSO module activates the drive STO function and stops the ramp monitoring. The emergency stop indication lamp comes on.

Note: You can set an additional delay for the STO activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).

4. a) The user releases the emergency stop button.
5. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. a) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not follow the user-defined stop ramp monitoring window



- A Safety function response time.
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).
- C Time to zero speed: When time C has elapsed from the start of the counter (step 3b, activation of the STO function), Acknowledgement of the STO function is possible. The user must set this to the time it takes for the motor to coast from the maximum speed to zero speed (parameter *STO.14 Time to zero speed with STO and modoff*).

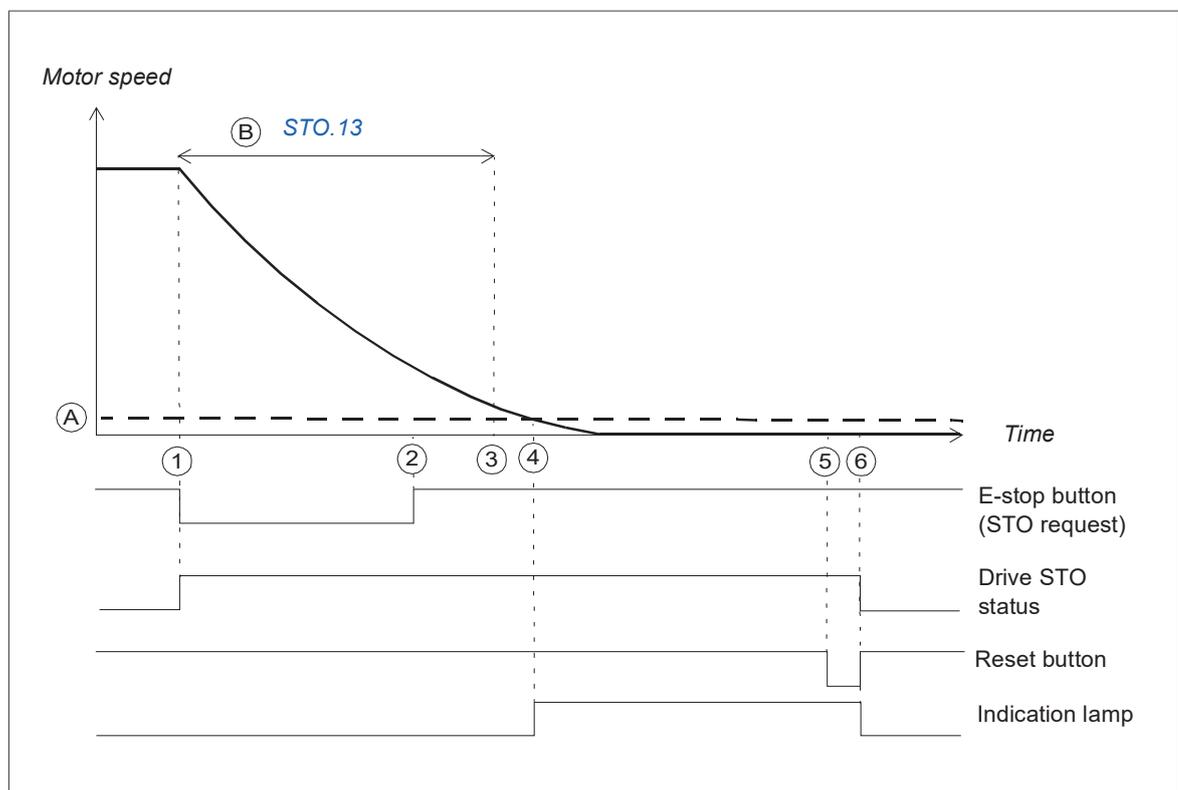
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).
3. b) The FSO module activates the FSO and drive STO functions and stops the ramp monitoring. The FSO module starts a counter for (C). The motor coasts to a stop.

4. b) The user releases the emergency stop button.
5. b) Time C has elapsed. The motor has stopped. The emergency stop indication lamp comes on. Acknowledgement of the STO function is possible.
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

■ Time schemes with a safety encoder

Emergency stop, stop category 0

This time scheme diagram illustrates the operation of the Emergency stop, stop category 0 safety function when a safety encoder is used. This option uses the Safe torque off (STO) function of the FSO-21 module.



- A Zero speed with encoder: Speed limit at which the motor has stopped, the safety function is completed and the emergency stop indication lamp comes on (parameter *FSOGEN.52 Zero speed with encoder*).
- B Restart delay: Delay from pushing the emergency stop button (and activation of the STO function) to the moment when the acknowledgement of the safety function is permitted at the earliest. With this parameter, it is possible to allow a restart of the drive while the motor is still running (fly-start) (parameter *STO.13 Restart delay after STO*).

1. The user pushes the emergency stop button. The FSO module activates the FSO and drive STO functions. The FSO module starts a timer for delay B.
2. The user releases the emergency stop button.

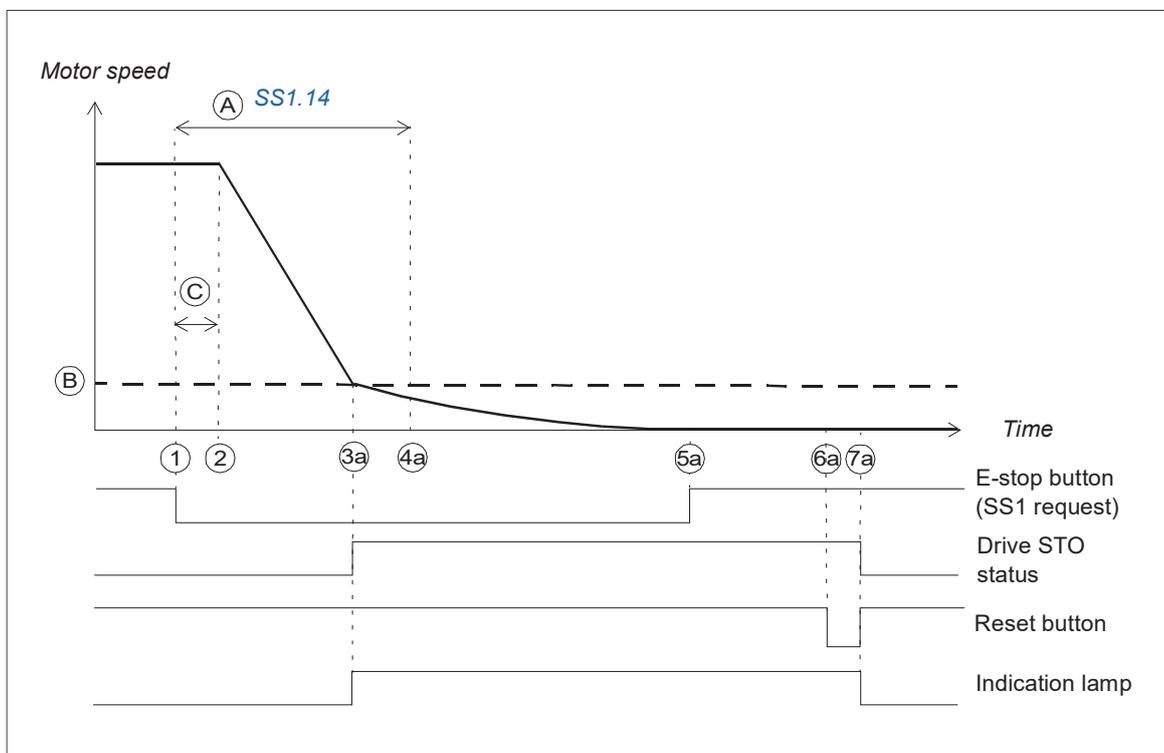
24 Option description

3. Time B has elapsed. Acknowledgement of the STO function is possible even though the motor is still running. (In this example, the user pushes the reset button in step 5.).
4. The motor speed goes below the zero speed limit (A). The motor has stopped and the emergency stop indication lamp comes on.
5. The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Emergency stop, stop category 1 with time monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with time monitoring when a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module.

Case A: The motor speed reaches the zero speed limit within the user-defined time



- A SS1-t monitoring time: When time A has elapsed from the start of the timer (step 1), the FSO module activates FSO and drive STO functions (case B). In case A, the FSO module has already activated the STO function. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *F SOGEN.52 Zero speed with encoder*).
- C Safety function response time.

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).

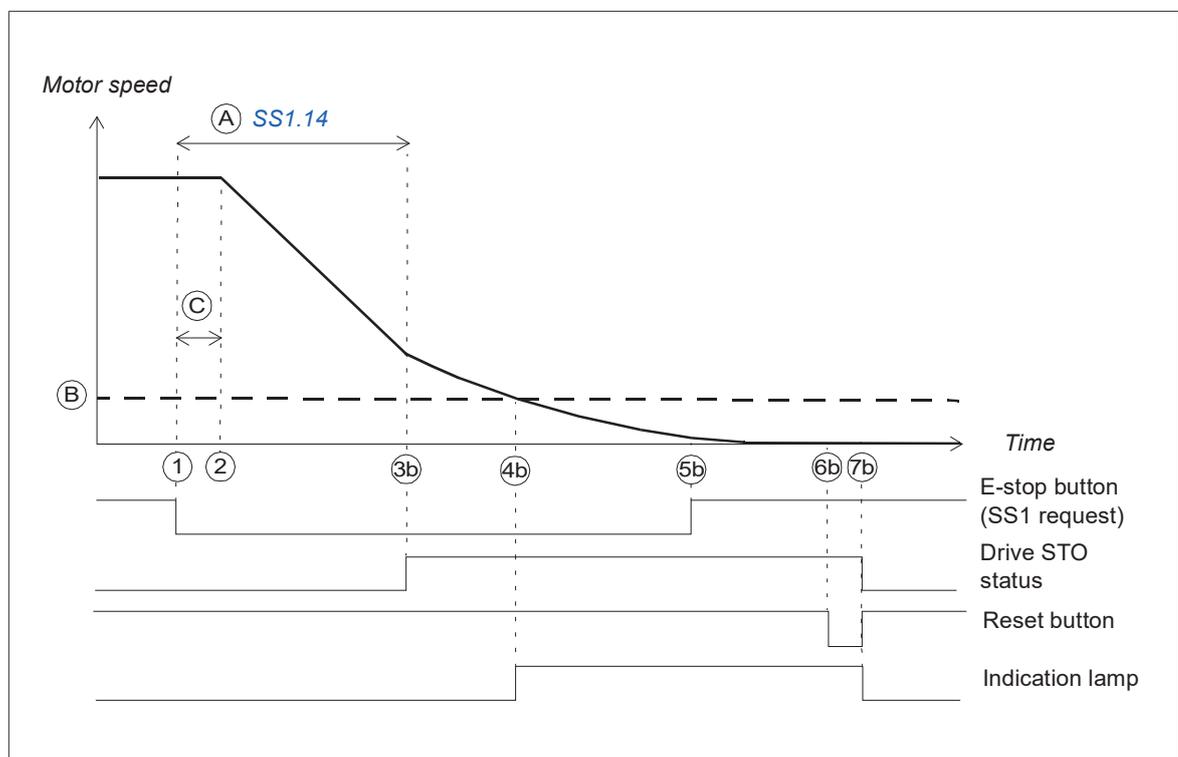
3. a) The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO function. The emergency stop indication lamp comes on.

Note: You can set an additional delay for the STO activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).

4. a) Time A has elapsed. The STO function is already active. In this case, this time has no effect.
5. a) The user releases the emergency stop button.
6. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. a) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not reach the zero speed limit within the user-defined time

Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.



- A SS1-t monitoring time: When time A has elapsed from the start of the timer (step 1), the FSO module activates FSO and drive STO functions (case B). In case A, the FSO module has already activated the STO function. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
- B Zero speed limit: Speed limit for activating the drive STO function. This is a user-defined value (parameter *FSGEN.52 Zero speed with encoder*).
- C Safety function response time.

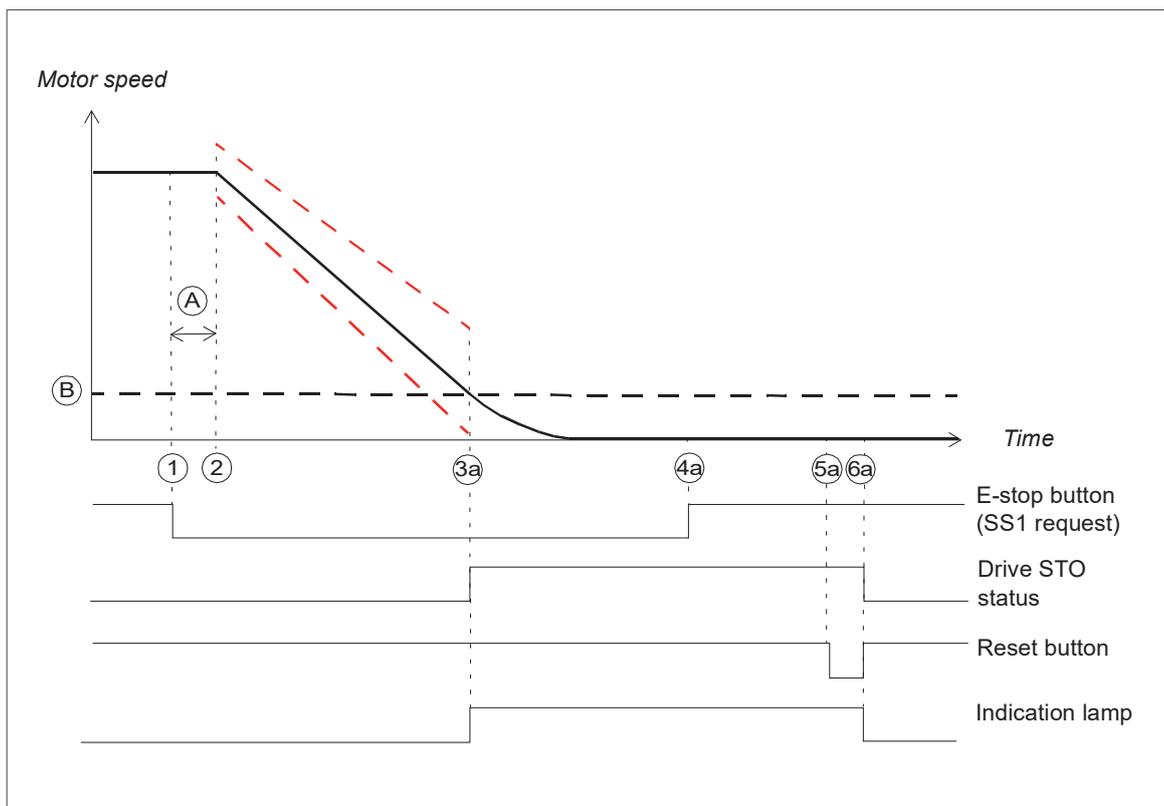
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).

3. b) The FSO module activates the FSO and drive STO functions. The motor coasts to a stop.
4. b) The motor speed reaches the zero speed limit (B). The emergency stop indication lamp comes on. The motor has stopped. Acknowledgement of the STO function is possible.
5. b) The user releases the emergency stop button.
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Emergency stop, stop category 1 with ramp monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with ramp monitoring when a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module.

Case A: The motor speed reaches the zero speed limit within the user-defined stop ramp monitoring window

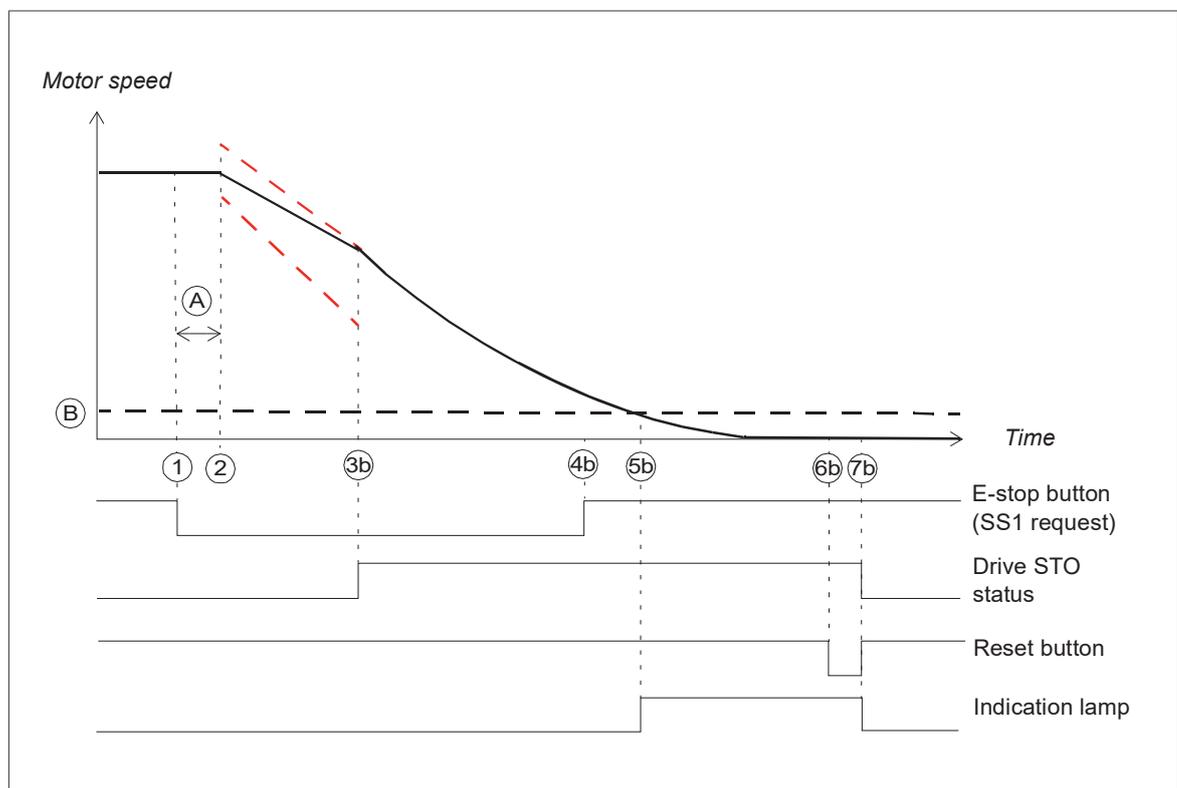


A Safety function response time.

B Zero speed limit: Speed limit for activating the STO function. This is a user-defined value (parameter *FSOGEN.52 Zero speed with encoder*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).
3. a) The motor speed reaches the zero speed limit (B). The FSO module activates the drive STO function and stops the ramp monitoring. The emergency stop indication lamp comes on.
Note: You can set an additional delay for the STO activation (parameter SS1.15 SS1-r ramp zero speed delay for STO).
4. a) The user releases the emergency stop button.
5. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. a) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not follow the user-defined stop ramp monitoring window



- A Safety function response time.
- B Zero speed limit: Speed limit for activating the STO function. This is a user-defined value (parameter FSOGEN.52 Zero speed with encoder).

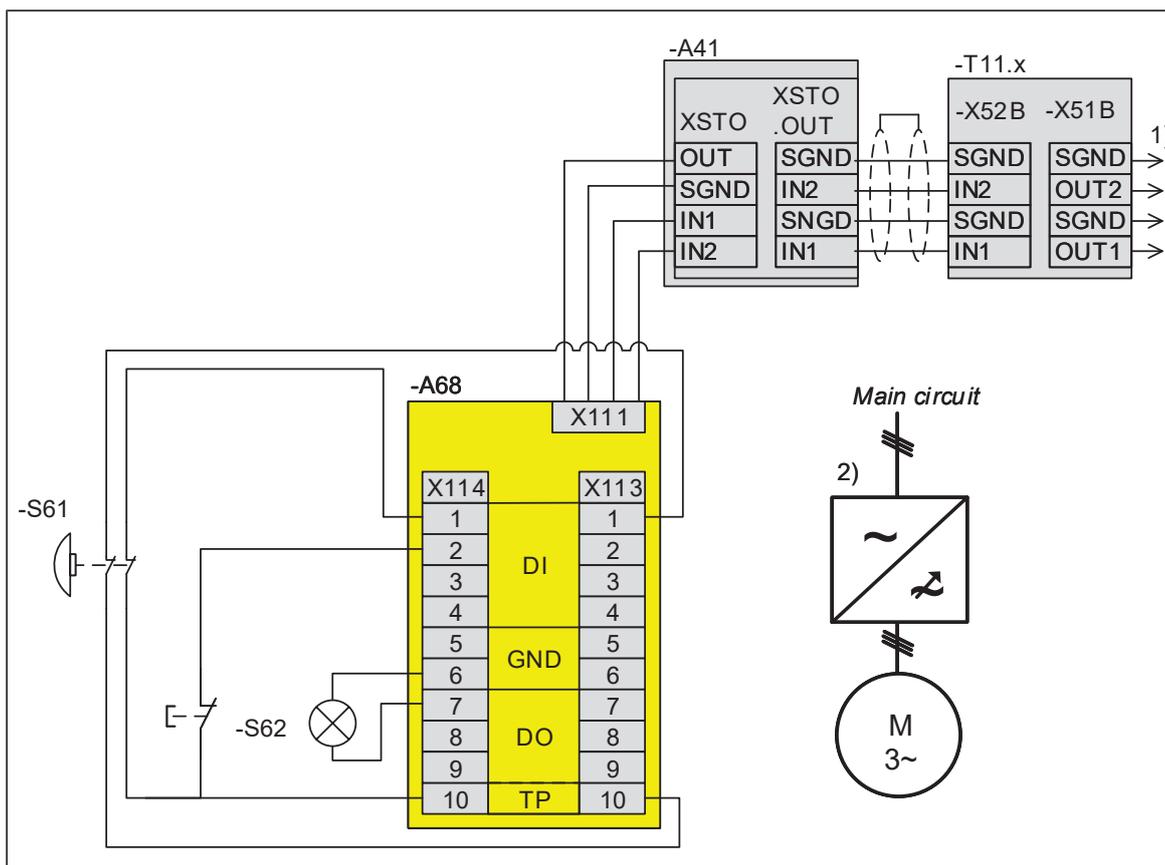
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).

3. b) The FSO module activates the FSO and drive STO functions and stops the ramp monitoring. The motor coasts to a stop.
4. b) The user releases the emergency stop button.
5. b) The motor speed reaches the zero speed limit (B). The emergency stop indication lamp comes on. The motor has stopped. Acknowledgement of the STO function is possible.
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

■ **Operation principle diagrams**

This diagram is an example circuit diagram without the safety encoder interface.

This figure shows a simplified operation principle. For a more detailed description, refer to the circuit diagrams delivered with the drive.



1)	To parallel inverter modules (if any)
2)	Drive module
A41	Inverter control unit
A68	Safety functions module FSO-12/-21
S61	Emergency stop button

S62	Emergency stop reset button with indicator light
X111	STO connections to inverter control unit
X113, X114	Terminal block in the FSO module
T11.x	Inverter module(s) under inverter unit T11 (only for R8i)
TP	Test pulse(s) for digital input

Step	Operation
	Initial status: The drive is in operation and the motor is running.
1	The user activates emergency stop with the emergency stop button [S61]. This activates the safety function in the FSO module.
2	<u>Emergency stop, stop category 0</u> : The FSO module [A68] activates the drive STO function. The motor coasts to a stop. <u>Emergency stop, stop category 1</u> : The drive decelerates the motor to zero speed. The FSO module [A68] then activates the drive STO function.
3	The emergency stop reset button indicator light [S62] comes on.
4	Normal operation resumes after the user: <ul style="list-style-type: none"> • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62], which resets the emergency stop circuit • resets the drive/inverter unit if a fault was generated (see FSO parameter <i>FSOGEN.61 STO indication ext request</i>, and drive parameter <i>31.22 STO indication run/stop</i>) • makes sure that the drive has received the start signal (depends on the configuration, see the firmware manual).

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.

Examples of different failures:

- a short or open circuit or redundancy failure of the emergency stop button wiring chain
- an internal failure in the FSO or FSE-31 modules, the safety encoder or the drive STO.

This section describes the fault reaction functions in the FSO and FSE-31 modules, the safety encoder and 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. See section [Resetting the FSO module \(page 30\)](#).

For more information, see the drive 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 the drive 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 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, see the drive 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. See the hardware and firmware manuals of the drive.



Electrical installation

Contents of this chapter

This chapter describes the wiring of the safety option done at the factory and contains guidelines for making user connections.

Wiring

One emergency stop button and one reset button are installed on the cabinet door and wired to the FSO module at the factory. There are double contacts in the emergency stop button and double wiring (redundant two-channel connection) between the button and the FSO module.

There is an extension terminal block [X68] inside the drive cabinet. The tables below 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

If necessary, install additional emergency stop buttons on site. Refer to the circuit diagrams delivered with the drive. Obey these general rules:

1. Use only double-contact buttons approved for emergency stop circuits.
2. Connect the emergency stop buttons 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.
Note: The safety circuit design can be different when modified according to the customer's safety requirements. Refer to the circuit diagrams delivered with the drive.
3. Use shielded, twisted pair cables. ABB recommends double-shielded cable and gold-plated contacts in the emergency stop button.
4. The maximum permitted cable length between the drive and the emergency stop button is 250 m (820 ft).
5. Obey the general control cable installation instructions given in the drive hardware manual and in the FSO module user's manual.

If necessary, install additional reset buttons and indication lamps for the emergency stop circuit on site. ABB recommends gold-plated NC contacts in the reset button. The maximum permitted cable length between the drive and the reset button (for the whole loop) is 250 m (820 ft). Refer to the circuit diagrams of the delivery. Obey the general control cable installation instructions given in the hardware manual and in the FSO module user's manual.

If you use a safety encoder in the application: Connect the safety encoder to the FSE-31 module on site. Obey the instructions of the encoder manufacturer and the following 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, see *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).



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Parameter settings

Contents of this chapter

This chapter contains 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, see the FSO module user's manual. For more information on Drive composer pro, see *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 pre-set 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, see 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 certain safety functions only. These tables list all the parameters that you must check and set for option +Q979. The example values are applicable only to option +Q979.

■ General parameters

These parameters are common to all safety functions.

Index	Name	Example value	Description
FSOGEN.11	Stop completed output	DO X114:7	Sets the digital output that indicates the completion of any stop function. Active when the FSO module has completed the STO, SSE or SS1 function. For option +Q979, ABB has configured the emergency stop indication lamp to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
FSOGEN.21	Motor nominal speed	1500 rpm	Sets the nominal motor speed. Must be equal to the value on the motor rating plate.
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. <i>Automatic:</i> You do not need to push a reset button after switching on the FSO module. The FSO module generates the acknowledgement signal automatically after the power-up. <i>Manual:</i> The FSO module reads the external acknowledgement signal through the digital input defined by parameter <i>FSOGEN.42</i> . Make sure that the value is <i>Automatic</i> .
FSOGEN.42	Acknowledgement button input	DI X114:2	Sets the digital input for the acknowledgement signal when parameter <i>FSOGEN.41 Power-up acknowledgement</i> or <i>STO.02 STO acknowledgement</i> is set to <i>Manual</i> . For option +Q979, ABB has configured the emergency stop reset button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.

Index	Name	Example value	Description
FSOGEN.51	Zero speed without encoder	90 rpm	<p>Sets the general zero speed limit for safety functions when no safety encoder is in use.</p> <p><u>Emergency stop, stop category 0</u>: This value has no effect in the operation.</p> <p><u>Emergency stop, stop category 1</u>: The FSO module activates the drive STO function when the drive has decelerated the motor speed below this value. Adjust the default value when necessary.</p>
FSOGEN.52	Zero speed with encoder	10 rpm	<p>Sets the general zero speed limit for safety functions when a safety encoder is in use.</p> <p><u>Emergency stop, stop category 0</u>: The indication lamp comes on when the motor speed goes below this value. Adjust the default value when necessary.</p> <p><u>Emergency stop, stop category 1</u>: The FSO module activates drive STO function when the drive has decelerated the motor speed below this value. Adjust the default value when necessary.</p> <p>Note: This parameter is used only with FSO-21 and when a safety encoder is used in the application.</p>
FSOGEN.61	STO indication ext request	Warning	<p>Sets the type of the indication that the FSO module generates and sends to the drive after external requests that end to a successful activation of the drive STO (STO, SSE or SS1).</p> <p>In the safety functions described in this manual, you can use this indication as the Emergency stop indication message. Adjust the default value when necessary.</p>
FSOGEN.62	STO indication safety limit	Fault	<p>Sets the type of the indication that the FSO module generates and sends to the drive/inverter unit for limit hits during ramp and time monitoring of safety ramps SAR0 and SAR1.</p> <p><u>Emergency stop, stop category 0</u>: This value has no effect in the operation.</p> <p><u>Emergency stop, stop category 1</u>: When the motor speed does not follow the stop ramp or the time limit is exceeded, the FSO module activates the STO function and generates this user-defined indication.</p> <p>Check the default setting and adjust if necessary. If you select <i>Fault</i>, you must reset the drive before you can restart it.</p>

■ 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 Emergency stop, stop category 0 safety function uses this function.

Index	Name	Example value	Description
STO.02	STO acknowledgement	Manual	<p>Sets the acknowledgement method used in the STO, SSE and SS1 functions.</p> <p><i>Manual:</i> The FSO module reads the external acknowledgment signal through the digital input defined by parameter <i>FSOGEN.42</i>.</p> <p>In the safety functions described in this manual, the user acknowledges the safety function manually with the emergency stop reset button. Make sure that the value is <i>Manual</i>.</p> <p> WARNING! If the value is set to <i>Automatic</i>, the FSO module resets the STO function automatically after the user releases the emergency stop button. The drive can restart automatically, if automatic start mode is used. This can cause danger.</p>
STO.11	STO input A	<p><u>Stop cat. 0:</u> DI X113:1 & X114:1</p> <p><u>Stop cat. 1:</u> None</p>	<p>Sets the digital input that is connected to the primary input of the STO function.</p> <p><u>Emergency stop, stop category 0:</u> For option +Q979, ABB has connected the emergency stop button to this digital input at the factory. Make sure that the setting corresponds to the circuit diagrams of the delivery.</p> <p><u>Emergency stop, stop category 1:</u> Make sure that this parameter is set to <i>None</i>. (An external signal cannot start the STO function.)</p>
STO.13	Restart delay after STO	2000 ms	<p>Sets the time after which the restart of the drive is allowed after the FSO module has activated the drive STO. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). This parameter is valid only if the STO function is requested from STO input A (<i>STO.11</i>).</p> <p><u>Emergency stop, stop category 0:</u> Adjust the value when necessary. If you do not want to use the fly-start feature, set this parameter to the same value as parameter <i>STO.14</i>.</p> <p><u>Emergency stop, stop category 1:</u> This value has no effect.</p>

Index	Name	Example value	Description
STO.14	Time to zero speed with STO and modoff	2000 ms	<p>The time it takes for the motor to coast to a standstill from maximum process speed. This must be measured with 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).</p> <p>Acknowledgement is allowed after coast stop in the STO, SSE and SS1 functions (when SBC is not used). If SBC is used, see parameter <i>SBC.13 SBC time to zero speed</i>.</p> <p>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 <i>STO.13 Restart delay after STO</i> defines the time after which the acknowledgement is allowed.</p> <p>If the drive STO is activated or modulation stopped while a monitoring safety function is indicating "unsafe", after this time acknowledgement is allowed. For example, if the drive modulation is lost during SLS deceleration ramp, SLS OK will be indicated after this time has elapsed.</p> <p>When an encoder is used: This parameter is relevant only if there is an encoder failure and the FSO module activates the STO function.</p>
SBC usage			
SBC.11	STO SBC usage	None	<p>Sets how the mechanical brake is used together with the STO function.</p> <p><i>None</i>: This feature is not in use.</p> <p>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. See the FSO module user's manual.</p>

■ Parameters for the SSE function

These parameters are related to the Safe stop emergency (SSE) function of the FSO module. The safety functions described in this manual do not use this function, but 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	<p>Sets the type of the SSE function.</p> <p><i>Immediate STO</i>: The FSO module activates the drive STO function immediately after the SSE request.</p> <p><i>Emergency ramp</i>: 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, see the FSO module user's manual. Zero speed is defined by parameter <i>FSOGEN.51 Zero speed without encoder</i> or <i>FSOGEN.52 Zero speed with encoder</i>.</p> <p>For option +Q979, ABB sets this parameter to value <i>Immediate STO</i> at the factory. Adjust the default value when necessary.</p>
SBC usage			
SBC.15	SSE/SS1 SBC speed	0 rpm	<p>Sets the absolute speed below which the FSO module activates the brake (SBC) while ramping.</p> <p><i>0 rpm</i>: The feature is not in use.</p> <p>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. See the FSO module user's manual.</p>

■ I/O parameters

For indication lamps, set the logic state of the corresponding digital output to *Active high*. For digital inputs, set the diagnostic pulse setting to *On*.

Index	Name	Example value	Description
SAFEIO.33	DI X113:1 diag pulse on/off	On ¹⁾	<p>Sets the diagnostic pulse of digital input X113:1 on or off.</p> <p><i>On</i>: The input monitors that it receives test pulses.</p> <p>For option +Q979, ABB has configured the emergency stop button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</p>
SAFEIO.37	DI X114:1 diag pulse on/off	On ¹⁾	<p>Sets the diagnostic pulse of digital input X114:1 on or off.</p> <p><i>On</i>: The input monitors that it receives test pulses.</p> <p>For option +Q979, ABB has configured the emergency stop button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</p>

Index	Name	Example value	Description
SAFEIO.38	DI X114:2 diag pulse on/off	On	Sets the diagnostic pulse of digital input X114:2 on or off. <i>On</i> : The input monitors that it receives test pulses. For option +Q979, ABB has configured the emergency stop reset button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.74	DO X114:7 logic state	Active high	Sets the logic state of digital output X114:7. <i>Active high</i> : The digital output is on when the indicated signal is active. For option +Q979, ABB has configured the emergency stop indication lamp to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.

¹⁾ The safety data given in this manual is based on the assumption that this diagnostic measure for the emergency stop button wiring is active (On). If pulsing is disabled, other measures should be considered to ensure sufficient diagnostic coverage of the emergency stop button wiring.

■ Parameters for Emergency stop, stop category 0

The Emergency stop, stop category 0 safety function uses the STO function of the FSO module, see section [Parameters for the STO function \(page 36\)](#). There are no additional parameters related to this function.

■ Parameters for Emergency stop, stop category 1

The Emergency stop, stop category 1 safety function uses the SS1 function of the FSO module. Set these parameters only for this function.

Index	Name	Example value	Description
SS1.01	SS1 activity and version	Version 1	Activates or deactivates the SS1 function and shows the version of the SS1 function. <i>Version 1</i> : Activates version 1 of the SS1 function.
SS1.11	SS1 input A	DI X113:1 & X114:1	Sets the digital input that is connected to the primary input of the SS1 function. For option +Q979, ABB has connected the emergency stop button to this input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery. Make also sure that you do not use the same input for other functions at the same time (such as the STO function).

40 Parameter settings

Index	Name	Example value	Description
SS1.13	SS1 type	SS1-r or SS1-t	<p>Sets the method used for the SS1 monitoring. Adjust the default value when necessary.</p> <p><u>Time monitoring (SS1-t)</u>: The FSO module monitors that a user-defined deceleration time limit is not exceeded. (See parameter <i>SS1.14</i>.)</p> <p><u>Ramp monitoring (SS1-r)</u>: The FSO module monitors that the motor decelerates along a user-defined stop ramp. (See SAR1 ramp parameters <i>200.112</i>, <i>SARx.21</i>, <i>SARx.22</i> and <i>SARx.02</i>.)</p>
SS1.14	SS1-t delay for STO	20000 ms	<p>Sets the SS1-t monitoring time after which the FSO module activates the drive STO at the latest, if the motor speed has not reached the zero speed limit (parameter <i>F SOGEN.51</i> or <i>F SOGEN.52</i>) yet. For more information, see the operation time scheme diagrams.</p> <p><u>Time monitoring</u>: This value sets the security delay that the FSO module monitors. Adjust the default value when necessary.</p> <p><u>Ramp monitoring</u>: This value has no effect in the operation.</p>
SS1.15	SS1-r ramp zero speed delay for STO	0 ms	<p>Sets an extra delay time for the activation of the drive STO at the zero speed limit in the SS1 function.</p> <p>With this parameter, the FSO module delays the STO activation so that the drive is able to reach the axle zero speed before the FSO module activates the STO function.</p> <p>The delay counter starts when the motor speed reaches the zero speed limit (parameter <i>F SOGEN.51</i> or <i>F SOGEN.52</i>). After this delay has elapsed, the FSO module activates the drive STO function. You can use this parameter when the motor rotates a high inertia load.</p> <p>Note: The FSO module activates the drive STO immediately if the drive stops modulating before the delay has passed (that is, the motor actual speed reaches 0 rpm). Adjust the default value when necessary.</p>
SAR1 ramp settings			
200.112	SAR1 ramp time to zero	2000 ms	<p>Sets the target time for the stop ramp SAR1 that is used in the SS1 function. Adjust the default value when necessary.</p> <p>Target time = The time in which the drive decelerates the motor from speed <i>200.202 SAR speed scaling</i> to zero.</p> <p>Note: With value <i>0 ms</i>, the drive uses the emergency stop ramp set by drive parameter <i>23.23</i>. Also in this case, the FSO module only monitors the actual ramp (ramp monitoring or time monitoring).</p>

Index	Name	Example value	Description
200.202	SAR speed scaling	1500 rpm	Sets a speed value that the FSO module uses as a reference point in ramp parameter calculations (see SAR1 ramp parameters 200.112, SARx.21, SARx.22 and SARx.02). Adjust the default value when necessary.
SARx.02	SAR initial allowed range	100 ms	Sets the initial allowed range for the SARx ramp. This parameter moves the location of the maximum monitoring ramp forward on the time axis, when monitoring is started. The slope of the ramp stays the same as defined with parameters 200.202 and SARx.12 (SAR0) or SARx.22 (SAR1). <u>Time monitoring</u> : This value has no effect in the operation. <u>Ramp monitoring</u> : Adjust the default value according to the application requirements.
SARx.21	SAR1 min ramp time to zero	1000 ms	Sets the minimum ramp time for the SAR1 ramp monitoring. <u>Time monitoring</u> : This value has no effect in the operation. <u>Ramp monitoring</u> : Sets the minimum deceleration time for the emergency stop. Adjust the default value according to the application requirements. Note : With value 0 ms, the minimum ramp is not monitored.
SARx.22	SAR1 max ramp time to zero	3000 ms	Sets the maximum ramp time for the SAR1 ramp monitoring. <u>Time monitoring</u> : This value has no effect in the operation. <u>Ramp monitoring</u> : Sets the maximum deceleration time for the emergency stop. Adjust the default value according to the application requirements.
SBC usage			
SBC.15	SSE/SS1 SBC speed	0 rpm	Sets the absolute speed below which the FSO module activates the brake (SBC) while ramping. <i>0 rpm</i> : 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. See the FSO module user's manual.

■ Changing the stop category from 0 to 1

Stop category 0 is the default setting. This category uses the STO function of the FSO module. Stop category 1 uses the SS1 function of the FSO module.

42 Parameter settings

To change the stop category from 0 to 1:

- set the parameters shown in this section
- set the parameters shown in section *Parameters for Emergency stop, stop category 1 (page 39)*
- if necessary, set the applicable parameters shown in section *Drive parameter settings (page 44)*.

Index	Name	Preset value (stop cat. 0)	Value in stop cat. 1
STO.11	STO input A	DI X113:1 & X114:1	None
FSOGEN.51	Zero speed without encoder	90 rpm	If you do not use a safety encoder, adjust the default value to meet the motor in use.
FSOGEN.52	Zero speed with encoder	10 rpm	If you use a safety encoder, adjust the default value to meet the motor in use.
FSOGEN.62	STO indication safety limit	Fault	Adjust the default value when necessary.

■ FSE-31 module and safety pulse encoder related parameters

Set these parameters when you use a safety pulse 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.
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. <i>STO</i> : The FSO module goes into Fail-safe mode and activates the drive STO function. <i>No STO</i> : 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. <i>Est switch not active load</i> : 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. See the FSO-21 module user's manual. Do not select this value in applications with an active load.

Index	Name	Example value	Description
S_ENCGEN.14	Enc speed cross comp tolerance	1 rpm	<p>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 meet the motor in use.</p> <p>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).</p> <p>The suitable 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.</p> <p>For more information, see the FSO-21 module user's manual.</p>
S_ENCGEN.41	Gear numerator encoder 1	1	<p>Sets the rotation direction for the safety encoder.</p> <p>With this parameter, you can change the rotation direction of the motor.</p> <p>Adjust the default value if necessary.</p>
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.
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	<p>Sets the number of HTL pulses per revolution for safety encoder 1.</p> <p>Adjust the default value to meet the safety encoder in use. Make sure that the value is according to the encoder nameplate.</p>
92.17	Accepted pulse freq of encoder 1	300 kHz	<p>Sets the maximum pulse frequency range of encoder 1.</p> <p>Adjust the default value to meet the motor and safety encoder in use. You can use this formula to define the value:</p> $r_max \cdot ppr_enc + 10\%$ <p>where</p> <ul style="list-style-type: none"> • 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

This section shows the drive parameter settings related to the safety function in the ACS880 primary control program.

The table that follows shows the parameters that 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 one or both Safe torque off (STO) signals are switched off or lost. <i>Warning/Warning</i> is the recommended setting. Note: ABB recommends that you do not set this parameter to <i>Fault/Fault</i> , <i>Fault/Warning</i> , or <i>Fault/Event</i> . If you use these settings, the drive will 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 shows 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 <i>Fault</i> . For more information, see 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.

The table that follows shows the parameters that you must set when the Emergency stop, stop category 1 function is used, and FSO parameter *200.112 SAR1 ramp time to zero* is set to 0.

No.	Name	Value	Description
21.04	Emergency stop mode	Eme ramp stop (Off3)	Selects the way the motor is stopped when an emergency stop command is received.
23.23	Emergency stop time	User-defined	Defines the deceleration rate for emergency stop as the time it would take for the speed to decrease to zero speed from the value of FSO parameter <i>200.202 SAR speed scaling</i> . Zero speed is defined by FSO parameter <i>FSOGEN.51 Zero speed without encoder</i> or <i>FSOGEN.52 Zero speed with encoder</i> . Set this parameter according to the application requirements.

If FSO parameter *200.112 SAR1 ramp time to zero* is set to 0, the drive parameters define the stop ramp that is used in the SS1 function (stop category 1). The FSO module monitors the actual stop ramp (ramp monitoring or time monitoring). For more information, see the firmware manual and FSO module user's 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 the safety function

Activation procedure:

1. Push the emergency stop button [S61]. The emergency stop is activated and the button locks in the “ON” (open) position.

Depending on the stop category, either AAA1 FSO STO request (stop category 0) or AAA3 FSO SS1 request (stop category 1) is shown.

When the emergency stop function is completed, the following indications are shown:

- the emergency stop reset button indicator light [S62] on the cabinet door is on, indicating that it is now possible to reset the emergency stop function.
- AA90 FSO stop completed is indicated.

If configured with parameter *31.22 STO indication run/stop*, an indication for Safe torque off is shown when the drive STO is activated.

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.

Note: The indication lamp comes on also when the FSO module has activated the drive STO function after fault situations. Also, the indication lamp comes on momentarily when the drive is started.

Resetting the safety function



WARNING!

Make sure that the drive does not start accidentally. This can occur after the acknowledgement of the safety function, if a level-triggered start command and the start enable signal are on at the same time.

1. Turn the emergency stop button [S61] until it releases.
2. Push the emergency stop reset button [S62] on the cabinet door for 0.1 ... 3 seconds. The emergency stop reset button indicator light [S62] goes off, and the emergency stop is deactivated.
3. If necessary, reset faults from the drive.
4. Make sure that the drive receives the start signal. See the firmware manual.
5. You can now restart the drive.

Note: If you switch off the power after you have released the emergency stop button [S61], the drive resets the safety function automatically. In this case, you do not have to push the emergency stop reset button [S62].

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 validate the correct operation of safety functions.

■ 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 before you validate the safety function. See the FSO module user's manual, chapter *Verification and validation*.

You must do the validation test using the checklist given in this manual:

- 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 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 proper 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 PC tool to do the start-up and validation test.

Action	<input checked="" type="checkbox"/>
 WARNING! Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.	<input type="checkbox"/>
Initial status	
<u>Safety encoder interface:</u> If you use a safety encoder in the safety application, validate the safety encoder interface as described in <i>FSO-21 safety functions module user's manual</i> (3AXD50000015614 [English]), chapter <i>Verification and validation</i> .	<input type="checkbox"/>
Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. See the hardware manual.	<input type="checkbox"/>
Make sure that the FSO STO function is configured and validated. 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 <i>S_ENCGEN.11</i> is set to <i>Est switch not active load</i> , both STO function with speed estimate and STO function with encoder feedback must be tested - most importantly, the value of parameter <i>STO.14</i> must be set according to the application requirements.	<input type="checkbox"/>
Checks and settings with no voltage connected	
Stop the drive and do the steps in section <i>Electrical safety precautions (page 9)</i> before you start the work.	<input type="checkbox"/>
If you have done any connections for the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the applicable circuit diagrams.	<input type="checkbox"/>



Action	<input checked="" type="checkbox"/>
<u>Inverter units with parallel R8i inverter modules:</u> Make sure that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules.	<input type="checkbox"/>
Settings with voltage connected	
Close the cabinet doors and power up the drive. See the hardware manual.	<input type="checkbox"/>
Make sure that the parameter settings related to the safety functions are correct. See chapter <i>Parameter settings</i> .	<input type="checkbox"/>
Create a backup file of the drive (button Backup/restore in the Drive composer pro PC tool).	<input type="checkbox"/>
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.	<input type="checkbox"/>
Validation test	
ABB recommends that you monitor these signals with the Drive composer PC tool: <ul style="list-style-type: none"> • 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) • <u>When using an encoder, also:</u> 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 	<input type="checkbox"/>
Make sure that it is safe to start, run and stop the motor(s) during the test.	<input type="checkbox"/>
Start the drive and make sure that the motor is running. If possible, use a motor speed close to the maximum speed of the application.	<input type="checkbox"/>
Push the emergency stop button [S61].	<input type="checkbox"/>
<u>Emergency stop, stop category 0:</u> Make sure that the drive stops the motor by coasting and that the correct warnings and indications are shown. <u>Emergency stop, stop category 1:</u> Make sure that the drive stops the motor by decelerating and that the correct warnings and indications are shown.	<input type="checkbox"/>
Make sure that the emergency stop reset button indicator light [S62] comes on.	<input type="checkbox"/>
Make sure that the drive generates none of these faults: <ul style="list-style-type: none"> • STO hardware failure (5090) • Safe torque off 1 loss (FA81) • Safe torque off 2 loss (FA82) If the drive generates one or more of these faults, see the hardware and firmware manuals for fault tracing instructions. If the FSO module generates a fault, see the FSO module user's manual, chapter <i>Fault tracing</i> .	<input type="checkbox"/>



50 Start-up and validation test

Action	<input checked="" type="checkbox"/>
Make sure that you cannot start the drive or motor from any control location. Make sure that the drive or motor does not start when you switch the start signal off and on, or push the start key of the panel when the panel is in local control mode.	<input type="checkbox"/>
Switch off the drive start signal.	<input type="checkbox"/>
Turn the emergency stop button [S61] until it releases and returns to the up position.	<input type="checkbox"/>
Push the emergency stop reset button [S62]. Make sure that: <ul style="list-style-type: none"> • the emergency stop reset button indicator light [S62] goes off. • the drive does not restart automatically at this point. 	<input type="checkbox"/>
Power up the drive: <ul style="list-style-type: none"> • If the drive tripped on a fault, reset the faults from the drive • Make sure that the operating switch is set to ON (1) • Switch on the drive start signal. For more information, see the hardware manual.	<input type="checkbox"/>
Restart the drive and make sure that the drive and the motor operate normally.	<input type="checkbox"/>
Do the test again from each operating location (for every emergency stop button and reset button).	<input type="checkbox"/>
Save the FSO safety file with the button Save safety file in the Drive composer pro PC tool.	<input type="checkbox"/>
Fill in and sign the validation test report. Store the report in the logbook of the machine.	<input type="checkbox"/>





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 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

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.

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 an emergency stop circuit or a drive, make sure that the functional safety of the machine is maintained by other means until the decommissioning is completed.



Technical data

Contents of this chapter

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

Safety data

■ Safety data values

This safety data is valid for the default design of the safety circuit described in this manual. If the final design is different from the default, ABB calculates 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 safety pulse encoder is not included in the calculations, because it is not included in the delivery. Only the FSE module is included in the calculations (if used).

ACS880-07/07LC/17/17LC/37/37LC drives without the FSE-31 module

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH ¹⁾ [1/h]	PFD _{avg} (T ₁ =2a)	PFD _{avg} (T ₁ =5a)	DC ²⁾ [%]	Cat.	HFT	CCF	Mission time [a]	T ₁ ³⁾⁴⁾ [a]
Frame sizes R6...R11												
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	5.3E-8	3.0E-4	3.5E-4	≥90	3	1	80	20	20/5/2
Stop cat. 1, ramp monitoring	3	3	e	5.3E-8	3.5E-4	4.7E-4	≥90	3	1	80	20	20/5/2

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH ¹⁾ [1/h]	PFD _{avg} (T ₁ =2a)	PFD _{avg} (T ₁ =5a)	DC ²⁾ [%]	Cat.	HFT	CCF	Mission time [a]	T ₁ ^{3) 4)} [a]
Frame sizes 1...8×R8i												
Stop cat. 0	3	3	e	5.0E-8	2.7E-4	2.7E-4	≥90	3	1	80	20	20/5/2
Stop cat. 1, time monitoring												
Stop cat. 1, ramp monitoring	3	3	e	5.0E-8	3.2E-4	3.9E-4	≥90	3	1	80	20	20/5/2
3AXD10000097591 J												

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 co-ordination of notified bodies for lower T₁ requirement.

⁴⁾ T₁ = 20a is used with high demand mode of operation. T₁ = 5a/2a is used with low demand mode of operation.

ACS880-07/07LC/17/17LC/37/37LC drives with the FSE-31 module

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH ¹⁾ [1/h]	PFD _{avg} (T ₁ =2a)	PFD _{avg} (T ₁ =5a)	DC ²⁾ [%]	Cat.	HFT	CCF	Mission time [a]	T ₁ ^{3) 4)} [a]
Frame sizes R6...R11												
Stop cat. 0	3	3	e	5.3E-8	3.0E-4	3.5E-4	≥90	3	1	80	20	20/5/2
Stop cat. 1, time monitoring												
Stop cat. 1, ramp monitoring	3	3	e	5.0E-8	3.5E-4	4.5E-4	≥90	3	1	80	20	20/5/2
Frame sizes 1...8×R8i												
Stop cat. 0	3	3	e	5.0E-8	2.7E-4	2.7E-4	≥90	3	1	80	20	20/5/2
Stop cat. 1, time monitoring												
Stop cat. 1, ramp monitoring	3	3	e	4.6E-8	3.2E-4	3.7E-4	≥90	3	1	80	20	20/5/2
3AXD10000097591 J												

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 co-ordination of notified bodies for lower T₁ requirement.

⁴⁾ T₁ = 20a is used with high demand mode of operation. T₁ = 5a/2a is used with low demand mode of operation.

■ Safety component types

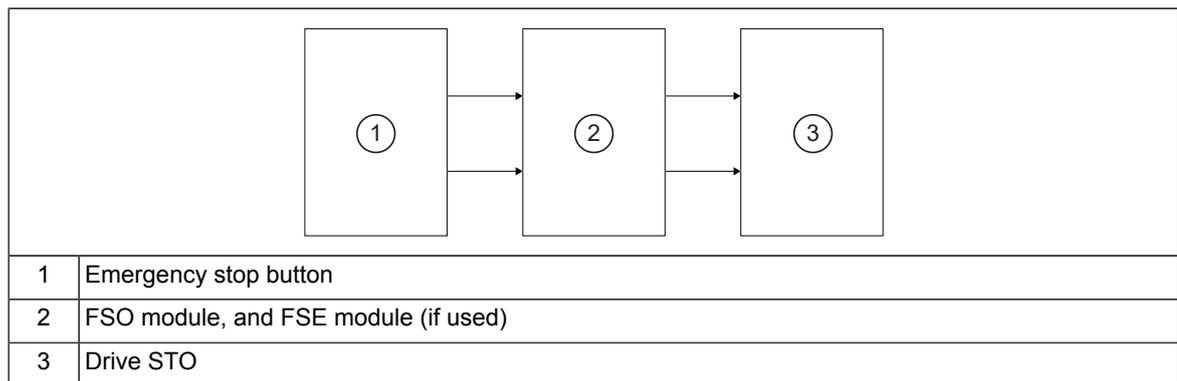
Safety component types as defined in IEC 61508-2:

- emergency stop button: type A
- FSO module: type B

- FSE module: type B
- drive STO circuit:
 - frame sizes R1...R9 and drives with R1i...R7i inverter modules: type A
 - 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 delivery are not included in the safety data calculations.



■ **Relevant failure modes**

Relevant failure modes are:

- the FSO module detects open circuits, short circuits and redundancy failures of the emergency stop input signal wirings. Similarly, it detects redundancy failures of the emergency stop button when the request is on.
- internal failures of the emergency stop button, 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 inside the cabinet
- short and open circuits in the cabinet terminal blocks of the safety circuits.

■ **Operation delays**

Emergency stop total delay and fault reaction response time (includes the response time of the drive STO):

- Stop category 0: less than 500 ms
- Stop category 1: Emergency stop ramp time + possible STO delay settings + less than 500 ms.

Note: If you use a safety pulse 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 to the FSO module user's manual.

Related standards and directives

Standard	Name
EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems – Part 2: Validation
EN ISO 13850:2015	Safety of machinery. Emergency stop. Principles for design.
EN 60204-1:2018 IEC 60204-1:2016	Safety of machinery – Electrical equipment of machines – Part 1: General requirements
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
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61511-1:2016	Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements
EN 61800-5-2:2007 IEC 61800-5-2:2016	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional
EN 62061:2005 + AC:2010 + A1:2013 + A2:2015 IEC 62061:2015 Ed. 1.2	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
2006/42/EC	European Machinery Directive
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. The declaration of conformity is delivered with the drive.

Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/searchchannels.

Product training

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

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