
OPTIONS FOR ABB DRIVES

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

User's manual



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

User's manual

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3AUA0000145921 Rev J

EN

Original instructions

EFFECTIVE: 2024-12-02

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Safety instructions

Contents of this chapter

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

Safety messages

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

The manual uses these warning symbols:



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



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



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

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



Instructions for functional safety circuits

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



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

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



Electrical safety precautions

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



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

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

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



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

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



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

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





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, and -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:

- Drives with a UCU-22, -23, or -24 control unit: UCON-22 control board, revision K or later¹⁾
- ACS880 primary control program (AINLX) version 1.80 or later, or ACS880 primary control program (YINLX) version 1.30 or later
- FSO-12 safety functions module: revision C or later
- Drive Composer pro: 1.6 or later.

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

Required versions with the FSO-21 module:

- Drives with a UCU-22, -23, or -24 control unit: UCON-22 control board, revision K or later¹⁾
 - ACS880 primary control program (AINLX) version 2.2 or later, or ACS880 primary control program (YINLX) version 1.30 or later
 - FSO-21 safety functions module: revision D or later
-

- FSE-31 pulse encoder interface module: revision D or later (if used)
- Drive Composer pro: 1.8 or later.

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

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 customer-defined wiring (if any). Refer to 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 |

| Manual | Code |
|--|--|
| ACS880-37 drives (160 to 3200 kW) hardware manual | 3AXD50000020437 |
| ACS880-37 drives (45 to 400 kW) hardware manual | 3AXD50000035159 |
| ACS880-37LC drives hardware manual | 3AXD50000251407 |
| Drive firmware | |
| ACS880 primary control program firmware manual (AINLX) | 3AUA0000085967 |
| ACS880 primary control program firmware manual (YINLX) | 3AXD50001000998 |
| ACS880 diode supply control program firmware manual | 3AUA0000103295 |
| ACS880 diode supply control program (YDILX) firmware manual | 3AXD50001096489 |
| ACS880 IGBT supply control program firmware manual | 3AUA0000131562 |
| ACS880 IGBT supply control program (YISLX and YLHLX) firmware manual | 3AXD50001019464 |
| PC tools | |
| Drive Composer start-up and maintenance PC tool user's manual | 3AUA0000094606 |
| Functional safety design tool user's manual | 3AXD10000102417 |
| Safety | |
| Functional safety; Technical guide No. 10 | 3AUA0000048753 |
| ABB Safety information and solutions | www.abb.com/safety |
| Options | |
| ACS-AP-I, -S, -W and ACH-AP-H, -W Assistant control panels user's manual | 3AUA0000085685 |
| FSO-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 ordered with option code +P947) | |

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



[ACS880-07 \(45 to 710 kW\) manuals](#)



[ACS880-07 \(560 to 2800 kW\) manuals](#)



[ACS880-07LC manuals](#)



[ACS880-17 \(45 to 400 kW\) manuals](#)



[ACS880-17 \(160 to 3200 kW\) manuals](#)



[ACS880-17LC manuals](#)



ACS880-37 (45 to 400 kW) manuals



ACS880-37 (160 to 3200 kW) manuals



ACS880-37LC manuals

Terms and abbreviations

| Term | Description |
|-------------------|--|
| Cat. | Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. The categories are: B, 1, 2, 3 and 4. (EN ISO 13849-1) |
| CCF | Common cause failure (EN ISO 13849-1) |
| DC | Diagnostic coverage (EN ISO 13849-1) |
| 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 |
| $PF_{D_{avg}}$ | 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, IEC 62061, IEC 61800-5-2) |
| 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 $PF_{D_{avg}}$) for the safety function or subsystem. Performing a proof test at a maximum interval of T_1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. Note that any T_1 values given cannot be regarded as a guarantee or warranty. |
| T_M | Mission time: the period of time covering the intended use of the safety function/device. After the mission time elapses, the safety device must be replaced. Note that any T_M values given cannot be regarded as a guarantee or warranty. (EN ISO 13849-1) |
| TP | Test pulse |
| Zero speed | For safety functions, the zero speed limit indicates the completion of the safe stopping function. |



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.

Option +Q979 supports these 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
-

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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 and -07LC drives with frame size nxDxT + n×R8i with main contactor/breaker (option +F250/+F255), ACS880-17, -17LC, -37, and -37LC drives with frame size n×R8i + n×R8i, and ACS880-17 and -37 drives with frame size R8, R11, R6i + R6i, or R7i + R7i: 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). Refer to the hardware and firmware manuals for more information.

For a detailed description of the STO function, refer to the hardware manual. For more information on the FSO module, refer to the applicable FSO module user's manual.

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, refer to section [Related standards and directives \(page 64\)](#).

■ Summary of wirings and settings

The wirings and settings of the emergency stop function are:

- The drive has an 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 connected to the FSO module. ABB connects the button at the factory. The customer can add buttons to the emergency stop circuit.
- One emergency stop reset button is installed on the cabinet door and connected to the FSO module. The reset button also includes an emergency stop indication lamp. ABB connects the button and the indication lamp at the factory. The customer 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 customer installs and connects the safety encoder to the FSE-31 module. The customer must make sure that the required safety integrity (SIL/PL) can be achieved with the 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.

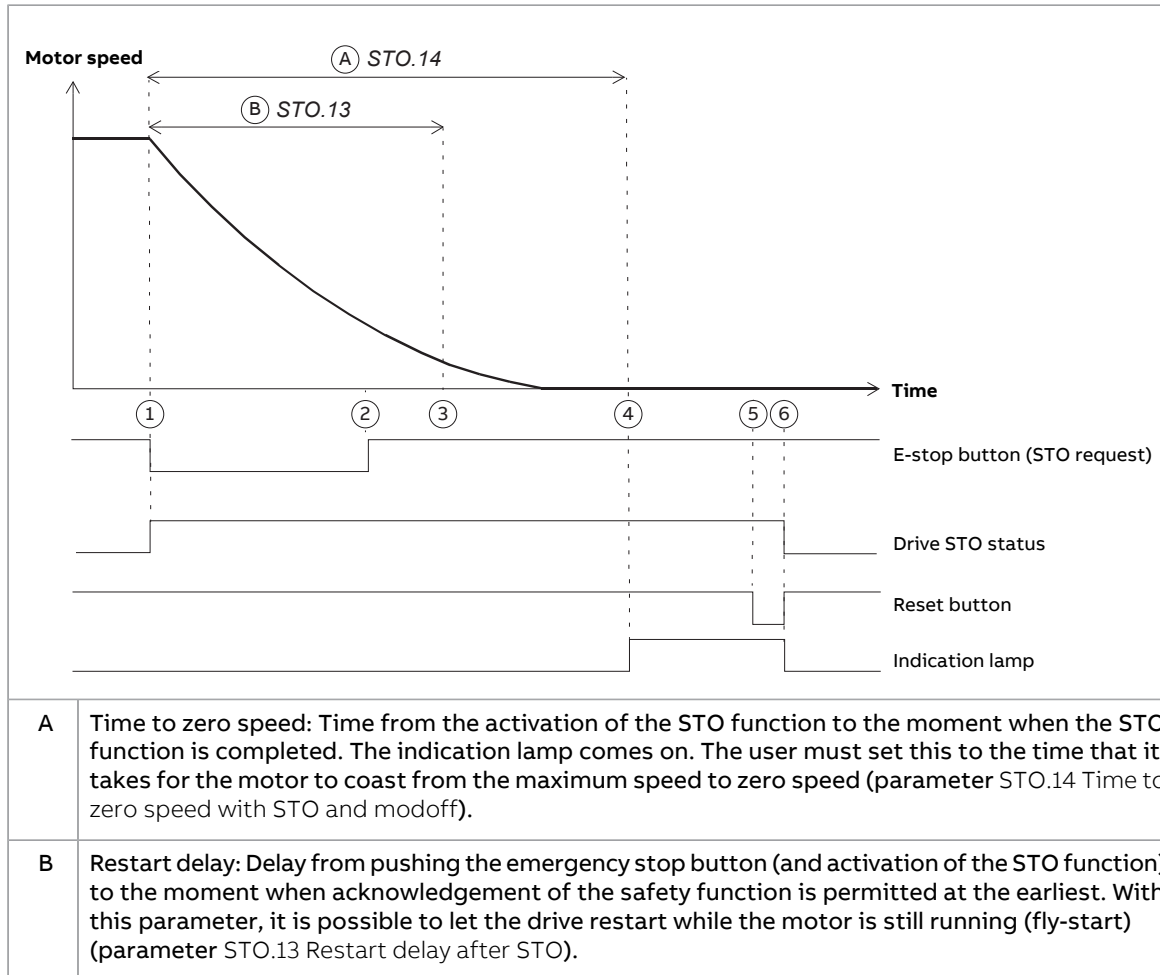
Note: The Emergency stop, stop category 1 function uses the SS1 function of the FSO module. The SS1 function uses SAR1 parameters to define the stop ramp. In some situations (for example, in internal fault situations or due to another safety function) the FSO module can activate the Safe stop emergency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

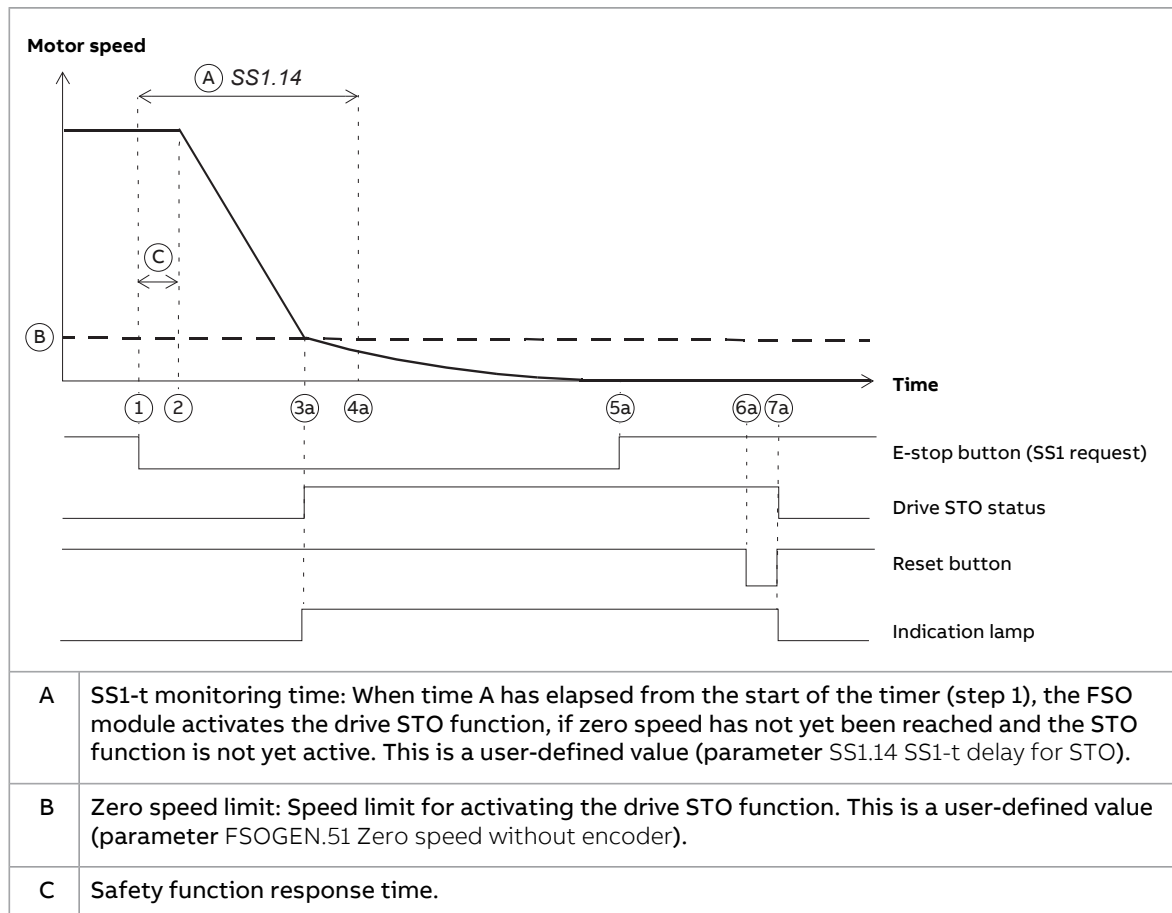


1. The user pushes the emergency stop button. The FSO module activates the drive STO function. The FSO module starts timers for delays A and B.
2. The user releases the emergency stop button.
3. Time B has elapsed. Acknowledgement of the STO function is possible even though the motor is still running. (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.

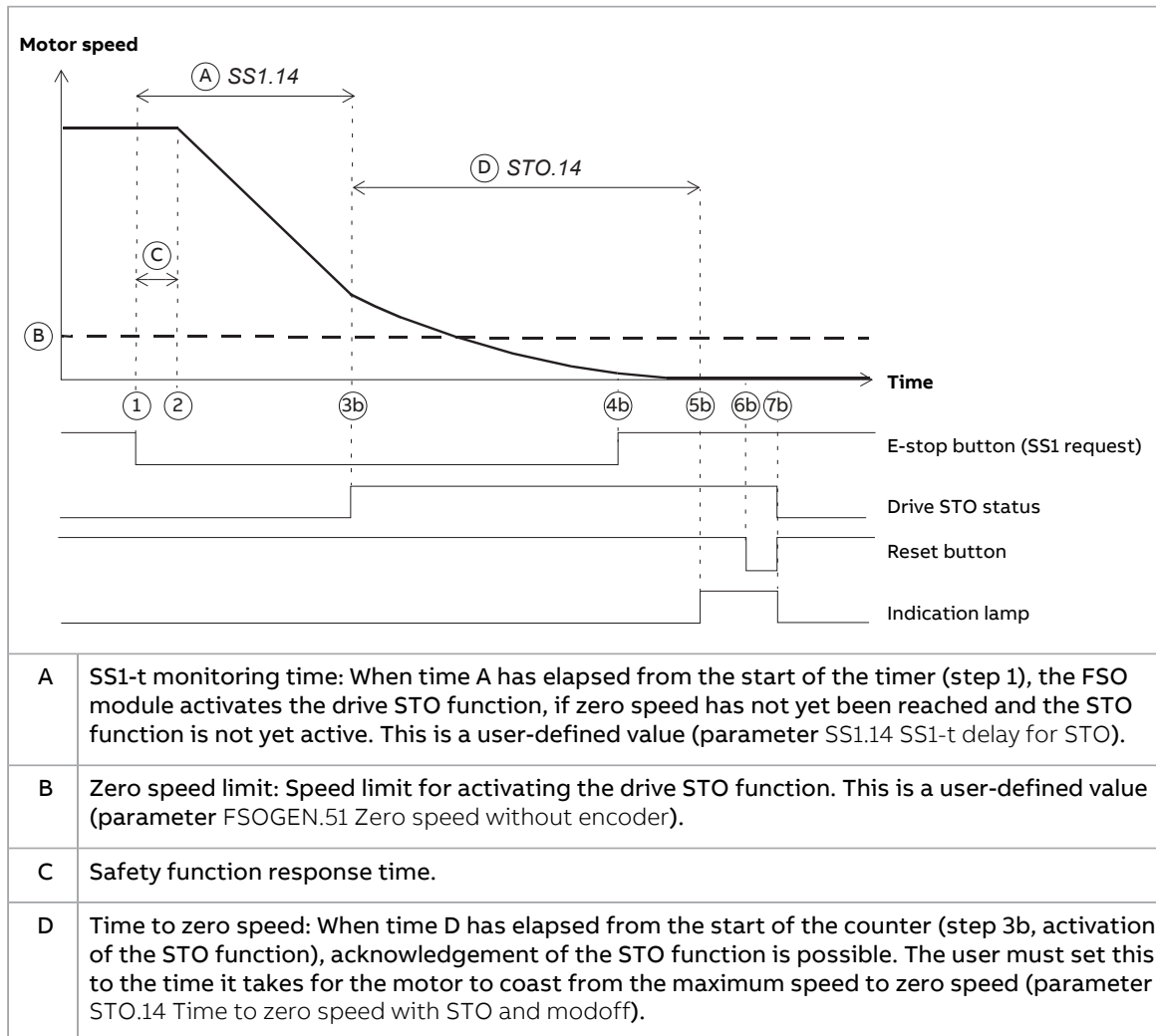
Case A: The motor speed reaches the zero speed limit within the user-defined time



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 is higher than the zero speed limit.

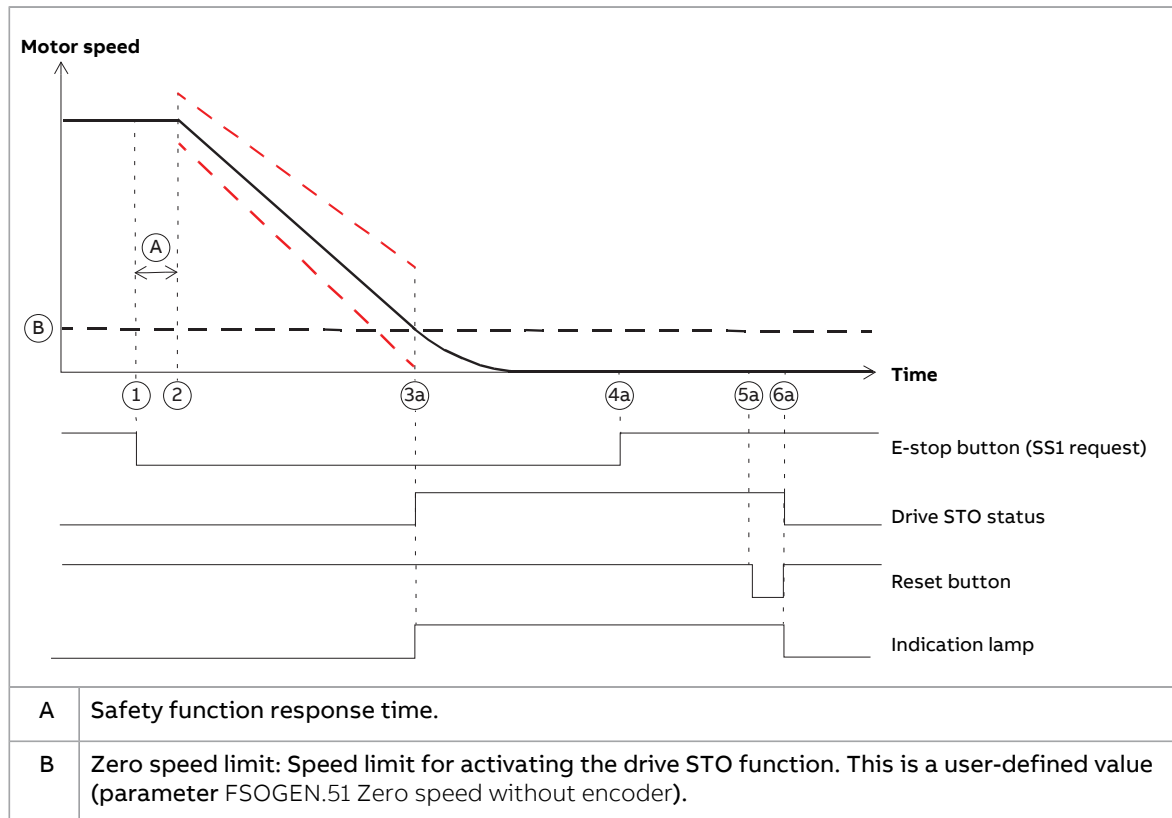


1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter 200.112 SAR1 ramp time to zero).
3. b) The FSO module activates the 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. If the FSO module is configured to generate a fault after a limit hit (parameter FSOGEN.62), the user must reset the drive before it is ready for a restart.

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

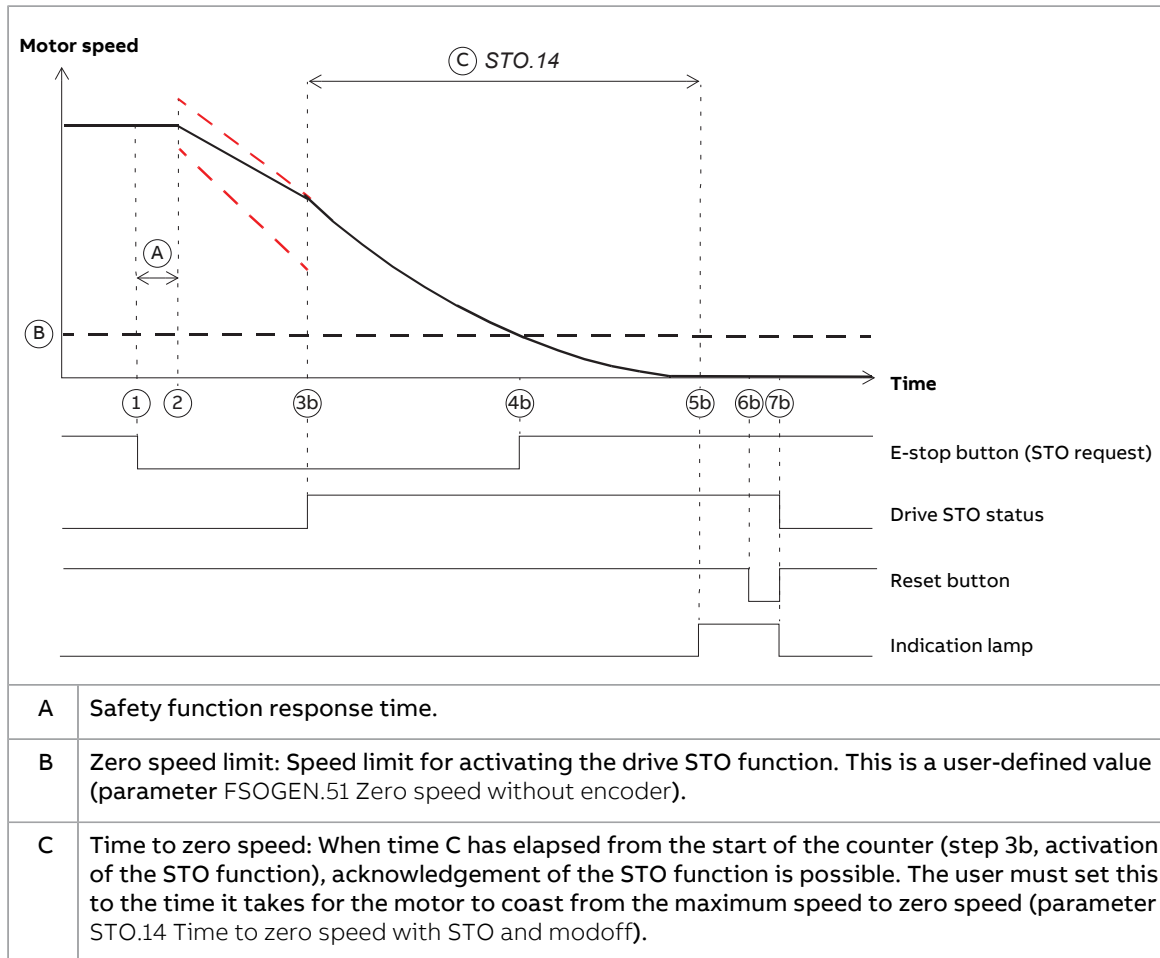


1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).
3. a) The motor speed reaches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

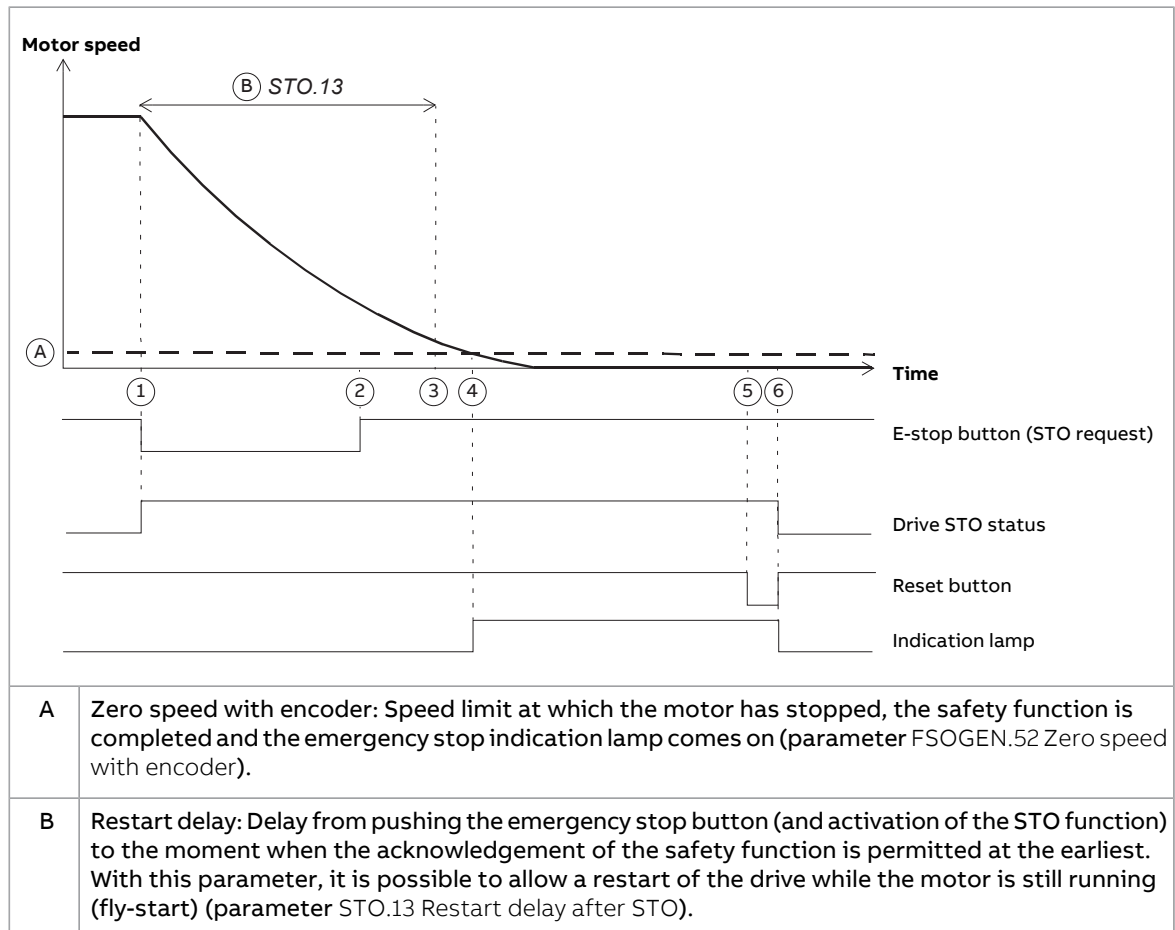


1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).
3. b) The FSO module activates 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. If the FSO module is configured to generate a fault after a limit hit (parameter FSOGEN.62), the user must reset the drive before it is ready for a restart.

■ 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.

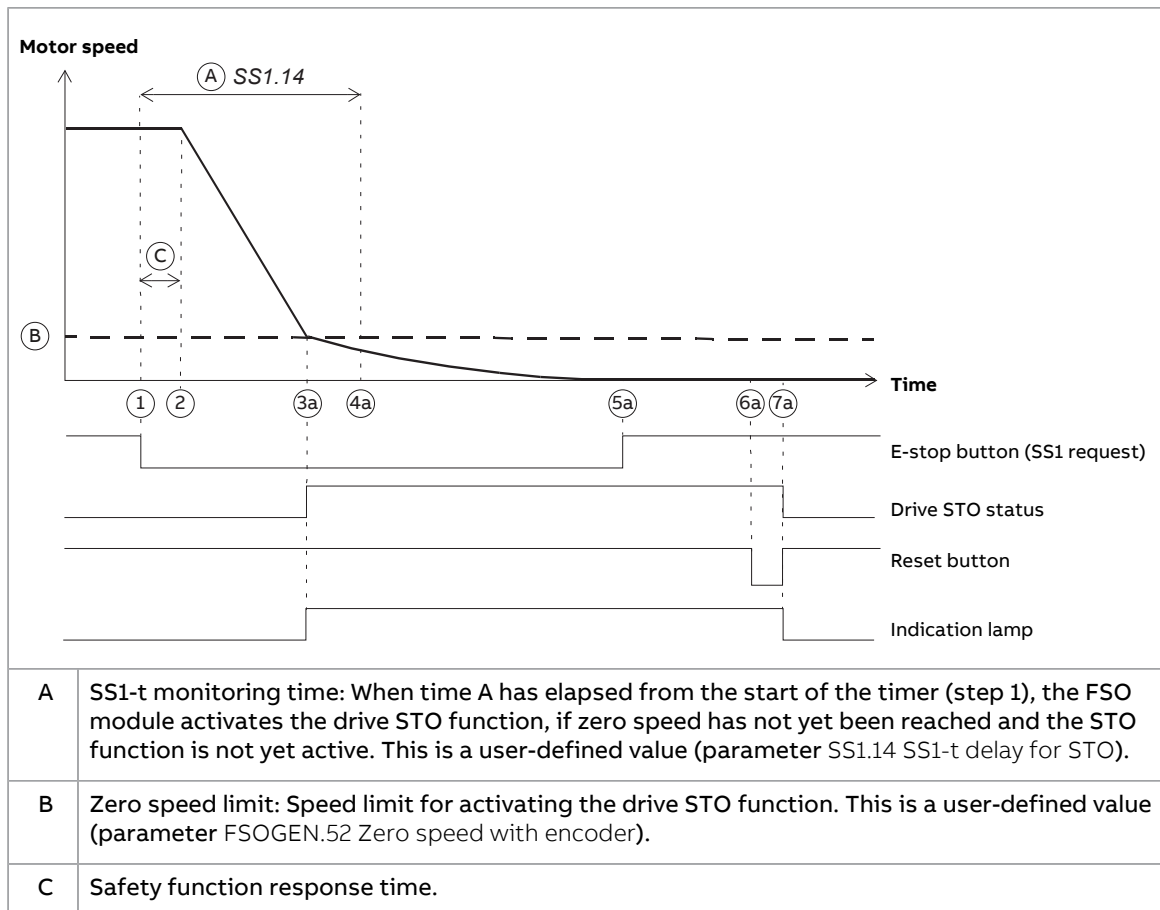


1. The user pushes the emergency stop button. The FSO module activates the drive STO function. The FSO module starts a timer for delay B.
2. The user releases the emergency stop button.
3. Time B has elapsed. Acknowledgement of the STO function is possible even though the motor is still running. (In this example, the user pushes the reset button in step 5).
4. 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.

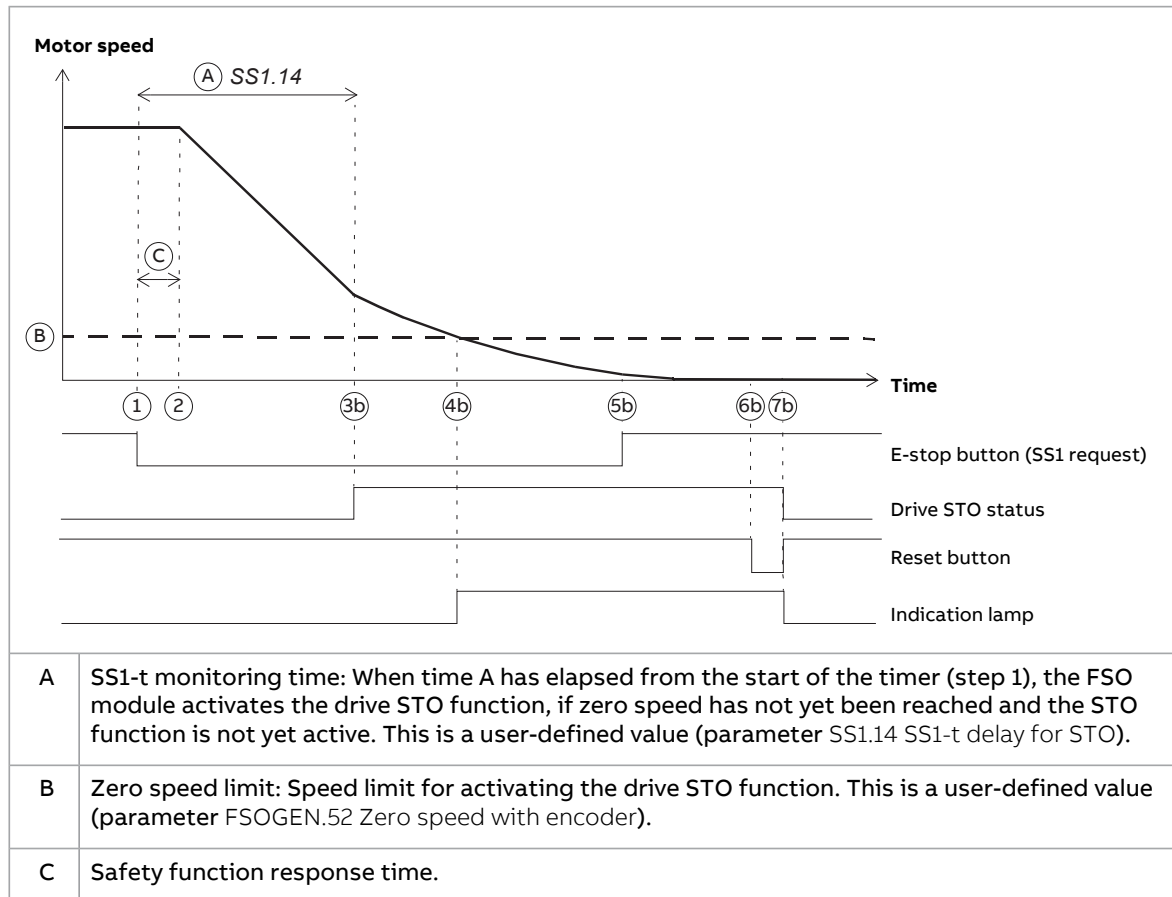
Case A: The motor speed reaches the zero speed limit within the user-defined time



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.

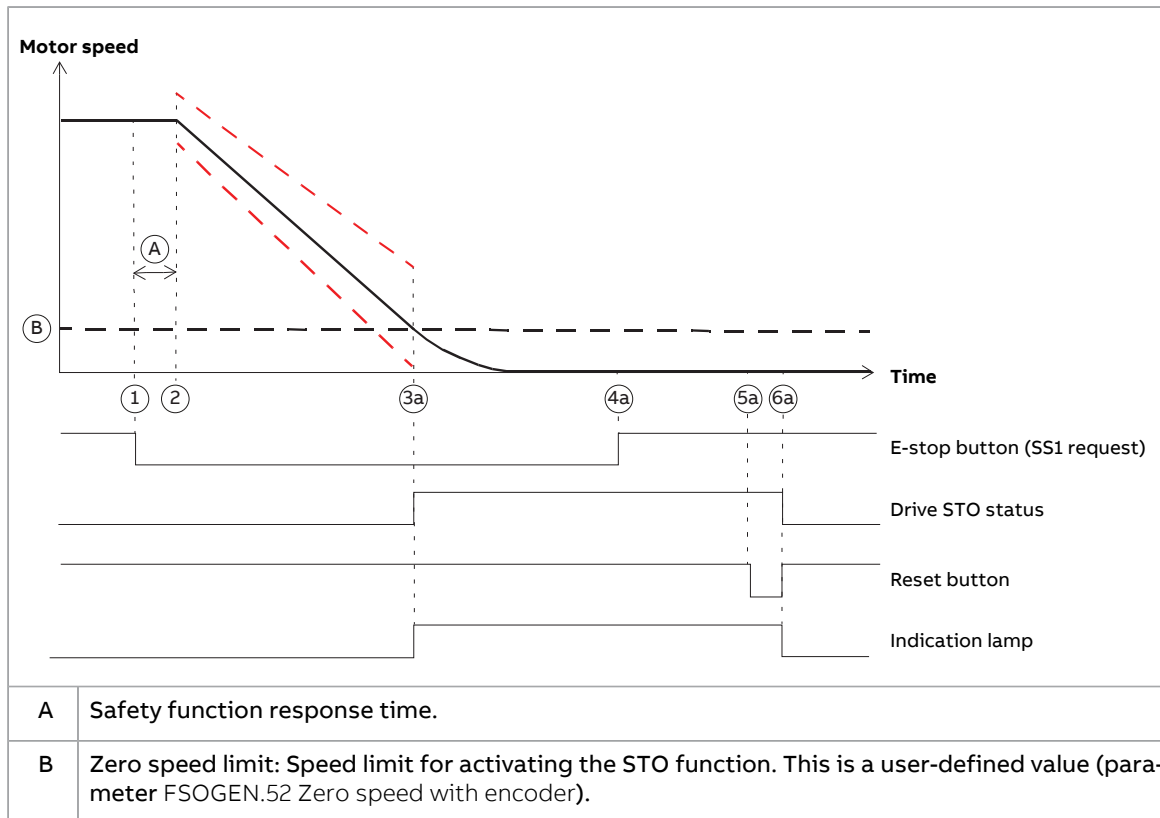


1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter 200.112 SAR1 ramp time to zero).
3. b) The FSO module activates the drive STO function. 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. If the FSO module is configured to generate a fault after a limit hit (parameter FSOGEN.62), the user must reset the drive before it is ready for a restart.

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

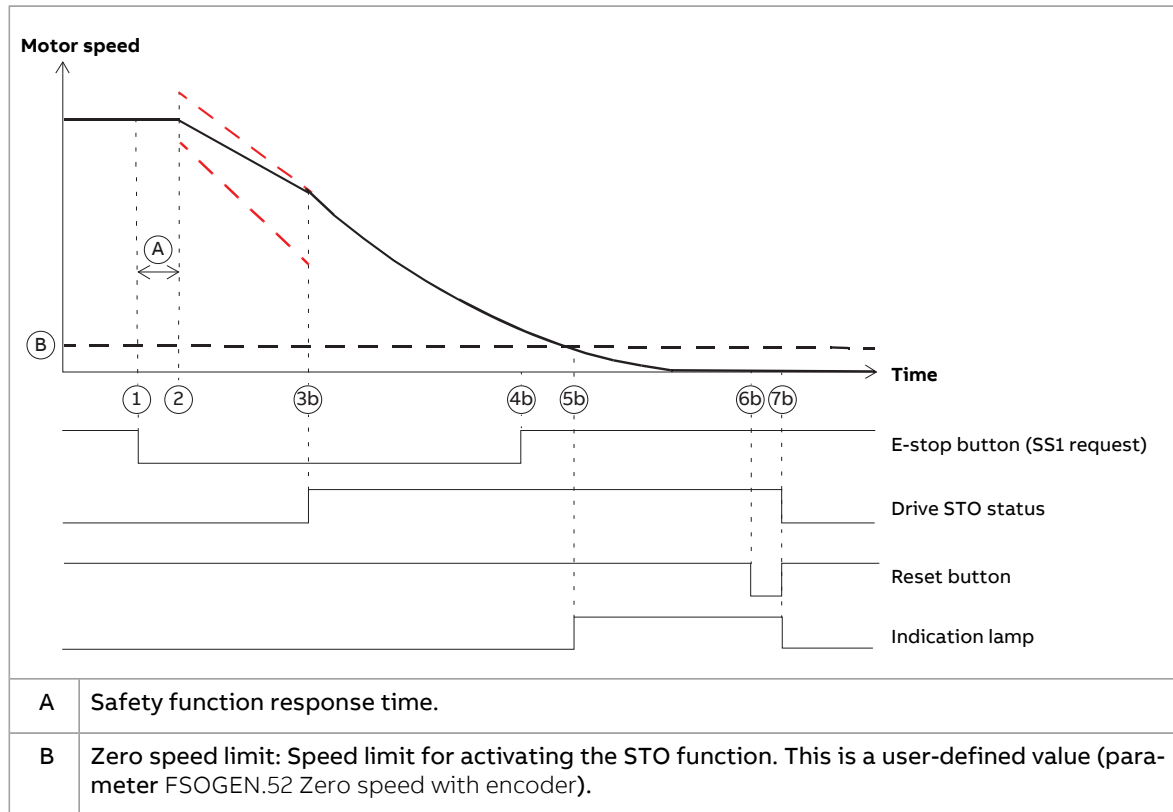


1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).
3. a) The motor speed reaches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



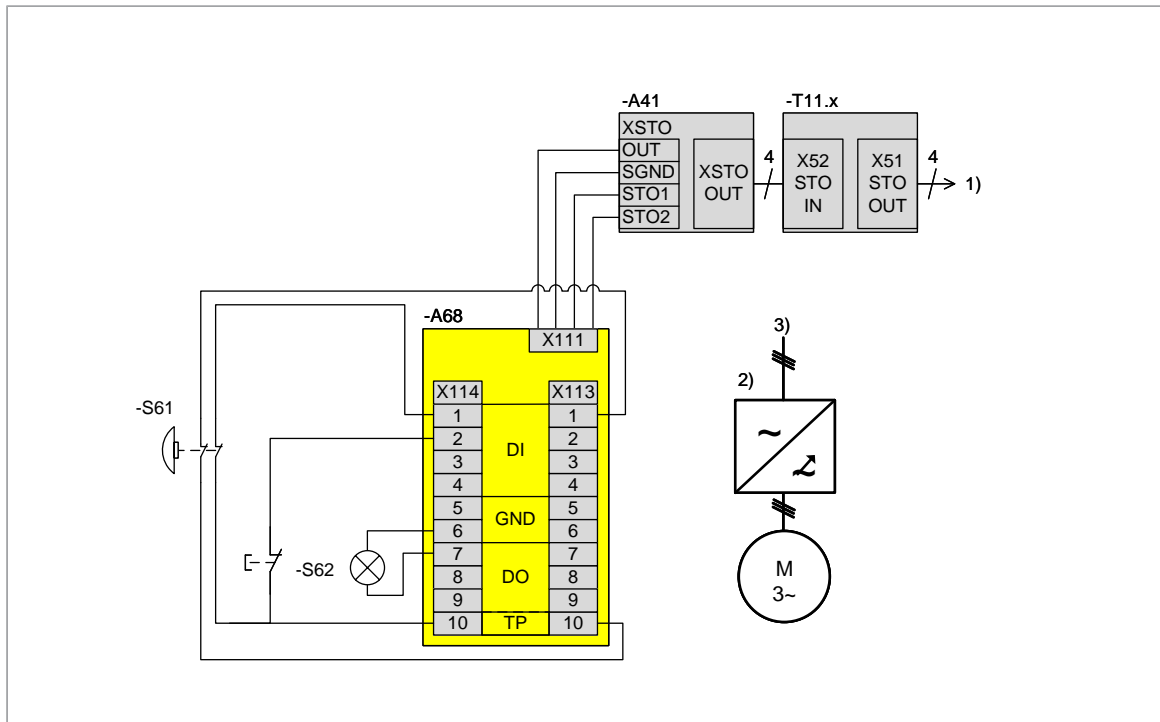
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters 200.112, SARx.21, SARx.22 and SARx.02).
3. b) The FSO module activates 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. If the FSO module is configured to generate a fault after a limit hit (parameter FSOGEN.62), the user must reset the drive before it is ready for a restart.

■ Operation principle diagrams

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

30 Option description

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



| | |
|------------|---|
| A41 | Inverter control unit |
| A68 | FSO-12 or FSO-21 safety functions module |
| 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 |
| 1) | To parallel inverter modules (if any) |
| 2) | Drive module |
| 3) | Main circuit |

| 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. |

| Step | Operation |
|------|---|
| 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 FSOGEN.61 STO indication ext request, and drive parameter 31.22 STO indication run/stop) • 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.

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

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 module
- an internal failure in the FSE-31 module or the safety encoder
- an internal failure in the drive STO.

■ FSO module

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

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

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

Resetting the FSO module

To reset the FSO module:

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

■ FSE-31 module and safety encoder

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

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

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

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

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

■ Drive STO function

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

4

Electrical installation

Contents of this chapter

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

Wiring



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

One emergency stop button and one reset button are installed on the cabinet door and connected to the drive 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 that follow show the connections between the extension terminal block [X68] and the FSO module connectors [X113] and [X114].

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

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

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 these rules:

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

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





Parameter settings

Contents of this chapter

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

Competence

The person who configures the safety functions in the FSO module must be a competent person as required by IEC 61508-1 clause 6. In this context, the person must have expertise and knowledge of functional safety, the safety functions and the configuration of the FSO module. ABB has training courses on the FSO module.

FSO module parameter settings

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

Always make sure that:

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

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

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

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

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

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

There are parameters that you must always set and parameters that are related to some safety functions only. These tables list all the parameters that you must check and set for option +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. Refer to the circuit diagrams of the delivery. |
| FSOGEN.21 | Motor nominal speed | 1500 rpm | Sets the synchronous motor speed. |
| FSOGEN.22 | Motor nominal frequency | 50 Hz | Sets the nominal motor frequency. Must be equal to the value on the motor rating plate. |
| FSOGEN.41 | Power-up acknowledgement | Automatic | Sets the power-up acknowledgement method of the FSO module. Automatic: It is not necessary to push a reset button after energizing the FSO module. The FSO module generates the acknowledgement signal automatically after the power-up. Manual: The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42 Acknowledgement button input. Make sure that the value is Automatic. |


| Index | Name | Example value | Description |
|-----------|------------------------------|---------------|--|
| FSOGEN.42 | Acknowledgement button input | DI X114:2 | <p>Sets the digital input for the acknowledgement signal when parameter FSOGEN.41 Power-up acknowledgement or STO.02 STO acknowledgement is set to Manual.</p> <p>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. Refer to the circuit diagrams of the delivery.</p> |
| FSOGEN.51 | Zero speed without encoder | 90 rpm | <p>Sets the general zero speed limit for safety functions when a safety encoder is not used.</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 used.</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> |

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| Index | Name | Example value | Description |
|-----------|-----------------------------|---------------|--|
| FSOGEN.62 | STO indication safety limit | Fault | <p>Sets the type of the indication that the FSO module generates and sends to the drive 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>If necessary, adjust the default setting. If you select Fault, 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>Manual: The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42.</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 Manual.</p> <p> WARNING If the value is set to Automatic, 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 be dangerous.</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 agrees with the circuit diagrams of the delivery.</p> <p><u>Emergency stop, stop category 1:</u> Make sure that this parameter is set to None. (An external signal cannot start the STO function.)</p> |

| Index | Name | Example value | Description |
|------------------|---|---------------|--|
| STO.13 | Restart delay after STO | 2000 ms | <p>Sets the time after which the restart of the drive is permitted after the FSO module has activated the drive STO.</p> <p>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 (STO.11).</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 STO.14.</p> <p><u>Emergency stop, stop category 1:</u> This value has no effect.</p> |
| STO.14 | Time to zero speed with STO and mod-off | 2000 ms | <p>The time it takes for the motor to coast to a standstill from maximum process speed. This must be measured with the Drive Composer pro PC tool when an encoder is used for motor control (otherwise you have to make sure that the motor shaft has stopped rotating by other means, eg, visually.).</p> <p>Acknowledgement is permitted after coast stop in the STO, SSE and SS1 functions (when SBC is not used). If SBC is used, see parameter SBC.13 SBC time to zero speed.</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 STO.13 Restart delay after STO defines the time after which the acknowledgement is permitted.</p> <p>If the drive STO is activated or modulation stopped while a monitoring safety function is indicating "unsafe", after this time acknowledgement is permitted. For example, if the drive modulation is lost during SLS deceleration ramp, SLS OK will be indicated after this time has elapsed.</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>None: 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. Refer to 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>Immediate STO: The FSO module activates the drive STO function immediately after the SSE request.</p> <p>Emergency ramp: The FSO module decelerates the motor to zero speed, and then activates the drive STO function. SAR0 parameters define the deceleration ramp. For more information, refer to the FSO module user's manual. Zero speed is defined by parameter FSOGEN.51 Zero speed without encoder or FSOGEN.52 Zero speed with encoder.</p> <p>For option +Q979, ABB sets this parameter to value Immediate STO 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>0 rpm: 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. Refer to 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>On: 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. Refer to the circuit diagrams of the delivery.</p> |

| Index | Name | Example value | Description |
|-----------|-----------------------------|------------------|---|
| 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>On: 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. Refer to the circuit diagrams of the delivery.</p> |
| SAFEIO.38 | DI X114:2 diag pulse on/off | On | <p>Sets the diagnostic pulse of digital input X114:2 on or off.</p> <p>On: The input monitors that it receives test pulses.</p> <p>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. Refer to the circuit diagrams of the delivery.</p> |
| SAFEIO.74 | DO X114:7 logic state | Active high | <p>Sets the logic state of digital output X114:7.</p> <p>Active high: The digital output is on when the indicated signal is active.</p> <p>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. Refer to the circuit diagrams of the delivery.</p> |

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, refer to section [Parameters for the STO function \(page 38\)](#). 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 | <p>Activates or deactivates the SS1 function and shows the version of the SS1 function.</p> <p>Version 1: Activates version 1 of the SS1 function.</p> |

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| Index | Name | Example value | Description |
|--------|-------------------------------------|--------------------|--|
| SS1.11 | SS1 input A | DI X113:1 & X114:1 | <p>Sets the digital input that is connected to the primary input of the SS1 function.</p> <p>For option +Q979, ABB has connected the emergency stop button to this input at the factory. Make sure that this value agrees with the wiring. Refer to the circuit diagrams of the delivery. Also make sure that you do not use the same input for other functions at the same time (for example, the STO function).</p> |
| 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 SS1.14.</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 200.112, SARx.21, SARx.22 and SARx.02.</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 FSOGEN.51 or FSOGEN.52) yet. For more information, refer to 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 FSOGEN.51 or FSOGEN.52). After this delay has elapsed, the FSO module activates the drive STO function. You can use this parameter when the motor rotates a 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).</p> <p>Adjust the default value when necessary.</p> |

| Index | Name | Example value | Description |
|--------------------|----------------------------|---------------|--|
| 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 200.202 SAR speed scaling to zero.</p> <p>Note: With value 0 ms, the drive uses the emergency stop ramp set by drive parameter 23.23. Also in this case, the FSO module only monitors the actual ramp (ramp monitoring or time monitoring).</p> |
| 200.202 | SAR speed scaling | 1500 rpm | <p>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).</p> <p>Adjust the default value when necessary.</p> |
| SARx.02 | SAR initial allowed range | 100 ms | <p>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).</p> <p><u>Time monitoring:</u> This value has no effect in the operation.</p> <p><u>Ramp monitoring:</u> Adjust the default value according to the application requirements.</p> |
| SARx.21 | SAR1 min ramp time to zero | 1000 ms | <p>Sets the minimum ramp time for the SAR1 ramp monitoring.</p> <p><u>Time monitoring:</u> This value has no effect in the operation.</p> <p><u>Ramp monitoring:</u> Sets the minimum deceleration time for the emergency stop. Adjust the default value according to the application requirements.</p> <p>Note: With value 0 ms, the minimum ramp is not monitored.</p> |
| SARx.22 | SAR1 max ramp time to zero | 3000 ms | <p>Sets the maximum ramp time for the SAR1 ramp monitoring.</p> <p><u>Time monitoring:</u> This value has no effect in the operation.</p> <p><u>Ramp monitoring:</u> Sets the maximum deceleration time for the emergency stop. Adjust the default value according to the application requirements.</p> |

| Index | Name | Example value | Description |
|-----------|-------------------|---------------|---|
| 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>0 rpm: 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. Refer to the FSO module user's manual.</p> |

■ 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.

To change the stop category from 0 to 1:

- set the parameters given in this section
- set the parameters given in section [Parameters for Emergency stop, stop category 1 \(page 41\)](#)
- if necessary, set the applicable parameters given in section [Drive parameter settings \(page 46\)](#).

| 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. |
| FSOGEN.52 | Zero speed with encoder | 10 rpm | If you use a safety encoder, adjust the default value. |
| FSOGEN.62 | STO indication safety limit | Fault | Adjust the default value when necessary. |

■ FSE-31 module and safety encoder related parameters

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

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

| Index | Name | Example value | Description |
|-------------|---------------------------------|---------------|---|
| S_ENCGEN.11 | FSE diagnostic failure reaction | STO | <p>Sets the action taken when there is a problem with the FSE-31 module or the safety encoder.</p> <p>STO: The FSO module goes into Fail-safe mode and activates the drive STO function.</p> <p>No STO: If there are no active safety functions, the FSO module sends a warning to the drive. If there are active safety functions, the FSO module goes into Fail-safe mode.</p> <p>Est switch not active load: With some restrictions, the FSO module sends a warning to the drive and starts to use an estimated value of the motor speed (safe speed estimate). If you select this value, you must also set the parameters related to safe speed estimate. Refer to the FSO-21 module user's manual. Do not select this value in applications with an active load.</p> |
| 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.</p> <p>Adjust the default value to agree with the motor.</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 correct value depends on the configuration (motor and load). Typically this value is 2 ... 10 rpm. A value that is too small will cause an encoder fault (A7D8) and a value that is too large will prevent encoder diagnostic related to this parameter.</p> <p>For more information, refer to 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>If necessary, adjust the default value.</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. |

46 Parameter settings

| Index | Name | Example value | Description |
|-------|----------------------------------|---------------|---|
| 92.02 | Encoder 1 source | Module 1 | Sets the safety encoder interface module that the safety encoder 1 is connected to. |
| 92.10 | Pulses/revolution | 2048 | Sets the number of HTL pulses per revolution for safety encoder 1. Adjust the default value to agree with the safety encoder. Make sure that the value is the same that is shown on the encoder nameplate. |
| 92.17 | Accepted pulse freq of encoder 1 | 300 kHz | Sets the maximum pulse frequency range of encoder 1. Adjust the default value to agree with the motor and safety encoder. You can use this formula to define the value: $r_max \cdot ppr_enc + 10\%$, where <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

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

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

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

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

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

The table that follows gives 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 200.202 SAR speed scaling. Zero speed is defined by FSO parameter FSOGEN.51 Zero speed without encoder or FSOGEN.52 Zero speed with encoder. 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, refer to the firmware manual and FSO module user's manual.



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.
Warning AAA1 FSO STO request (stop category 0) or AAA3 FSO SS1 request (stop category 1) is shown.
When the emergency stop function is completed, these 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, refer to 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.
5. You can now restart the drive.

For more information, refer to the hardware and firmware manuals.

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 make sure that the safety function operates correctly and according to the safety requirements.

■ Competence

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

■ Validation procedure

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

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

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



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

The validation test must include at least the following steps:

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

■ Validation test reports

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


- a description of the safety application (including a figure)
- a description and revisions of safety components that are used in the safety application
- a list of all safety functions that are used in the safety application
- a list of all safety-related parameters and their values
- documentation of start-up activities, references to failure reports and resolution of failures
- the test results for each safety function, checksums, date of the tests, and confirmation by the test personnel.

You must store any new validation test reports done due to changes or maintenance in the logbook of the machine.



Start-up and validation test

You must use the Drive Composer pro PC tool to do the start-up and validation test.

| | |
|---|-------------------------------------|
| Action | <input checked="" type="checkbox"/> |
|  ▲WARNING Obey the safety instructions of the drive. 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 FSO-21 safety functions module user's manual (3AXD50000015614 [English]) , chapter Verification and validation . | <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. Refer to the hardware manual. | <input type="checkbox"/> |
| Make sure that the FSO STO function is configured and validated. Refer to the FSO module user's manual. Internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal. The STO function must be validated before other safety functions. Note: If parameter S_ENCEN.11 is set to Est switch not active load, both STO function with speed estimate and STO function with encoder feedback must be tested - most importantly, the value of parameter STO.14 must be set according to the application requirements. | <input type="checkbox"/> |

| | |
|--|-------------------------------------|
| Action | <input checked="" type="checkbox"/> |
| Checks and settings with no voltage connected | |
| Stop the drive and do the steps in section Electrical safety precautions (page 11) before you start the work. | <input type="checkbox"/> |
| If you made connections to the emergency stop circuit on site (for example, added emergency stop buttons or connected shipping splits of large drives), do a check of the connections against the applicable circuit diagrams. | <input type="checkbox"/> |
| Inverter units with parallel R8i inverter modules: Make sure that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules. | <input type="checkbox"/> |
| Settings with voltage connected | |
| Close the cabinet doors and power up the drive. Refer to the hardware manual. | <input type="checkbox"/> |
| Make sure that the parameter settings related to the safety functions are correct. Refer to chapter Parameter settings . | <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 at least 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 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"/> |
| Emergency stop, stop category 0: Make sure that the drive stops the motor by coasting and that the correct warnings and indications are shown. | <input type="checkbox"/> |
| Emergency stop, stop category 1: 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 STO function is activated. | <input type="checkbox"/> |
| Make sure that the correct indications for STO activation are shown (as defined by parameter 31.22). | <input type="checkbox"/> |



54 Start-up and validation test

| Action | <input checked="" type="checkbox"/> |
|---|-------------------------------------|
| <p>Make sure that the drive generates none of these faults:</p> <ul style="list-style-type: none"> • STO hardware failure (5090) • Safe torque off 1 loss (FA81) • Safe torque off 2 loss (FA82) <p>If the drive generates these faults, refer to the fault tracing instructions in this manual. If the FSO module generates a fault, refer to the FSO module user's manual, chapter Fault tracing.</p> | <input type="checkbox"/> |
| <p>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.</p> | <input type="checkbox"/> |
| <p>Switch off the drive start signal.</p> | <input type="checkbox"/> |
| <p>Turn the emergency stop button [S61] until it releases and returns to the up position.</p> | <input type="checkbox"/> |
| <p>Push the emergency stop reset button [S62]. Make sure that:</p> <ul style="list-style-type: none"> • the emergency stop reset button indicator light [S62] goes off • the drive does not restart automatically. | <input type="checkbox"/> |
| <p>Power up the drive:</p> <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. <p>For more information, see the hardware manual.</p> | <input type="checkbox"/> |
| <p>Restart the drive and motor. Make sure that they operate normally.</p> | <input type="checkbox"/> |
| <p>Do the test again from each operating location (for each emergency stop button and reset button).</p> | <input type="checkbox"/> |
| <p>Create a backup file of the drive parameters with the Drive Composer pro PC tool.</p> | <input type="checkbox"/> |
| <p>Save the FSO safety file with the button Save safety file in the Drive Composer pro PC tool.</p> | <input type="checkbox"/> |
| <p>Fill in and sign the validation test report. Store the report in the logbook of the machine.</p> | <input type="checkbox"/> |





Fault tracing

Contents of this chapter

This chapter provides general diagnostics and troubleshooting tips.

Fault tracing

■ STO circuit connections

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

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

Refer to the circuit diagrams delivered with the drive.

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

■ Other

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

Reporting problems and failures related to safety functions

Contact ABB.

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Maintenance

Contents of this chapter

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

Safety circuit maintenance

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

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

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

Proof test interval

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

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

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

The person responsible for the design of the complete safety system should also note the Recommendation of Use CNB/M/11.050 published by the European co-ordination of Notified Bodies for Machinery concerning dual-channel safety-related systems with electromechanical outputs:

- When the safety integrity requirement for the safety function is SIL 3 or PL e (cat. 3 or 4), the proof test for the function must be done at least every month.
- When the safety integrity requirement for the safety function is SIL 2 (HFT = 1) or PL d (cat. 3), the proof test for the function must be done at least every 12 months.

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

Functional safety components

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

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

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

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

Contact your local ABB service representative for more information.

Competence

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

Residual risk

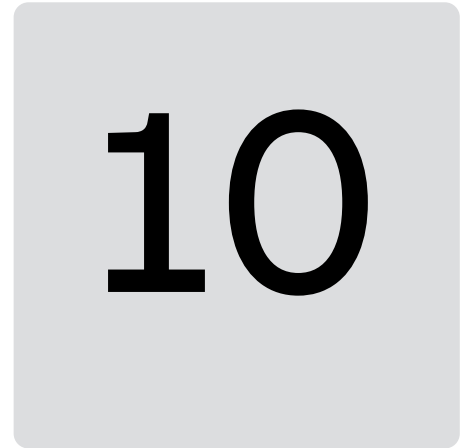
The safety functions are used to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. Thus, the warnings for the residual risks must be given to the operators.

Intentional misuse

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

Decommissioning

When you decommission 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 gives the safety data, ambient conditions, and list of standards related to the product.

Safety data

■ Safety data values

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

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

The safety encoder is not included in the calculations, because it is not included in the delivery. Only the FSE-31 module is included in the calculations (if used).

| Stop category and monitoring method | SIL | SC | PL | PFH ¹⁾ [1/h] | PFD _{avg} (T ₁ =2a) | PFD _{avg} (T ₁ =5a) | DC ²⁾ [%] | Cat. | HFT | CCF | T _M [a] | T ₁ ^{3) 4)} [a] |
|--|-----|----|----|-------------------------|---|---|----------------------|------|-----|-----|--------------------|-------------------------------------|
| Frame sizes R6...R9 | | | | | | | | | | | | |
| Stop category 0 | 3 | 3 | e | 5.7E-08 | 2.0E-04 | 2.4E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop category 1, time monitoring | | | | | | | | | | | | |
| Stop category 1, ramp monitoring without encoder | 3 | 3 | e | 5.7E-08 | 3.3E-04 | 5.1E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |

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| Stop category and monitoring method | SIL | SC | PL | PFH ¹⁾ [1/h] | PFD _{avg} (T ₁ =2a) | PFD _{avg} (T ₁ =5a) | DC ²⁾ [%] | Cat. | HFT | CCF | T _M [a] | T ₁ ^{3) 4)} [a] |
|--|-----|----|----|----------------------------|--|--|-------------------------|------|-----|-----|-----------------------|--|
| Stop category 1, ramp monitoring with encoder | 3 | 3 | e | 6.6E-08 | 2.0E-04 | 3.2E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Frame sizes R10...R11 | | | | | | | | | | | | |
| Stop category 0 | 3 | 3 | e | 5.7E-08 | 2.0E-04 | 2.5E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop category 1, time monitoring | | | | | | | | | | | | |
| Stop category 1, ramp monitoring without encoder | 3 | 3 | e | 5.7E-08 | 3.4E-04 | 5.2E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop category 1 ramp monitoring, with encoder | 3 | 3 | e | 6.6E-08 | 2.1E-04 | 3.4E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Frame sizes R6i...R7i | | | | | | | | | | | | |
| Stop cat. 0 | 3 | 3 | e | 5.7E-08 | 2.0E-04 | 2.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop cat. 1, time monitoring | | | | | | | | | | | | |
| Stop cat. 1, ramp monitoring without encoder | 3 | 3 | e | 5.7E-08 | 3.4E-04 | 5.3E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop category 1 ramp monitoring, with encoder | 3 | 3 | e | 6.6E-08 | 2.1E-04 | 3.4E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Frame sizes 1...8×R8i | | | | | | | | | | | | |
| Stop cat. 0 | 3 | 3 | e | 5.4E-08 | 1.7E-04 | 1.8E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop cat. 1, time monitoring | | | | | | | | | | | | |
| Stop cat. 1, ramp monitoring without encoder | 3 | 3 | e | 5.4E-08 | 3.1E-04 | 4.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| Stop category 1 ramp monitoring, with encoder | 3 | 3 | e | 6.3E-08 | 1.8E-04 | 2.7E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 3AXD10000097591 M | | | | | | | | | | | | |

1) PFH values are according to EN ISO 13849.

2) DC for low demand mode is 90% (determined by the DC of the worst component in the subsystem).

3) See the Recommendation of Use CNB/M/11.050 published by the European 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.

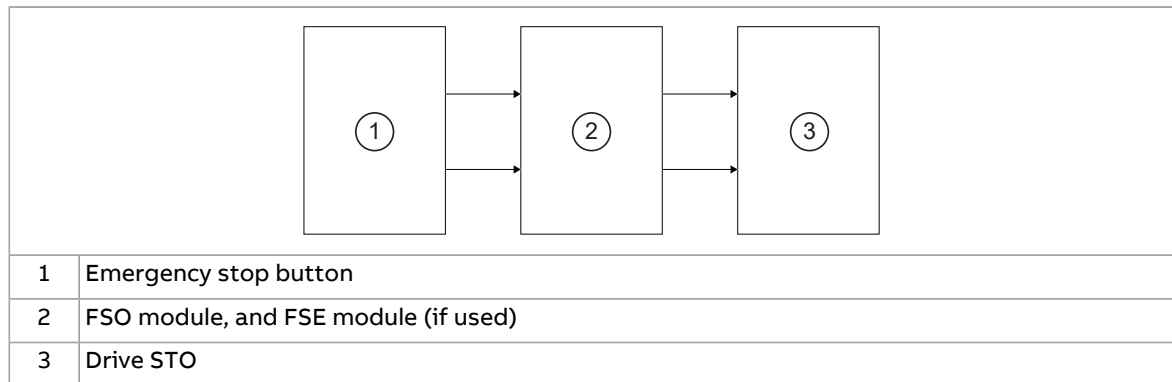
■ Safety component types

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 R6i...R7i inverter modules: type A
 - drives with R6i...R7i inverter modules and UCU-22, -23 or -24 control unit: type B
 - frame sizes R10 and R11 and drives with R8i inverter modules: type B.

■ Safety block diagrams

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



■ Relevant failure modes

Relevant failure modes are:

- 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.

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 emergency stop request is on.

■ 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 encoder, you must add the delays of the encoder when defining the total response time for the safety function and the fault reaction function.

Ambient conditions

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

Related standards and directives

| Standard | Name |
|--|---|
| IEC 61800-5-2:2016 EN 61800-5-2:2007 | Adjustable speed electrical power drive systems - Part 5-2: Safety requirements – Functional |
| IEC 62061:2021 + AMD1:2024 EN IEC 62061:2021 | Safety of machinery – Functional safety of safety-related control systems |
| EN ISO 13849-1:2023 | Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design |
| EN ISO 13849-2:2012 | Safety of machinery - Safety-related parts of control systems - Part 2: Validation |
| IEC 61508-1:2010 | Functional safety of electrical/electronic/programmable electronics safety related systems – Part 1: General requirements |
| IEC 61508-2:2010 | Functional safety of electrical/electronic/programmable electronics safety related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems |
| IEC 61511-1:2016 + AMD1:2017 | Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements |
| IEC 61000-6-7:2014 | Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations |
| IEC 61326-3-1:2017 | Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications |
| EN ISO 13850:2015 | Safety of machinery – Emergency stop – Principles for design |
| 2006/42/EC | European Machinery Directive |
| | Supply of Machinery (Safety) Regulations 2008 (UK) |
| Other | Machine-specific C-type standards |

Compliance with the European Machinery Directive

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



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

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

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



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

Further information

Product and service inquiries

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

Product training

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

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