User’s manual
Emergency stop, configurable stop category 0 or 1 (option +Q979) for ACS880-07/17/37 drives
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<thead>
<tr>
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<td>Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.</td>
<td></td>
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You can find manuals and other product documents in PDF format on the Internet. See section Document library on the Internet on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.
User’s manual

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

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Introduction to the manual

Contents of this chapter

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

Applicability

This manual applies to ACS880-07/17/37 drives which have the option +Q979: Emergency stop, configurable stop category 0 or 1 with STO, with FSO. In this emergency stop option, the Safe torque off (STO) circuit of the drive is opened. The main contactor/breaker of the drive is not opened.

For the option +Q979, ABB installs the FSO-12 safety functions module (option +Q973) or the FSO-21 safety functions module (option +Q972) to the drive. When a safety pulse encoder is used, ABB installs the FSE-31 pulse encoder interface module (option +L521) and the FSO-21 module to the drive. Only the FSO-21 module supports the FSE-31 module and the use of safety pulse encoders.

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

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

Only a qualified electrician who has appropriate knowledge on functional, machine and process safety is allowed to install, start up and maintain the safety circuit.

**WARNING!** This safety function does not disconnect the voltage of the main and auxiliary circuits from the drive. Never work on the electrical parts of the drive or the motor before you have also disconnected the drive system from the electric supply, from rotating permanent magnet motors and from rotating motors equipped with sine filters, and made sure by measuring that there is no dangerous voltage present.

**WARNING!** After you have made additions to the drive safety circuit or modified it, changed circuit boards inside the drive, replaced the FSO or FSE module or modified FSO module parameters, always test the operation of the safety circuit according to its acceptance test procedure. The change can affect unexpectedly. All customer-made changes are on the customer’s responsibility.

**WARNING!** The Safe torque off functionality is only achieved through the XSTO connector of the inverter or drive control unit. True Safe torque off functionality is not achieved through the XSTO connectors of other control units (such as the supply control unit). In the supply, the XSTO input must not be used for any safety function purposes to ensure personnel safety. The Safe torque off function is supported by any ACS880 inverter or drive firmware. It is not supported by supply firmware.

**WARNING!** Read and obey all safety instructions in the drive hardware manual. If you ignore them, injury or death, or damage to the equipment can occur.

This manual does not repeat the complete safety instructions of the drive but it only includes the instructions related to the scope of this manual.

Target audience

This manual is intended for people who install, start up, use and service the safety option of the drive. Read the manual before working on the drive. You are expected to know the fundamentals of electricity, wiring, electrical components, electrical schematic symbols, and functional safety.
Contents
The chapters of this manual are briefly described below.

*Introduction to the manual* (this chapter) introduces this manual and gives safety instructions.

*Option description and instructions* describes the safety function and instructs how to wire and use it.

*Parameter settings* lists the parameters that you have to set for the safety function.

*Start-up and acceptance test* gives instructions on how to start up, test and validate the safety function.

*Maintenance* gives instructions on how to maintain the safety function.

*Technical data* gives general rules, notes and definitions related to safety functions and lists the related standards and directives. The safety data is also given.

Related documents

- Product manuals (see the inside of the front cover)
- Circuit diagrams delivered with the drive
- Part lists delivered with the drive
- Safety data report (if the safety circuit is application engineered)

Abbreviations
Abbreviations used in this manual are listed below.

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<thead>
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<th>Abbreviation</th>
<th>Description</th>
<th>Reference</th>
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<td>Cat.</td>
<td>Category</td>
<td>EN/IEC 60204-1</td>
</tr>
<tr>
<td></td>
<td>1. Stop category according to EN/IEC 60204-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The stop categories are: 0 (uncontrolled stop) and 1 (controlled stop)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Classification of the safety-related parts of a control system in respect</td>
<td>EN ISO 13849-1</td>
</tr>
<tr>
<td></td>
<td>of their resistance to faults and their subsequent behavior in the fault</td>
<td></td>
</tr>
<tr>
<td></td>
<td>condition, and which is achieved by the structural arrangement of the parts,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fault detection and/or by their reliability. The categories are: B, 1, 2, 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and 4.</td>
<td></td>
</tr>
<tr>
<td>CCF</td>
<td>Common cause failure (%)</td>
<td>EN ISO 13849-1</td>
</tr>
<tr>
<td>DC</td>
<td>Diagnostic coverage</td>
<td>EN ISO 13849-1</td>
</tr>
<tr>
<td>DI</td>
<td>Digital input</td>
<td></td>
</tr>
<tr>
<td>DO</td>
<td>Digital output</td>
<td></td>
</tr>
<tr>
<td>E-stop</td>
<td>Emergency stop</td>
<td></td>
</tr>
</tbody>
</table>
Frame (size)  
Relates to the construction type of the drive in question. For example, several drive types with different power ratings can have the same basic construction, and a frame size is used in reference to all those drive types.

With the ACS880-07/17/37 (smaller), the frame size marking of the drive indicates the physical size of the drive, eg, R6.

With the ACS880-07 (larger), the frame size marking of the drive indicates the quantity and frame size of the diode supply modules plus the quantity and frame size of the inverter modules, eg, “2×D8T +3×R8i”.

With the ACS880-17 and ACS880-37 (larger), the frame size marking of the drive indicates the quantity and frame size of the IGBT supply modules plus the quantity and frame size of the inverter modules, eg, “2×R8i +3×R8i”.

FSE-31 Pulse encoder interface module

FSO-12 Safety functions module which does not support the use of encoders

FSO-21 Safety functions module which supports the FSE-31 module and the use of safety encoders

HFT Hardware fault tolerance

GND Ground

IGBT Insulated gate bipolar transistor

modoff No modulation

NC Normally closed

PFD avg Average probability of dangerous failure on demand

PFH Average frequency of dangerous failures per hour

POUS Prevention of unexpected start-up

PL Performance level (levels are: a, b, c, d and e). Corresponds to SIL.

R8i Frame size designation of the inverter module

SAR Safe acceleration range. In the FSO module, there are two sets of SAR parameters (SAR0 and SAR1) that are used to decelerate the motor(s) and to define the ramp monitoring limits. SAR1 parameters are used in the Emergency stop, stop category 1 safety function described in this manual.

SC Systematic capability

SIL Safety integrity level (levels are: 1, 2, 3 and 4)

SILCL SIL claim limit. Maximum SIL that can be claimed for a safety function or subsystem

SS1 Safe stop 1

SSE Safe stop emergency

STO Safe torque off. In this manual, this term is used in two different contexts:
- the STO circuit in the drive (the drive STO function)
- the STO safety function in the FSO module.

Safety functions in the FSO module (eg, STO, SSE, SS1 and POUS) activate the drive STO function, that is, open the drive STO circuit. In addition, some safety functions can activate the STO safety function in the FSO module, which in turn opens the drive STO circuit.
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 all relevant standards, directives and local electrical code, and that the system is tested, verified and validated correctly.
### Quick reference guide for implementing a safety system

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the appropriate functional safety standard for the implementation: EN ISO 13849-1, EN/IEC 62061, IEC 61511 or other.</td>
</tr>
<tr>
<td>If you select EN/IEC 62061 or IEC 61511, make a safety plan. See EN/IEC 62061 or IEC 61511.</td>
</tr>
<tr>
<td>Assess safety: analyze and evaluate risks (estimate SIL/PL) and define risk reduction strategies. Define the safety requirements.</td>
</tr>
<tr>
<td>Design the safety system. The part of the design made by ABB is described in chapter <em>Option description and instructions</em> on page 15.</td>
</tr>
<tr>
<td>Verify the achieved SIL/PL with, for example, FSDT-01 Functional safety design tool or similar. See <em>Functional safety design tool user's manual</em> (3AXD10000102417 [English]).</td>
</tr>
<tr>
<td>Connect the wiring. See section <em>Wiring</em> on page 30.</td>
</tr>
<tr>
<td>Set the necessary parameters. See chapter <em>Parameter settings</em> on page 35.</td>
</tr>
</tbody>
</table>
| Validate that the implemented system meets the safety requirements:  
  • Do the acceptance test. See chapter *Start-up and acceptance test* on page 45. |   |
| Write the necessary documentation. |   |
Option description and instructions

Contents of this chapter

This chapter describes the operation of the option +Q979: Emergency stop, configurable stop category 0 or 1 and instructs how to wire and use it.

Overview

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

When a safety pulse encoder is used in the safety application, also the FSE-31 pulse encoder interface module (option +L521) is installed in the drive. ABB installs the FSE module to the drive and sets the delivery configuration for the cabinet safety option at the factory.

- Emergency stop, stop category 0

  This is an uncontrolled stop (EN/IEC 60204-1). When the user pushes the emergency stop button, he/she actually activates the Safe torque off (STO) function of the FSO module. This activates the STO function of the drive. The STO function disables the control voltage of the power semiconductors of the drive output stage. This prevents the drive from generating the torque required to rotate the motor. The motor coasts to a stop.
• **Emergency stop, stop category 1**

This is a controlled stop (EN/IEC 60204-1). When the user pushes the emergency stop button, he/she actually activates the Safe stop 1 function (SS1) of the FSO module. After the drive has decelerated the motor below a user-defined zero speed limit, the FSO module activates the STO function of the drive.

The SS1 function operates either 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.

The user cannot start the drive before he/she has released the emergency stop button and pushed the emergency stop reset button. This resets the emergency stop circuit and deactivates the drive STO function.

**Note:** ACS880-07 drives, frames nxDXT + nxR8i with a main contactor/breaker (option +F250/+F255), ACS880-17/37 drives, frames nxR8i + nxR8i and ACS880-17/37 drives, frame R8 and R11: When the STO function is activated in the inverter unit, the main contactor/breaker is opened after a user-defined delay (defined with parameter 94.11, the default value is 600 s). See the hardware and firmware manuals for more information.

For a detailed description of the Safe torque off function, see the hardware manual of your drive.

For more information on the safety functions of the FSO module, see *FSO-12 safety functions module user’s manual* (3AXD50000015612 [English]) or *FSO-21 safety functions module user’s manual* (3AXD50000015614 [English]).

For more information on the FSE module, see *FSE-31 pulse encoder interface module user’s manual* (3AXD50000016597 [English]).

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

The STO and SS1 functions comply with EN/IEC 61800-5-2:2007. For a complete list of related standards and European directives, see section Related standards and directives on page 55.

### **Summary of wirings and settings**

The wirings and settings of the emergency stop function are:

- **The drive is equipped with the FSO safety functions module (option +Q973 or +Q972). ABB installs the module at the factory.**

- **One emergency stop button is installed on the cabinet door and wired to the FSO module. ABB wires the button at the factory. The user can add buttons to the emergency stop circuit.**

- **One emergency stop reset button is installed on the cabinet door and wired to the FSO module. The reset button also includes an emergency stop indication lamp (see the next bullet). ABB wires the button and the indication lamp at the factory. The user can add reset buttons to the reset circuit.**

- **The digital output of the FSO module to which the emergency stop indication lamp is connected, is selected as the output for the Stop completed signal. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.**
• **Emergency stop, stop category 0:**
  • The digital input of the FSO module to which the emergency stop button is connected, is selected as the input 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 digital input of the FSO module to which the emergency stop button is connected, is selected as the input for the SS1 request. This is an FSO module parameter that the user must set at the start-up.
  • The SS1 function is set to use either the time monitoring or ramp monitoring mode. This is an FSO module parameter that the user must set at the start-up.
  • The stop ramp that is used to decelerate the motors and the monitoring limits (stop ramp time or ramp monitoring limits) are set according to application needs. These are FSO module parameters that the user must set at the start-up.

Additional wirings when a safety pulse encoder is used:
• The drive is equipped with the FSE-31 pulse encoder interface module (option +L521). ABB installs the module at the factory.
• The motor must be equipped with a safety pulse encoder. The user installs the safety pulse encoder and wires it to the FSE-31 module. The user must make sure that the required safety integrity (SIL/PL) can be achieved with the used safety encoder(s).

For a detailed description of wirings, see sections *Wiring* on page 30 and *Circuit diagram* on page 29. For a detailed description of parameter settings, see chapter *Parameter settings* on page 35.
Operation principle

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

Time schemes without a 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. For more information, see the FSO module user’s manual.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The user pushes the emergency stop button and the FSO module activates the FSO and drive STO functions. The FSO module starts counters for times A and B. <strong>Note:</strong> The safety function request to the FSO module must be active for at least 20 ms.</td>
</tr>
<tr>
<td>2</td>
<td>The user releases the emergency stop button.</td>
</tr>
<tr>
<td>3</td>
<td>Time B has elapsed. The user can push the reset button, that is, 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.)</td>
</tr>
<tr>
<td>4</td>
<td>Time A has elapsed. The motor has stopped and the emergency stop indication lamp goes on.</td>
</tr>
<tr>
<td>5</td>
<td>The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module). <strong>Note:</strong> The pressing time of the reset button must be between 0.3 s...3 s.</td>
</tr>
</tbody>
</table>
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. For more information, see the FSO module user’s manual.

Case A: The motor speed goes below the zero speed limit within the user-defined time.

Case B: The motor speed does not go below the zero speed limit within the user-defined time.
A Security delay: When time A has elapsed from the start of the counter (step 1), the FSO module activates FSO and drive STO functions (case B). In case A, the FSO module has already activated the STO function. This is a user-defined value (parameter SS1.14 SS1-t delay for STO).

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

C Safety function response time.

D Time to zero speed: When time D has elapsed from the start of the counter (step 3b, activation of the STO function), the user can push the reset button, that is, the acknowledgement of the STO function is possible. The user must set this time longer than the time the motor coasts from the maximum speed to zero speed (parameter STO.14 Time to zero speed with STO and modoff).

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a counter for time A. <strong>Note</strong>: The safety function request to the FSO module must be active for at least 20 ms.</td>
</tr>
<tr>
<td>2</td>
<td>The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter 200.112 SAR1 ramp time to zero).</td>
</tr>
<tr>
<td><strong>Case A</strong></td>
<td>The motor speed goes below the zero speed limit within the user-defined time.</td>
</tr>
<tr>
<td>3a</td>
<td>The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO function. The emergency stop indication lamp goes on. <strong>Note</strong>: You can set an additional delay for the STO activation (parameter SS1.15 SS1-r ramp zero speed delay for STO).</td>
</tr>
<tr>
<td>4a</td>
<td>Time A has elapsed. The STO function is already active. In this case, this time has no effect.</td>
</tr>
<tr>
<td>5a</td>
<td>The user releases the emergency stop button.</td>
</tr>
<tr>
<td>6a</td>
<td>The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module). <strong>Note</strong>: The pressing time of the reset button must be between 0.3 s...3 s.</td>
</tr>
<tr>
<td>7a</td>
<td>The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The drive is ready for a restart.</td>
</tr>
<tr>
<td><strong>Case B</strong>: Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>The FSO module activates the FSO and drive STO functions and starts a counter for time D. The motor coasts to a stop.</td>
</tr>
<tr>
<td>4a</td>
<td>The user releases the emergency stop button.</td>
</tr>
<tr>
<td>5b</td>
<td>Time D has elapsed. The motor has stopped and the emergency stop indication lamp goes on. The user can push the reset button, that is, acknowledgement of the STO function is possible.</td>
</tr>
<tr>
<td>6b</td>
<td>The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module). <strong>Note</strong>: The pressing time of the reset button must be between 0.3 s...3 s.</td>
</tr>
<tr>
<td>7b</td>
<td>The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before the drive is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter FSOGEN.62 STO indication safety limit]).</td>
</tr>
</tbody>
</table>
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. For more information, see the FSO module user’s manual.

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

Case B: The motor speed does not follow the user-defined stop ramp monitoring window.
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. 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 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. For more information, see *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]).

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1    | The user pushes the emergency stop button and the FSO module activates the FSO and drive STO functions. The FSO module starts a counter for time B.  
**Note:** The safety function request to the FSO module must be active for at least 20 ms. |
| 2    | The user releases the emergency stop button. |
| 3    | Time B has elapsed. The user can push the reset button, that is, 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 goes on. |
| 5    | The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module).  
**Note:** The pressing time of the reset button must be between 0.3 s...3 s. |
| 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. |

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

B  Restart delay: Delay from pushing the emergency stop button (and activation of the STO function) to the moment that the user can push the reset button at the earliest (and acknowledge the STO function). With this parameter, it is possible to allow a restart of the drive while the motor is still running (fly-start) (parameter *STO.13 Restart delay after STO*).
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 a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module. For more information, see FSO-21 safety functions module user’s manual (3AXD50000015614 [English]).

**Case A:** The motor speed goes below the zero speed limit within the user-defined time.

**Case B:** The motor speed does not go below the zero speed limit within the user-defined time.
A Security delay: When time A has elapsed from the start of the counter (step 1), the FSO module activates FSO and drive STO functions (case B). In case A, the FSO module has already activated the STO function. This is a user-defined value (parameter SS1.14 SS1-t delay for STO).

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

C Safety function response time.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a counter for time A. &lt;br&gt;<strong>Note:</strong> The safety function request to the FSO module must be active for at least 20 ms.</td>
</tr>
<tr>
<td>2</td>
<td>The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter 200.112 SAR1 ramp time to zero).</td>
</tr>
</tbody>
</table>

**Case A:** The motor speed goes below the zero speed limit within the user-defined time.

3a | The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO function. The emergency stop indication lamp goes on. **Note:** You can set an additional delay for the STO activation (parameter SS1.15 SS1-r ramp zero speed delay for STO).

4a | Time A has elapsed. The STO function is already active. In this case, this time has no effect.

5a | The user releases the emergency stop button.

6a | The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module). <br>**Note:** The pressing time of the reset button must be between 0.3 s...3 s.

7a | 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:** Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.

3b | The FSO module activates the FSO and drive STO functions. The motor coasts to a stop.

4b | The motor speed goes below the zero speed limit (B). The motor has stopped and the user can push the reset button, that is, acknowledgement of the STO function is possible. The emergency stop indication lamp goes on.

5b | The user releases the emergency stop button.

6b | The user pushes the reset button (this resets the emergency stop circuit and removes the emergency stop request from the FSO module). <br>**Note:** The pressing time of the reset button must be between 0.3 s...3 s.

7b | The FSO module deactivates the STO function in the drive. The emergency stop indication lamp goes off. The user must reset the drive before the drive is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit (parameter FSOGEN.62 STO indication safety limit)).
Emergency stop, stop category 1 with ramp monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with ramp monitoring a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module. For more information, see FSO-21 safety functions module user’s manual (3AXD50000015614 [English]).

**Case A:** The motor speed goes below the zero speed limit within the user-defined stop ramp monitoring window.

**Case B:** The motor speed does not follow the user-defined stop ramp monitoring window.
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. 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).
Circuit diagram

This diagram is an example circuit diagram without the safety encoder interface. For more information, see the circuit diagrams of the delivery.

![Circuit Diagram]

Initial status: The drive is in operation and the motor is running.

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The user activates the emergency stop function by pushing the emergency stop button [S61]. This activates the safety function in the FSO module.</td>
</tr>
<tr>
<td>2.</td>
<td>The drive decelerates/coasts the motor to zero speed using the user-defined stop category (0 or 1). The STO circuit in the drive/inverter unit is opened.</td>
</tr>
<tr>
<td>3.</td>
<td>The emergency stop indication lamp [P62] illuminates as described in section <em>Operation principle</em> on page 18.</td>
</tr>
</tbody>
</table>
| 4.   | Normal operation resumes after the user:  
  - releases the emergency stop button [S61] to normal (up) position  
  - resets emergency stop circuit by pushing the emergency stop reset button [S62]  
  - switches the external start signal of drive off and on (only in external control mode)  
  - resets the drive if a fault is generated (see FSO parameter *FSOGEN.61 STO indication ext request* on page 37 and drive parameter 31.22 *STO indication run/stop* on page 44). |
Wiring

One emergency stop button and one reset button are installed on the cabinet door and wired to the FSO module at the factory. There are double contacts in the emergency stop button and double wiring (two-channel connection) between the button and the FSO module. This function must be used in a redundant manner, that is, the emergency stop button must be connected to both terminals with a separate contact.

There is an extension terminal block [X68] for the connections to the FSO module inside the drive cabinet. The FSO module connectors [X113] and [X114] have been wired to [X68]. This table shows the connections between the extension terminal block and the FSO module.

<table>
<thead>
<tr>
<th>FSO X113:</th>
<th>X68</th>
<th>FSO X114:</th>
<th>X68</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>8,9</td>
<td>6</td>
<td>22, 23</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>13, 14, 15, 16</td>
<td>10</td>
<td>27, 28, 29, 30</td>
</tr>
</tbody>
</table>

If necessary, install additional emergency stop buttons on site. See the table above and the circuit diagrams of the delivery. Obey these general rules:

1. Use only double-contact buttons approved for the emergency stop circuits.

2. Connect the emergency stop buttons with two conductors (two-channel connection). **Note:** Keep the channels separate. If you use only one channel, or if the first and second channels are connected together (for example, in a chain), the cross-fault detection of the FSO module trips and activates the fault reaction function (see page 32) as it detects a redundancy failure. **Note:** If you change the input and the parameter settings in the FSO module into a one-channel implementation, it affects the safety integrity of the safety function. The safety data that ABB has calculated for the function is not valid.

3. Use a shielded, twisted pair cable. We recommend a double-shielded cable and gold-plated contacts in the emergency stop button.

4. The maximum allowed cable length between the drive and the emergency stop button (for the whole loop) is 250 m (820 ft).

5. Obey the general control cable installation instructions given in the 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. We recommend gold-plated NC contacts in the reset button. The maximum allowed cable length between the drive and the reset button (for the whole loop) is 250 m (820 ft). See the circuit diagrams of the delivery. Obey the general control cable installation instructions given in the hardware manual and in *FSO-12 safety functions module user’s manual* (3AXD50000015612 [English]).

When a safety pulse encoder is used, ABB installs the FSO-21 and FSE-31 modules and the wirings between the FSO module and the drive at the factory.

The user must wire the safety pulse encoder to the FSE module on site. Obey these rules:
- Use a double-shielded, twisted pair cable.
- The maximum allowed cable length between the safety pulse encoder and the FSE module is 300 m (980 ft).

For more information, see *FSE-31 pulse encoder interface module user’s manual* (3AXD50000016597 [English]).

**Use of the safety function**

- **Activating**
  1. Push the emergency stop button [S61]. The emergency stop activates and the button locks in the “ON” (open) position.

- **Resetting**
  1. Make sure that the external start signal of the drive is switched off (it is possibly still on if no pulse start is in use).
  2. Turn the emergency stop button [S61] until it releases.
  4. Reset the drive if necessary.
  5. You can now restart the drive.

**Note:** If you switch off the power after you have released the emergency stop button [S61] (step 2), the drive resets the safety function automatically. In this case, you do not have to push the reset button [S62].
Emergency stop indications

When the emergency stop function has been completed:
• the indication lamp [P62] of the reset button [S62] illuminates. This indicates that it is possible to reset the Emergency stop function.

Note: The indication lamp goes on also when the FSO module has activated the drive STO function after fault situations. In addition, the indication lamp goes on and off when the drive is started.

The indications that the FSO module generates are configurable. For more information, see chapter Parameter settings on page 35 and chapter Fault tracing in the FSO module user’s manual.

Fault reaction function

Definition: The safety function has a ‘fault reaction function’ that attempts to bring the systems to a safe state if it detects any failure within the safety system:
• a short or open circuit or redundancy failure of the emergency stop button wiring chain, or
• any internal failure within the FSO or FSE modules, the safety encoder or the drive STO.

This section describes the fault reaction functions in the FSO and FSE modules, the safety encoder and the drive.

FSO module

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

The FSO module goes into the Fail-safe mode. The FSO module LED STATUS/FAULT is red until the fault has been repaired.

To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module by switching the power off and on, by pressing the Boot FSO button on the Safety view of Drive composer pro or with drive parameter 96.09 FSO reboot. For more information, see the drive firmware manual and the FSO module user’s manual.
**FSE module**

When a safety function is active, the fault reaction function of the FSO module trips the drive if it detects a failure in the FSE module. The FSO module activates the STO function. This activates the drive STO function. The drive STO function is active until the fault has been repaired.

When there are no active safety functions, the fault reaction function depends on the value of FSO parameter S_ENCGEN.11 *FSE diagnostic failure reaction* (see section *General parameters* on page 36).

The FSO module goes into the Fail-safe mode. The FSO module LED STATUS/FAULT is red and the FSE module LED STATUS is off until the fault has been repaired. Also the drive indicates some of the FSE module faults.

To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module by switching the power off and on, by pressing the **Boot FSO** button on the Safety view of Drive composer pro or with drive parameter 96.09 FSO reboot.

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

**Safety encoder**

The FSE module indicates the internal faults of the safety encoder as cabling faults. This activates the fault reaction function in the FSE module. This causes the FSO module to go into the Fail-safe mode (see previous sections).

The FSO module LED STATUS/FAULT is red and the FSE module LED ENC STATUS is off until the fault has been repaired. Also the drive indicates the safety encoder fault.

The FSO module LED STATUS/FAULT is red and the FSE module LED ENC STATUS is off until the fault has been repaired. Also the drive indicates the safety encoder fault.

To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module by switching the power off and on, by pressing the **Boot FSO** button on the Safety view of Drive composer pro or with drive parameter 96.09 FSO reboot.

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, by switching the power off and on).

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

**STO function in the drive**

The STO function in the drive has internal fault diagnostics and a fault reaction function which causes a fault trip in case it detects a redundancy fault of STO control signals or any internal failure. See the hardware and firmware manuals of the drive.
Parameter settings

Contents of this chapter
This chapter lists the parameters that you have to set in the FSO module and the drive.

Introduction
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 as well as the configuration of the FSO module. We recommend our training courses on the FSO module.

The example parameter values in this chapter are valid for the example Emergency stop, stop category 0 and stop category 1 safety functions presented in this manual (+Q979). We assume that the FSO module is only used in either of the example safety functions and not in any other safety function at the same time. However, the actual deliveries vary. You must always check the pre-set parameter values against the delivery specific circuit diagrams and your application needs, and adjust the parameters values when necessary.

FSO module
You need the Drive composer pro PC tool to set the FSO module parameters, and a password to be able to download the configuration to the FSO module from Drive composer pro. For the default password of the FSO module, see the FSO module user’s manual. For more information on the Drive composer pro PC tool, see Start-up and maintenance PC tool Drive composer user’s manual (3AUA0000094606 [English]).

Note: When the motor is running, you cannot change the password, adjust the parameters, or upload or download the FSO configuration file.
Follow the configuration steps described in the FSO module user’s manual, chapter Configuration.

There are parameters that you must set always and parameters that are related only to certain safety functions. These tables list all the parameters that you must check and set for the option +Q979. The example values apply only to the option +Q979.

### General parameters

These parameters are common to all safety functions.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSOGEN.11</td>
<td>Stop completed output</td>
<td>DO X114:7</td>
<td>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 the option +Q979, ABB has configured the emergency stop indication lamp to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</td>
</tr>
<tr>
<td>FSOGEN.21</td>
<td>Motor nominal speed</td>
<td>1500 rpm</td>
<td>Sets the nominal motor speed. Adjust the default value to meet the ratings of the motor in use.</td>
</tr>
<tr>
<td>FSOGEN.22</td>
<td>Motor nominal frequency</td>
<td>50 Hz</td>
<td>Sets the nominal motor frequency. Adjust the default value to meet the ratings of the motor in use.</td>
</tr>
</tbody>
</table>
| FSOGEN.41 | Power-up acknowledgement    | Automatic     | Sets the power-up acknowledgement method of the FSO module.  
  Automatic: You do not need to push a reset button after switching on the FSO module. The FSO module generates the acknowledgement signal automatically after the power-up.  
  Manual: The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42. Make sure that the value is Automatic. |
| FSOGEN.42 | Acknowledgement button input | DI X114:2     | Selects the digital input for the acknowledgement signal when parameter FSOGEN.41 Power-up acknowledgement or STO.02 STO acknowledgement has value Manual. For the option +Q979, ABB has configured the emergency stop reset button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery. |
| FSOGEN.51 | Zero speed without encoder  | 90 rpm         | Sets the general zero speed limit for safety functions when no safety encoder is in use.  
  Emergency stop, stop category 0: This value has no effect in the operation.  
  Emergency stop, stop category 1: 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. |
| FSOGEN.52 | Zero speed with encoder     | 10 rpm         | Sets the general zero speed limit for safety functions when a safety encoder is in use.  
  Emergency stop, stop category 0: The indication lamp goes on when the motor speed goes below this value. Adjust the default value when necessary.  
  Emergency stop, stop category 1: The FSO module activates drive STO function when the drive has decelerated the motor speed below this value. Adjust the default value when necessary. |
Parameters for the STO function

These parameters are related to the STO function of the FSO module. The Emergency stop, stop category 0 function uses this function. In addition, the FSO module can activate the STO function in internal fault situations.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO.02</td>
<td>STO acknowledgement</td>
<td>Manual</td>
<td>Sets the acknowledgement method used in the STO, SSE and SS1 functions. Manual: The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42. 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. WARNING! If the value is Automatic, the FSO module resets the STO function automatically after the user has released the emergency stop button and the drive can restart automatically. This can cause danger.</td>
</tr>
<tr>
<td>STO.11</td>
<td>STO input A</td>
<td>DI X113:1 &amp; X114:1 Stop cat. 0: Emergency stop, stop category 0: For the option +Q979, ABB has configured the emergency stop button to this digital input at the factory. Make sure that the setting corresponds to the circuit diagrams of the delivery. Emergency stop, stop category 1: Make sure that this parameter has value None. (An external signal cannot start the STO function.) Note: The default value after factory reset is DI X113:1 &amp; X114:1. Always check this parameter after factory reset.</td>
<td></td>
</tr>
</tbody>
</table>
### Index

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO.13 Restart delay after STO</td>
<td>2000 ms Sets the time after which the restart of the drive is allowed after the FSO module has activated the STO function and opened the drive STO circuit. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). This parameter is valid only if the STO function is requested from STO input A (STO.11). Emergency stop, stop category 0: 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. Emergency stop, stop category 1: This value has no effect.</td>
</tr>
<tr>
<td>STO.14 Time to zero speed with STO and modoff</td>
<td>2000 ms Sets the time after which the motor has stopped and the acknowledgement (and restart of the drive) is allowed after coast stop in the STO, SSE and SS1 functions. Set the value of this parameter to the estimated time in which the motor coasts to a stop from the maximum speed. Emergency stop, stop category 0: This parameter sets the time after which the STO function is completed. Parameter STO.13 defines the time after which the restart of the drive is allowed. Adjust the value when necessary. Emergency stop, stop category 1: This parameter is used only when the motor speed does not follow the ramp settings or the time monitoring limit is exceeded and the FSO module activates the STO function. Adjust the value when necessary. Note: The default value after factory reset is 3,600,000 ms. Always check this parameter after factory reset. When a safety encoder is used: This parameter is relevant only if an encoder or FSE module failure occurs. The FSO module goes into the Fail-safe mode and activates the STO function. For more information, see the FSO-21 module user’s manual.</td>
</tr>
<tr>
<td>SBC usage SBC.11 STO SBC usage</td>
<td>None Sets how the mechanical brake is used together with the STO function. None: This feature is not in use. In this manual, we assume that you do not use a brake. If you do, you must take care of its on/off control by the FSO module and change this and other settings. See the FSO module user’s manual.</td>
</tr>
</tbody>
</table>
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.

### SSE.13 SSE function

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immediate STO or Emergency ramp</td>
<td></td>
<td>Sets the type of the SSE function. <strong>Immediate STO</strong>: The FSO module activates the drive STO function immediately after the SSE request. <strong>Emergency ramp</strong>: The FSO module first ramps down the motor speed and when the speed is below the zero speed limit (parameter FSOGEN.51 or FSOGEN.52) it activates the STO function. SAR0 parameters define the deceleration ramp (for more information, see the FSO module user’s manual). See also the Note on page 23. For the +Q979 option, ABB has set this parameter to value <strong>Immediate STO</strong> at the factory. Adjust the default value when necessary. <strong>Note</strong>: The default value after factory reset is <strong>Emergency ramp</strong>. Always check this parameter after factory reset.</td>
</tr>
</tbody>
</table>

### SBC usage

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SBC.15 SSE/SS1 SBC speed</td>
<td>0 rpm</td>
<td>Sets the absolute speed below which the FSO module activates the brake (SBC) while ramping. <strong>0 rpm</strong>: This feature is not in use. In this manual, we assume that you do not use a brake. If you do, you must take care of its on/off control by the FSO module and change this and other settings. See the FSO module user’s manual.</td>
</tr>
</tbody>
</table>

### I/O parameters

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAFEIO.33</td>
<td>DI X113:1 diag pulse on/off</td>
<td>On <em>†</em></td>
<td>Sets the diagnostic pulse of digital input X113:1 on or off. <strong>On</strong>: The input monitors that it receives test pulses. In the safety functions described in this manual, the emergency stop button is configured to this digital input by default. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</td>
</tr>
<tr>
<td>SAFEIO.37</td>
<td>DI X114:1 diag pulse on/off</td>
<td>On <em>†</em></td>
<td>Sets the diagnostic pulse of digital input X114:1 on or off. <strong>On</strong>: The input monitors that it receives test pulses. In the safety functions described in this manual, the emergency stop button is configured to this digital input by default. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</td>
</tr>
<tr>
<td>SAFEIO.38</td>
<td>DI X114:2 diag pulse on/off</td>
<td>On</td>
<td>Sets the diagnostic pulse of digital input X114:2 on or off. <strong>On</strong>: The input monitors that it receives test pulses. In the safety functions described in this manual, the emergency stop reset button is configured to this digital input by default. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.</td>
</tr>
</tbody>
</table>
Parameter settings

Parameters for Emergency stop, stop category 0

The Emergency stop, stop category 0 safety function uses the STO function of the FSO module, see section Parameters for the STO function above. 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.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
</table>
| SAFEIO.74 | DO X114:7 logic state | Active high | Sets the logic state of digital output X114:7. *Active high:* The digital output is on when the indicated signal is active. In the safety functions described in this manual, the emergency stop indication lamp is configured to this digital output by default. Make sure that this value corresponds the actual wiring. See the circuit diagrams of the delivery.

*) The safety data (see page 51) 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.

### Index

<table>
<thead>
<tr>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS1.01</td>
<td>SS1 activity and version</td>
<td>Version 1</td>
</tr>
<tr>
<td>SS1.11</td>
<td>SS1 input A</td>
<td>DI X113:1 &amp; X114:1</td>
</tr>
<tr>
<td>SS1.13</td>
<td>SS1 type</td>
<td>SS1-r or SS1-t</td>
</tr>
<tr>
<td>SS1.14</td>
<td>SS1-t delay for STO</td>
<td>20000 ms</td>
</tr>
</tbody>
</table>
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 to 1, set the parameters listed in section *Parameters for Emergency stop, stop category 1* on page 40 and in this table. See also section *SS1 ramp parameters* on page 44.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Pre-set value (stop cat. 0)</th>
<th>Value in stop cat. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO.11</td>
<td>STO input A</td>
<td>DI X113:1 &amp; X114:1</td>
<td>None</td>
</tr>
<tr>
<td>FSOGEN.51</td>
<td>Zero speed without encoder</td>
<td>90 rpm</td>
<td>If you do not use a safety encoder, adjust the default value to meet the motor in use.</td>
</tr>
<tr>
<td>FSOGEN.52</td>
<td>Zero speed with encoder</td>
<td>10 rpm</td>
<td>If you use a safety encoder, adjust the default value to meet the motor in use.</td>
</tr>
<tr>
<td>FSOGEN.62</td>
<td>STO indication safety limit</td>
<td>Fault</td>
<td>Adjust the default value when necessary.</td>
</tr>
</tbody>
</table>
## FSE module and safety pulse encoder parameters

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200.231 FSE 3X act and par version</td>
<td>Version 1</td>
<td>Activates the FSE-31 encoder interface and shows the version of the encoder parameter groups (91 and 92).</td>
</tr>
<tr>
<td></td>
<td>200.232 Number of encoders</td>
<td>Single encoder CH1</td>
<td>Shows the number of safety pulse encoders connected to the FSE module.</td>
</tr>
<tr>
<td></td>
<td>S_ENCGEN.01 Safe pulse encoder version</td>
<td>Version 1</td>
<td>Activates the safety pulse encoder and shows the version parameter group S_ENCGEN.</td>
</tr>
<tr>
<td></td>
<td>S_ENCGEN.11 FSE diagnostic failure reaction</td>
<td>STO</td>
<td>Sets the action taken when there is a problem with the FSE module. STO: The FSO module goes into the Fail-safe mode and activates the drive STO function. Note: This parameter is relevant only when there are no active safety functions.</td>
</tr>
<tr>
<td></td>
<td>S_ENCGEN.14 Enc speed cross comp tolerance</td>
<td>1 rpm</td>
<td>Sets the encoder speed cross comparison tolerance. This defines how much the axle speed of the motor can change within 1 ms. Adjust the default value to meet the motor in use.</td>
</tr>
<tr>
<td></td>
<td>S_ENCGEN.41 Gear numerator encoder 1</td>
<td>1</td>
<td>Sets the rotation direction for the safety pulse encoder. With this parameter, you can change the rotation direction of the motor. Adjust the default value if necessary.</td>
</tr>
<tr>
<td>91.11</td>
<td>Module 1 type</td>
<td>FSE-31</td>
<td>Sets the type of the safety pulse encoder interface module 1.</td>
</tr>
<tr>
<td>91.12</td>
<td>Module 1 location</td>
<td>2</td>
<td>Sets the slot in which the safety pulse encoder interface module 1 is located.</td>
</tr>
<tr>
<td>92.01</td>
<td>Encoder 1 type</td>
<td>HTL1</td>
<td>Activates or deactivates the communication with the safety pulse encoder interface module 1 and sets the type for the safety pulse encoder.</td>
</tr>
<tr>
<td>92.02</td>
<td>Encoder 1 source</td>
<td>Module 1</td>
<td>Sets the safety pulse encoder interface module that the safety pulse encoder 1 is connected to.</td>
</tr>
<tr>
<td>92.10</td>
<td>Pulses/revolution</td>
<td>2048</td>
<td>Sets the number of HTL pulses per revolution for safety pulse encoder 1. Adjust the default value to meet the safety pulse encoder in use. Make sure that the value is according to the encoder nameplate.</td>
</tr>
<tr>
<td>92.17</td>
<td>Accepted pulse freq of encoder 1</td>
<td>300 kHz</td>
<td>Sets the maximum pulse frequency range of encoder 1. Adjust the default value to meet the motor and safety pulse encoder in use. You can use this formula to define the value: r_max x ppr_enc + 10%, where</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• r_max = the maximum motor speed used in the application (or the motor nominal speed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ppr_enc = Pulses/revolution of the safety pulse encoder (parameter 92.10).</td>
</tr>
</tbody>
</table>
Drive

Parameter 31.22 STO indication run/stop

The parameter setting in ACS880 primary control program:
- parameter 31.22 STO indication run/stop is set to value Warning/Warning.

We recommend that you do not set parameter 31.22 STO indication run/stop to value 0, 1 or 2. This prevents the drive from making a fault every time the FSO module activates the STO function.

Safety pulse encoder parameters

The drive parameter settings in ACS880 primary control program when you use a safety pulse encoder:
- parameter 90.41 Motor feedback selection is set to value Encoder 1.
- parameter 90.45 Motor feedback fault is set to value Warning.
  Note: If you want that the drive trips on encoder faults, set this parameter to value Fault. For more information, see the firmware manual.
- parameter 92.21 Encoder cable fault mode is set to value A, B, Z.

SS1 ramp parameters

You must set these parameters only for the Emergency stop, stop category 1 option.

If FSO parameter 200.112 SAR1 ramp time to zero is set to 0, drive parameters define the stop ramp that is used in the SS1 function (stop category 1). Set:
- 21.04 Emergency stop mode to value Eme ramp stop (Off3)
- 23.23 Emergency stop time to a suitable value.

Also in this case, the FSO module monitors the actual stop ramp (ramp monitoring or time monitoring).

For more information, see the firmware manual of your drive.
Start-up and acceptance test

Contents of this chapter
This chapter describes the start-up and acceptance procedure of the safety function.

Safety encoder interface
When you use a safety pulse 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.

Start-up and acceptance test
You need the Drive composer pro PC tool to perform the start-up and acceptance test.

Initial status: Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. See the hardware manual.

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WARNING!</strong> Obey the Safety instructions, page 10. If you ignore them, injury or death, or damage to the equipment can occur.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Checks and settings with no voltage connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you have done any connections of the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the appropriate circuit diagrams.</td>
</tr>
<tr>
<td>Drives with R8i inverter modules: Check that the STO OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules. The STO circuit is disabled in spare part modules.</td>
</tr>
</tbody>
</table>
Start-up and acceptance test

Settings with voltage connected

Make sure that the parameters relevant to the safety function are set as described in chapter Parameter settings on page 35.

Create a backup file of the drive (button Backup/restore in the Drive composer pro PC tool).

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.

Acceptance test procedure

Make sure that the motor can be run and stopped freely during the test.

We recommend that you monitor these signals with the Drive composer pro PC tool:
- 01.01 Motor speed used (rpm)
- 01.02 Motor speed estimated (rpm)
- 01.07 Motor current (A)
- 01.10 Motor torque (%)
- 23.01 Speed ref ramp input (rpm)
- 23.02 Speed ref ramp output (rpm)
- 90.01 Motor speed for control (rpm)
- 90.10 Encoder 1 speed (rpm) (if you use an encoder)
- 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

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.

Push the emergency stop button [S61].

Make sure that the indication lamp [P62] goes on as described in section Operation principle on page 18.

Stop category 0: Make sure that the drive stops the motor by coasting and generates the appropriate warnings and indications.

Stop category 1: Make sure that the drive stops the motor by decelerating and generates the appropriate warnings and indications.

See section Emergency stop indications on page 32 and the FSO module user’s manual.

Make sure that you cannot start the drive and motor from any control location: Make sure that the motor does not start even if you switch the start signal off and on (in the external control mode) or push the start key of the control panel (in the local control mode). The LOC and REM buttons of the control panel or the Drive composer PC tool switch between the local and external controls.

Drives with R8i inverter modules: Ensure that “STO hardware failure” (5090) is not generated.

Turn the emergency stop button [S61] until it releases and returns to the up position.
Push the emergency stop reset button [S62].
  • Make sure that the indication lamp goes [P62] off.
  • Make sure that the drive does not restart automatically at this point.

Switch off the drive start signal (only in external control mode).
  If the drive generates a fault message, reset the drive.

Restart the drive and motor and check that they operate normally.

Repeat the test from each operating location (every emergency stop button and reset button).

Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted to operation.
Maintenance

Contents of this chapter
This chapter gives maintenance instructions for the safety function.

Maintenance
After the operation of the safety circuit has been tested at start-up, it does not need any scheduled maintenance during its specified lifetime.

In addition to proof testing, it is a good practice to check the operation of the safety function when other maintenance procedures are carried out on the machinery. Do the acceptance test described in chapter Start-up and acceptance test on page 45.

If you change any wiring or component after the start-up, replace the FSO or FSE module, modify FSO module parameters or restore parameters to their factory default values, you must:
• Use only ABB approved spare parts.
• Register the change to the change log for the safety circuit.
• Test the safety function again after the change. Obey the rules given in chapter Start-up and acceptance test on page 45.
• Document the tests and store the report into the logbook of the machine.
Proof test interval

After the operation of the safety function is validated at start-up, the safety function must be maintained by periodic proof testing. 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, EN/IEC 62061 and EN ISO 13849-1). Regardless of the mode of operation, it is a good practice to check the operation of the safety function at least once a year. Do the test as described in section Start-up and acceptance test on page 45.

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

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

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

Competence

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

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. Therefore the warnings for the residual risks must be given to the operator.

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 safety of the machine is maintained until the decommissioning is complete.
Technical data

Contents of this chapter

This chapter gives general rules, notes and definitions related to safety functions and lists the related standards and directives. The safety data is also given.

Safety data

Safety performance with different safety pulse encoders

See *FSE-31 pulse encoder interface module user’s manual* (3AXD50000016597 [English]).

Safety data values

The safety data below is valid for the default design of the safety circuit presented in this manual. In case the final design differs from the default, ABB calculates new safety data and delivers it separately to the customer.

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

The safety pulse encoder is not included in the calculations since it is not included in the delivery. Only the FSE module is included in the calculations (if used).
ACS880-07/17/37 drives without the FSE module

<table>
<thead>
<tr>
<th>Stop category and monitoring method</th>
<th>SIL / SILCL</th>
<th>SC</th>
<th>PL</th>
<th>$\text{PFH}^1$ [1/h]</th>
<th>$\text{PFD}_{\text{avg}}$ ($T_1=2\text{a}$)</th>
<th>$\text{PFD}_{\text{avg}}$ ($T_1=5\text{a}$)</th>
<th>DC$^2$ [%]</th>
<th>Cat.</th>
<th>HFT</th>
<th>CCF</th>
<th>Lifetime [a]</th>
<th>$T_1^{3,4}$ [a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame sizes R6...R11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop cat. 0</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.4E-8</td>
<td>3.0E-04</td>
<td>3.5E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, time monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.4E-8</td>
<td>3.5E-04</td>
<td>4.7E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, ramp monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.0E-8</td>
<td>2.7E-04</td>
<td>2.7E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, ramp monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.0E-8</td>
<td>4.9E-04</td>
<td>3.9E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
</tbody>
</table>

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 $T_1$ requirement.  
4) $T_1 = 20\text{a}$ is used with high demand mode of operation. $T_1 = 5\text{a}/2\text{a}$ is used with low demand mode of operation. See also section Proof test interval on page 50.

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

<table>
<thead>
<tr>
<th>Stop category and monitoring method</th>
<th>SIL / SILCL</th>
<th>SC</th>
<th>PL</th>
<th>$\text{PFH}^1$ [1/h]</th>
<th>$\text{PFD}_{\text{avg}}$ ($T_1=2\text{a}$)</th>
<th>$\text{PFD}_{\text{avg}}$ ($T_1=5\text{a}$)</th>
<th>DC$^2$ [%]</th>
<th>Cat.</th>
<th>HFT</th>
<th>CCF</th>
<th>Lifetime [a]</th>
<th>$T_1^{3,4}$ [a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame sizes R6...R11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop cat. 0</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.4E-8</td>
<td>3.0E-04</td>
<td>3.5E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, time monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.0E-8</td>
<td>3.5E-04</td>
<td>4.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, ramp monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>5.0E-8</td>
<td>3.5E-04</td>
<td>4.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
<tr>
<td>Stop cat. 1, ramp monitoring</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.6E-8</td>
<td>3.2E-04</td>
<td>3.7E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>&gt;90</td>
<td>20</td>
</tr>
</tbody>
</table>

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 $T_1$ requirement.  
4) $T_1 = 20\text{a}$ is used with high demand mode of operation. $T_1 = 5\text{a}/2\text{a}$ is used with low demand mode of operation. See also section Proof test interval on page 50.
### Safety component types

Safety component types as defined in IEC 61508-2:
- FSO module: type B
- FSE module: type B
- emergency stop button: type A
- drive STO circuit:
  - frame sizes R1...R9 and drives with R1i...R7i inverter modules: type A
  - frame sizes R10 and R11 and drives with R8i inverter modules: type B.

### Safety block diagram

The components that are included in the safety circuit are shown in the safety block diagram below.

![Safety block diagram](image)

### Relevant failure modes, diagnostics

Relevant failure modes are:
- the FSO module detects any open circuits and short circuits and redundancy failures of the emergency stop input signal wirings. Similarly, it detects redundancy failures of the emergency stop button when the request is on.
- internal failures of the emergency stop button, the FSO and FSE modules and the STO function in the drive.

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

### Fault exclusions

Fault exclusions (not considered in the calculations):
- any short and open circuits in the cables of the safety circuit inside the cabinet
- any 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 100 ms
- Stop category 1: Emergency stop ramp time + possible STO delay settings + (<100 ms).

**Note:** When you define the total response time for the safety function and the fault reaction function, you must add the delays of the safety pulse encoder (if used).
General rules, notes and definitions

- **Validation of the safety functions**
  You must do an acceptance test (validation) to validate the correct operation of safety functions.

**Validation procedure**
You must do the acceptance test using the checklist given in chapter *Start-up and acceptance test* on page 45:
- at initial start-up of the safety function
- after any changes related to the safety function (wiring, components, safety function related parameter settings etc.)
- after any maintenance action related to the safety function.

The acceptance test must include at least the following steps:
- having an acceptance test plan
- testing all commissioned functions for proper operation, from each operation location
- documenting all acceptance tests
- signing and storing the acceptance test report for further reference.

**Acceptance test reports**
You must store the signed acceptance test reports in the logbook of the machine. The report must include, as required by the referred standards:
- 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 acceptance test reports performed due to changes or maintenance in the logbook of the machine.

**Competence**
The acceptance test of the safety function must be carried out by a competent person with expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.

**Ambient conditions**
For the environmental limits for the safety functions and the drive, refer to the hardware manual.

**Reporting problems and failures related to safety functions**
Contact your local ABB representative.
## Related standards and directives

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60204-1:2016</td>
<td></td>
</tr>
<tr>
<td>EN 61800-5-2:2007</td>
<td>Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional</td>
</tr>
<tr>
<td>IEC 61800-5-2:2016</td>
<td></td>
</tr>
<tr>
<td>EN ISO 13849-1:2015</td>
<td>Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design</td>
</tr>
<tr>
<td>IEC 61511-1:2016</td>
<td>Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements</td>
</tr>
<tr>
<td>IEC 61326-3-1:2008</td>
<td>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</td>
</tr>
<tr>
<td>2006/42/EC</td>
<td>European Machinery Directive</td>
</tr>
<tr>
<td>Other</td>
<td>Machine-specific C-type standards</td>
</tr>
</tbody>
</table>

### 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 (option +Q979) is in the scope of the Machinery Directive as a safety component. This function complies with European harmonized standards such as EN/IEC 61800-5-2. The declaration of conformity is delivered with the drive.
Further information

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

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

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