OPTIONS FOR ABB DRIVES

Safely-limited speed with the encoder interface (option +Q965) for ACS880 multidrives

User's manual
Safely-limited speed with the encoder interface (option +Q965) for ACS880 multidrives

User's manual

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Further information
Safety instructions

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

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

The manual uses these warning symbols:

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

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

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

Instructions for functional safety circuits
This manual does not repeat the complete safety instructions of the drive but only includes the instructions related to the scope of this manual.
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. All user-made changes are on the user’s responsibility.

**WARNING!** This safety function does not disconnect the voltage of the main and auxiliary circuits from the drive. Do not work on the electrical parts of the drive or the motor before you have isolated the drive system from all power supplies and made sure by measuring that there is no dangerous voltage present.

**WARNING!** Always test the operation of the safety circuit according to its acceptance test procedure at the start-up and after any changes to the safety circuit.

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

If you are not a qualified electrical professional, do not do installation or maintenance work.

### Electrical safety precautions

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

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

If you are not a qualified electrical professional, do not do installation or maintenance work.

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

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Make sure that re-connection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - If the drive is equipped with a DC/DC converter unit (optional): Open the DC switch/disconnector ([Q11], option +F286) of the DC/DC converter. Open the disconnecting device of the energy storage connected to the DC/DC converter unit (outside the drive cabinet).
   - If you have a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Disconnect any dangerous external voltages from the control circuits.
   - After you disconnect power from the drive, always wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
3. Protect any other energized parts in the work location against contact.
4. Take special precautions when close to bare conductors.
5. Measure that the installation is de-energized.
   • Use a multimeter with an impedance greater than 1 Mohm.
   • Make sure that the voltage between the drive input power terminals (L1, L2, L3) and the grounding (PE) busbar is close to 0 V.
   • Make sure that the voltage between the drive output terminals (T1/U, T2/V, T3/W) and the grounding (PE) busbar is close to 0 V.

6. Ask the person in control of the electrical installation work for a permit to 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
The manual applies to ACS880 air-cooled and liquid-cooled multidrives which have the option +Q965: Safely-limited speed with the encoder interface. For the option +Q965, ABB installs the FSO-21 safety functions modules (option +Q972) and the FSE-31 pulse encoder interface modules (option +L521) to the inverter units.

Required versions when using the FSO-21 module with option +Q965:
- 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
- Drive composer pro: 1.8 or later.

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

Target audience
The manual is intended for people who install, start up, 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

<table>
<thead>
<tr>
<th>Task</th>
<th>☑</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect the user-defined wiring (if any). See the wiring instructions in this manual and the circuit diagrams delivered with the drive.</td>
<td></td>
</tr>
<tr>
<td>Check and/or set the safety function related parameters (as listed in this manual).</td>
<td></td>
</tr>
<tr>
<td>Do the acceptance test to ensure that the implemented system meets the safety requirements. Instructions for the acceptance test can be found in this manual.</td>
<td></td>
</tr>
<tr>
<td>Document the acceptance test procedure. Guidelines for the acceptance test report can be found in this manual.</td>
<td></td>
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</table>

Related manuals

<table>
<thead>
<tr>
<th>Manual</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive hardware</td>
<td></td>
</tr>
<tr>
<td>ACS880 multidrive cabinets mechanical installation instructions</td>
<td>3AUA0000101764</td>
</tr>
<tr>
<td>ACS880 multidrive cabinets and modules electrical planning instructions</td>
<td>3AUA0000102324</td>
</tr>
<tr>
<td>Supply units</td>
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</tr>
<tr>
<td>ACS880-207 IGBT supply units hardware manual</td>
<td>3AUA0000130644</td>
</tr>
<tr>
<td>ACS880-307 (+A003) diode supply units hardware manual</td>
<td>3AUA0000102453</td>
</tr>
<tr>
<td>ACS880-307 (+A018) diode supply units hardware manual</td>
<td>3AXD50000011408</td>
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<tr>
<td>ACS880-907 regenerative rectifier units hardware manual</td>
<td>3AXD50000020546</td>
</tr>
<tr>
<td>Inverter units</td>
<td></td>
</tr>
<tr>
<td>ACS880-107 inverter units hardware manual</td>
<td>3AUA0000102519</td>
</tr>
<tr>
<td>Drive firmware</td>
<td></td>
</tr>
<tr>
<td>ACS880 primary control program firmware manual</td>
<td>3AUA0000085967</td>
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<tr>
<td>ACS880 primary control program quick start-up guide</td>
<td>3AUA0000098062</td>
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<td>ACS880 diode supply control program firmware manual</td>
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<tr>
<td>ACS880 IGBT supply control program firmware manual</td>
<td>3AUA0000131562</td>
</tr>
<tr>
<td>ACS880 regenerative rectifier control program firmware manual</td>
<td>3AXD50000020827</td>
</tr>
<tr>
<td>PC tools</td>
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</tr>
<tr>
<td>Drive composer start-up and maintenance PC tool user's manual</td>
<td>3AUA0000094606</td>
</tr>
<tr>
<td>Functional safety design tool user’s manual</td>
<td>3AXD10000102417</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td>ACS880 multidrive cabinets and modules safety instructions</td>
<td>3AUA0000102301</td>
</tr>
<tr>
<td>Functional safety; Technical guide No. 10</td>
<td>3AUA0000048753</td>
</tr>
<tr>
<td>Safety and functional safety; A general guide</td>
<td>1SFC001008B0201</td>
</tr>
</tbody>
</table>
You can find manuals and other product documents in PDF format on the Internet. See Document Library. For manuals not available in the Document library, contact your local ABB representative.

For additional ABB safety information and solutions visit http://www.abb.com/safety.

Terms and abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CAT</td>
<td>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)</td>
</tr>
<tr>
<td>FSE-31</td>
<td>Optional pulse encoder interface module for safety encoder</td>
</tr>
<tr>
<td>FSO-21</td>
<td>Safety functions module which supports the FSE-31 module and the use of safety encoders</td>
</tr>
<tr>
<td>HFT</td>
<td>Hardware fault tolerance (IEC 61508)</td>
</tr>
<tr>
<td>IGBT</td>
<td>Insulated gate bipolar transistor</td>
</tr>
<tr>
<td>PL</td>
<td>Performance level. Levels a...e correspond to SIL (EN ISO 13849-1)</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable logic controller</td>
</tr>
<tr>
<td>POUS</td>
<td>Prevention of unexpected start-up</td>
</tr>
<tr>
<td>Safety function response time</td>
<td>Worst case elapsed time following an actuation of a safety sensor connected to a fieldbus before the corresponding safe state of its safety actuator(s) is achieved in the presence of errors or failures in the safety function channel.</td>
</tr>
<tr>
<td>SAR</td>
<td>Safe acceleration range</td>
</tr>
<tr>
<td>SBC</td>
<td>Safe brake control</td>
</tr>
<tr>
<td>SC</td>
<td>Systematic capability (IEC 61508)</td>
</tr>
<tr>
<td>SIL</td>
<td>Safety integrity level (1...3) (IEC 61508)</td>
</tr>
<tr>
<td>SILCL</td>
<td>Maximum SIL (level 1...3) that can be claimed for a safety function or subsystem (IEC/EN 62061)</td>
</tr>
<tr>
<td>SLS</td>
<td>Safety-limited speed</td>
</tr>
<tr>
<td>SLS monitoring limit</td>
<td>The speed limit at which SLS monitoring is started, located in the middle of SLS trip limit and SLS limit.</td>
</tr>
<tr>
<td>SMS</td>
<td>Safe maximum speed</td>
</tr>
<tr>
<td>SS1</td>
<td>Safe stop 1 (IEC/EN 61800-5-2)</td>
</tr>
<tr>
<td>SSE</td>
<td>Safe stop emergency</td>
</tr>
<tr>
<td>SSM</td>
<td>Safe speed monitor without encoder</td>
</tr>
<tr>
<td>STO</td>
<td>Safe torque off (IEC/EN 61800-5-2)</td>
</tr>
<tr>
<td>Zero speed</td>
<td>For safety functions, the zero speed limit indicates the completion of the safe stopping function.</td>
</tr>
</tbody>
</table>
Option description

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

Overview
The functional safety option +Q965 includes the Safely-limited speed (SLS) function that prevents the motor from exceeding the user-defined speed limits. The option +Q965 also includes the Safe maximum speed (SMS) and Safe speed monitor (SSM) functions. The SMS function is used to protect the machine from exceeding the dimensioned maximum speed of the machine/process. The SSM function provides a safe output signal to indicate whether the motor speed is between user-defined limits.

The option +Q965 requires that the FSO-21 safety functions module(s) (option +Q972) and the FSE-31 pulse encoder interface module(s) (option +L521) are installed in the inverter units. ABB installs the FSO and FSE-31 modules to the inverter units and sets the delivery configuration for the cabinet safety option at the factory. The user defines the operation of the SLS, SMS and SSM functions with the FSO module parameters at the start-up, for example, by setting the appropriate speed limits.

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

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

Note: Any safety function request to the FSO module must be active for at least 20 ms.

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

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

### Summary of wirings and setting

**General information:**
- The inverter units are equipped with the FSE-31 pulse encoder interface modules (option +L521). ABB installs the modules at the factory.
- The motors must be equipped with safety pulse encoders. The user installs the safety pulse encoders and wires them to the FSE-31 modules. The user must make sure that the required safety integrity (SIL/PL) can be achieved with the used safety encoders.

The wirings and settings of the SLS function are:
- The inverter units are equipped with the FSO-21 safety functions modules (option +Q972). ABB installs the modules at the factory.
- The user wires the SLS activation signal (for example, a switch) to the FSO module.
- The user wires the SLS indication signal (for example, an indication lamp or a gate opening signal) to the FSO module.
- The digital input of the FSO module to which the SLS activation signal is connected, is selected as the input for the SLS request. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.
- The digital output of the FSO module to which the SLS indication signal is connected, is selected as the output for the SLS output. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.
- The speed limits (SLS and trip limits) must be set according to application needs. These are FSO module parameters that the user must set at the start-up.
- The SLS function is set to use either the time monitoring or ramp monitoring method to monitor the deceleration of the motors to the desired speed (before SLS monitoring is started). This is an FSO module parameter that the user must set at the start-up.
- The deceleration ramp that is used to decelerate the motor(s) to the desired speed (before SLS monitoring is started) is set according to application needs. This is an FSO module or inverter unit parameter that the user must set at the start-up.
- The monitoring limits for the deceleration ramp (a time limit or ramp monitoring limits) are set according to application needs. These are FSO module parameters that the user must set at the start-up.

The wirings and settings of the SMS function are:
- The inverter units are equipped with the FSO-21 safety functions modules (option +Q972). ABB installs the modules at the factory.
- There are two different versions of the SMS function. Version 1 monitors the motor speed and trips the drive if the user-defined trip limit is exceeded. Version 2 of the SMS function is similar to the SLS function except that it can only be configured to be continuously on or off. ABB activates the SMS function (Version 1) at the factory. This is an FSO module parameter that the user must check/set at the start-up.
- The SMS positive and negative speed limits are FSO module parameters that the user must set at the start-up.

The wirings and settings of the SSM function are:
• The inverter units are equipped with the FSO-21 safety functions modules (option +Q972). ABB installs the modules at the factory.
• ABB activates the SSM function at the factory (Always on). This is done with FSO module parameters that the user must check/set at the start-up.
• The user wires the SSM indication signal (for example, an indication lamp) to the FSO module.
• The digital output of the FSO module to which the SSM indication signal is connected, is selected as the output for the SSM output. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.
• The SSM positive and negative speed limits are FSO module parameters that the user must set at the start-up.

For a detailed description of wirings, see sections Wiring and Operation principle diagram. For a detailed description of parameter settings, see chapter Parameter settings.

Operation principle

■ SLS function

The SLS function makes sure that the motor speed does not exceed the user-defined speed limits when the function is active. The user defines the SLS limits and SLS trip limits at the start-up. When the user activates the SLS function, the inverter unit takes the SLS parameters into use and controls the motor speed accordingly until the user deactivates the SLS request.

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

When the SLS function is active, the inverter unit limits the motor speed so that it cannot exceed the SLS limits.

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

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

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

For more information, see chapter Parameter settings and FSO module user’s manual.

SLS with speed below the monitored speed

This time scheme diagram illustrates the operation of the SLS function. The motor speed is below the monitored speed when the user activates the SLS function.
1. The user or a PLC activates the SLS request of the FSO module, that is, switches the digital inputs of the FSO module from 1 to 0.

2. After the safety function response time (A), the FSO module starts to monitor the motor speed. The FSO module energizes the digital output that indicates the SLS status. (From (2) to (3)) The inverter unit limits the motor speed so that it stays at or below the SLS1 limit positive. The FSO module monitors the actual motor speed. (2b) If the motor speed still goes above the SLS1 trip limit positive (C), the FSO module activates the SSE function and the motor coasts to a stop (in this case, the SSE function has been configured as “Immediate STO”, see section Parameters for the SSE function).

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

3. The user or a PLC deactivates the SLS request of the FSO module, that is, switches the digital input of the FSO module from 0 to 1. The FSO module acknowledges the SLS1 function automatically. This is set to be automatic by an FSO parameter (SLSx.02), and no external acknowledgement input is in use. The FSO module stops SLS monitoring and de-energizes the SLS indication signal.

   (3b) The motor speed goes below the zero speed limit (D). If the FSO module activated the SSE function at 2b, the STO acknowledgement becomes allowed now. The user must reset the inverter unit if the STO indication parameter (FSOGEN.62 or 31.22) has been set so that a fault is generated. See chapter General parameters.

**SLS with speed above the monitored speed - time monitoring**

This time scheme diagram illustrates the operation of the SLS function with time monitoring. The motor speed is above the monitored speed when the SLS function is activated.
1. The user or a PLC activates the SLS request of the FSO module, that is, switches the digital inputs of the FSO module from 1 to 0. The FSO module starts a counter for time (B).

2. (From (2) to (3)) After the safety function response time (A), the inverter unit starts to decelerate the motor speed. The inverter unit decelerates the motor speed using the inverter unit ramp parameters (see section Ramp parameters). The FSO module starts SLS monitoring and energizes the digital output that indicates the SLS status when the motor speed is in the middle of the SLS1 trip limit and the SLS1 limit.

3. The actual motor speed reaches the SLS1 limit positive.
(From (3) to (4)) The inverter unit limits the motor speed reference so that the motor speed stays at or below the SLS1 limit positive. The FSO module monitors the actual motor speed. If the motor speed still reaches the SLS1 trip limit positive (D), the FSO module activates the SSE function (see section SLS with speed below the monitored speed).

(3b) Time (B) has elapsed. The FSO module starts SLS monitoring (if not already started).

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

Note: In this case, the FSO activates the SLS indication when the motor speed goes below the SLS limit positive (C).
4. The user or a PLC deactivates the SLS request of the FSO module, that is, switches the digital input of the FSO module from 0 to 1. The FSO module acknowledges the SLS function automatically. This is set to be automatic by an FSO parameter (SLSx.02), and no external acknowledgement input is in use. The FSO module stops SLS monitoring and de-energizes the digital output that indicates the SLS status. The inverter unit returns to normal operation and starts to follow its ordinary speed reference. The inverter unit accelerates the motor to the desired speed along its acceleration ramp (inverter unit parameter).

5. Normal operation.

**SLS with speed above the monitored speed - ramp monitoring**

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

1. The user or a PLC activates the SLS request of the FSO module, that is, switches the digital inputs of the FSO module from 1 to 0.

2. (From (2) to (3)) After the safety function response time (A), the inverter unit starts to decelerate the motor speed. The ramp is defined and monitored using the SAR1 parameters of the FSO module (see SAR1 parameters 200.112 - SARx.22 and SARx.02). The FSO module monitors the actual deceleration rate of the motor against the ramp monitoring settings. The FSO module starts SLS monitoring and energizes the digital output that indicates the SLS status when the motor speed is in the middle of the SLS1 trip limit and the SLS1 limit.

(2b) If the motor speed does not follow the ramp monitoring limits, the FSO module activates the STO function. The motor coasts to a stop.

**Note:** In this case, the FSO activates the SLS indication when the motor speed goes below the SLS1 limit positive (B).
3. The actual motor speed reaches the SLS1 limit positive. 
   (From (3) to (4)) The inverter unit limits the motor speed reference so that the motor speed stays below the SLS1 limit positive. The FSO module monitors the actual motor speed. If the motor speed still reaches the SLS1 trip limit positive (C), the FSO module activates the SSE function (see section SLS with speed below the monitored speed). 
   (3b) The motor speed goes below the zero speed limit (D). If the motor speed did not follow the ramp at 2b, the STO acknowledgement becomes allowed now. The user must reset the inverter unit if the STO indication parameter (FSOGEN.62 or 31.22) has been set so that a fault is generated. See chapter General parameters.

4. The user or a PLC removes the SLS request of the FSO module, that is, switches the digital inputs of the module from 0 to 1. The FSO module acknowledges the SLS function automatically. This is set to be automatic by an FSO parameter (SLSx.02), and no external acknowledgement input is in use. The FSO module stops SLS monitoring and de-energizes the digital output that indicates the SLS status. The inverter unit returns to normal operation and starts to follow its ordinary speed reference. The inverter unit accelerates the motor to the desired speed along its acceleration ramp (inverter unit parameter).

5. Normal operation

**SLS reaction when modulation is lost during deceleration ramp, with ramp monitoring**

The following functionality is relevant only with speed estimate feedback for functional safety purposes.

If SLS function is activated when motor speed is above the SLS trip limit, FSO will force the drive to decelerate to SLS limit. If the drive stops modulating during this deceleration ramp, user can select the reaction of the SLS function (parameter SLSx.05) from the following:

- Modoff delay time
- Monitoring active
- Monitoring active and modoff delay time
- Monitoring and modoff delay time disabled.

Following examples explain the FSO behavior with each of the selections when speed estimate feedback is used for functional safety purposes. These features are used with SLS1…SLS4 functions and the variable SLS function. Note that these features are also used with FSO-21 and FSE-31 when feedback change from encoder to speed estimate is allowed. For more instructions, see FSO module user’s manual.

<table>
<thead>
<tr>
<th>SLS ramp modoff selection (par. SLSx.05)</th>
<th>FSO reaction during SLS deceleration ramp if drive modulation is lost</th>
<th>See figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modoff delay time</td>
<td>If drive modulation is lost, STO is activated after the delay defined with parameter SLSx.06. If modulation returns before SLSx.06 delay has elapsed, monitoring and deceleration towards SLS monitoring limit start again</td>
<td>1</td>
</tr>
<tr>
<td>Monitoring active</td>
<td>SAR1/ time monitoring depending on SLS settings is kept on regardless of the modulation status. FSO stores the last valid speed estimate before drive modulation has lost. SAR1/ time monitoring limit hit is generated based on that.</td>
<td>2, 4</td>
</tr>
<tr>
<td>Monitoring active and modoff delay time</td>
<td>If drive modulation is lost, STO is activated either when modoff delay time SLSx.06 or monitoring limit is reached depending which condition is met first.</td>
<td>3</td>
</tr>
</tbody>
</table>
If drive modulation is lost, SAR1 time monitoring is stopped and SLS indication is given after STO.14 delay. If modulation returns during deceleration ramp, monitoring and deceleration towards SLS monitoring limit start again.

**Note:** No tripping fault is given due to loss of drive modulation.

### Monitoring and mod off delay time disabled

If modulation returns before mod off delay time has run out with Mod off delay times selected (parameter SLSx.05 is set to Mod off delay time) is described in the time diagram and table below.

<table>
<thead>
<tr>
<th>Motor speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

1) TIME is not restarted like SAR, if TIME is elapsed in the background while modulation is off, it behaves similarly when modulation comes back as TIME would now elapse. NOTE: If speed is below limit at this point it is OK situation.

### Example 1: Mod off delay time – modulation returns before mod off delay

The operation of the SLS function in case of the modulation of the drive is lost during the deceleration ramp and the modulation returns before the Mod off delay time has run out with Mod off delay time selected (parameter SLSx.05 is set to Mod off delay time) is described in the time diagram and table below.
Example 2: SAR1 ramp monitoring active

The operation of the SLS function in case the modulation of the drive is lost during the deceleration ramp with Monitoring active selected (parameter SLSx.05 is set to Monitoring active) is described in the time diagram and table below.

<table>
<thead>
<tr>
<th></th>
<th>Actual motor speed (coasting after modoff)</th>
<th>SLS trip limit</th>
<th>SLS limit</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SAR1 ramp monitoring</th>
<th>Actual motor speed (coasting after modoff)</th>
<th>SLS trip limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actual motor speed (coasting after modoff)</td>
<td>SLS trip limit</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SAR1 ramp monitoring</th>
<th>Actual motor speed (coasting after modoff)</th>
<th>SLS trip limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Motor speed

Time

SLS request
SAR1 monitoring
Drive modulation
STO.14 delay
STO active
SLS indication

A  SAR1 ramp monitoring
B  Actual motor speed (coasting after modoff)
C  SLS trip limit
D  SLS limit
E  Last valid speed estimate of FSO
Example 3: SAR1 ramp monitoring and SLS modoff delay time active

The operation of the SLS function in case the modulation of the drive is lost during the deceleration ramp with Monitoring active and modoff delay time selected (parameter SLSx.05 is set to Monitoring active and modoff delay time) is described in the time diagram and table below.

<table>
<thead>
<tr>
<th>Motor speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
</tr>
<tr>
<td>Drive modulation</td>
</tr>
<tr>
<td>SLS request</td>
</tr>
<tr>
<td>SAR1 monitoring</td>
</tr>
<tr>
<td>SLSx.06 Modoff delay time monitoring</td>
</tr>
<tr>
<td>Drive modulation</td>
</tr>
</tbody>
</table>

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

---

24 Option description
Example 4: Time monitoring active

The operation of the SLS function in case the modulation of the drive is lost during the deceleration ramp with Monitoring active selected (parameter SLSx.05 is set to Monitoring active) is described in the time diagram and table below.

<table>
<thead>
<tr>
<th>Motor speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual motor speed (coasting after modoff)</td>
<td></td>
</tr>
<tr>
<td>SLS trip limit</td>
<td></td>
</tr>
<tr>
<td>SLS limit</td>
<td></td>
</tr>
<tr>
<td>Last valid speed estimate of FSO</td>
<td></td>
</tr>
</tbody>
</table>

Option description 25
Example 5: Monitoring and modoff delay time disabled

The operation of the SLS function in case the modulation of the drive is lost during the deceleration ramp with Monitoring and modoff delay time disabled selected (parameter SLSx.05 is set to Monitoring and modoff delay time disabled) is described in the time diagram and table below.

<table>
<thead>
<tr>
<th>SLS indication</th>
<th>Motor speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Drive modulation</td>
<td>SLS request</td>
</tr>
<tr>
<td>C</td>
<td>SLSx.04 time delay monitoring</td>
<td>SLSx.04 time delay monitoring</td>
</tr>
<tr>
<td>D</td>
<td>STO.14 delay</td>
<td>STO.14 delay</td>
</tr>
</tbody>
</table>

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

- **SMS function**

The FSO module includes two versions of the SMS function. This manual describes version 1. Version 2 of the SMS function is similar to the SLS function except that it can only be configured to be continuously on or off.

The user activates the desired version of the SMS function and sets the SMS maximum and minimum speed limits at the start-up. For more information, see section Parameter settings and FSO module user’s manual.

If the motor speed reaches the SMS trip limit positive or negative, the FSO module activates the Safe stop emergency (SSE) function. Depending on parameter settings, the FSO module activates the inverter unit STO function either immediately or after a deceleration ramp. The motor coasts to a stop or decelerates to zero speed.

This time scheme diagram illustrates the operation of the SMS function (version 1).
1. The motor speed reaches the SMS trip limit positive.

2. After the safety function response time (A), the FSO module activates the SSE function which in turn activates the inverter unit STO function. The motor coasts to a stop. In this case, the SSE function is configured as “Immediate STO” (parameter SSE.13).

3. When the motor speed reaches the zero speed limit (D), the FSO module acknowledges the SSE function (in this case automatic acknowledgement is used and no external acknowledgement input is in use, see parameter STO.02) and deactivates the inverter unit STO function. The user must reset the inverter unit if the STO indication parameter (FSOGEN.62 or 31.22) has been set so that a fault is generated. See chapter Parameter settings.

### SSM function

When the motor speed is between the SSM limits, the SSM indication signal in the FSO module is on.

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

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

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

Drive modulation loss when encoder feedback is used

In the case when drive modulation is lost during the safe deceleration ramps and motor speed does not decelerate within monitoring limits due to coasting, FSO generates a monitoring limit hit indication and activates STO based on measured motor speed when encoder feedback is used with FSO-21 and FSE-31 for functional safety purposes in the following situations:
- SAR1 ramp monitoring with SS1, SLS or SDI functions
- SAR0 ramp monitoring with SSE function as Emergency ramp
- time monitored ramp with any of previously mentioned safety functions.

Note: Parameters SLSx.05 and SLSx.06 are not used when FSO-21 is using encoder feedback. If feedback change from encoder to estimate is allowed with parameter S_ENCGEN.11, SLSx.05 and SLSx.06 become relevant if encoder fails and FSO switches to use speed estimate configuration.

Operation principle diagram

You can use a switch or a PLC to connect the SLS activation signal to the FSO module. SLS networks are created by connecting the SLS activation signal to the FSO modules with external wirings outside the cabinet. For more information, see the circuit diagrams delivered with the inverter unit.

This example diagram shows two drives equipped with FSO modules in a network. The SLS function is activated from an SLS switch. This is common to both FSO modules. The SLS and SSM indications are separate.
Note: In different trip limit situations (for example, when the motor speed reaches an SLS or SMS trip limit), the FSO module trips only the inverter unit in which it is installed.

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

---

The dashed line in the figure indicates a user-defined installation.

1) 24 V SLS input (user-defined)
2) User-defined indication system
3) To parallel FSO modules (if any)
4) To parallel inverter modules (if any)
5) Speed signal from safety pulse encoder

A68 Safety functions module FSO-12/-21
A468 FSE-31 Pulse encoder interface
X111 STO connections to inverter control unit
X113, X114 Terminal block in the FSO module
X113:2 SLS request 1
Initial status: The inverter unit is in operation and the motor is running. This procedure describes the SLS function.

1. In this example, the SLS function is requested from a switch. This activates the safety function in both FSO modules.

2. In both inverter units:
   - If the motor speed is above the user-defined SLS limit, the inverter unit decelerates the motor speed to the SLS limit. The SLS indications go on.
   - The inverter unit limits the motor speed reference so that it stays below the SLS limit.
   - The FSO module monitors the actual motor speed against the SLS trip limits.

   **Note:** If the motor speed reaches the SLS trip limit, the FSO module activates the SSE function. The motor coasts to a stop or decelerates to zero speed according to FSO parameter settings. The FSO module activates the inverter unit STO (only in the inverter unit in which the FSO is installed, not in the other inverter unit).

3. Normal operation resumes after the SLS request is removed. The SLS indications go off.
   If the motor speed reached the SLS trip limit during the SLS monitoring and if the STO indication parameter (FSOGEN.62 or 31.22) has been set so that a fault is generated, the user must reset the inverter unit. See chapter Parameter settings.

## 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 SLS activation switch wiring chain, or
- any internal failure within the FSO or FSE-31 modules, the safety encoder or the inverter unit STO.

This section describes the fault reaction functions in the FSO and FSE-31 modules, the safety encoder and the inverter unit STO.

### FSO module

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

The FSO module goes into Fail-safe mode. The STATUS/FAULT LED of the FSO module 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 inverter unit parameter 96.09 FSO reboot.

For more information, see the inverter unit firmware manual and the FSO module user’s manual.

### FSE-31 module

When a safety function is active, the fault reaction function of the FSO module trips the inverter unit if it detects a failure in the FSE-31 module. The FSO module activates the STO function. This activates the inverter unit STO function. The inverter unit 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).

The FSO module goes into Fail-safe mode. The STATUS/FAULT LED of the FSO module is red and the STATUS LED of the FSE-31 module is off until the fault has been repaired. Also the inverter unit indicates some of the FSE-31 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 inverter unit parameter 96.09 FSO reboot.

For more information, see the inverter unit 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

Internal faults of the safety encoder and the FSE-31 module will cause the FSO module to go into Fail-safe mode.

The STATUS/FAULT LED of the FSO module is red and the ENC STATUS LED of the FSE-31 module is off until the fault has been repaired. Also the inverter unit indicates a 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 inverter unit parameter 96.09 FSO reboot.

The safety encoder goes into Safe state. To exit 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 inverter unit 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 inverter units

The STO function in the inverter units 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 inverter unit.
Parameter settings

This section lists the parameters that you have to set in the FSO modules and the inverter units.

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 default parameter values below represent example values for the safety functions presented in this manual. Actual parameter values of the delivery may vary. You must always check that the parameter settings match your application needs.

**FSO module parameter settings**

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 parameter values, nor upload or download the FSO configuration file.

**Note:** 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. Remember to configure the STO and SSE functions (see sections Parameters for the STO function and Parameters for the SSE function).

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

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

**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.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>
### Description

**Set 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**.

### Table of Parameters

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSOGEN.41</td>
<td>Power-up acknowledgement</td>
<td>Automatic</td>
<td>Sets the power-up acknowledgement method of the FSO module. <strong>Automatic</strong>: 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. <strong>Manual</strong>: The FSO module reads the external acknowledgement signal through the digital input defined by parameter FSOGEN.42. Make sure that the value is <strong>Automatic</strong>.</td>
</tr>
<tr>
<td>FSOGEN.42</td>
<td>Acknowledgement button input</td>
<td>None</td>
<td>Selects the digital input for the acknowledgement signal when parameter FSOGEN.41 Power-up acknowledgement or STO.02 STO acknowledgement has value <strong>Manual</strong>. In the safety functions described in this manual, parameters FSOGEN.41 Power-up acknowledgement and STO.02 STO acknowledgement have value <strong>Automatic</strong>, and this digital input is not used. The safety functions are configured not to require a reset/acknowledgement of the safety function after power-up or the removal of the safety function request.</td>
</tr>
<tr>
<td>FSOGEN.52</td>
<td>Zero speed with encoder</td>
<td>10 rpm</td>
<td>Sets the general zero speed limit for safety functions when a safety encoder is in use. This parameter is relevant when the SSE function is activated and if parameter SSE.13 SSE function is set to <strong>Emergency ramp</strong>. See section Parameters for the SSE function. <strong>Note</strong>: You cannot set trip limits below this value.</td>
</tr>
</tbody>
</table>
Parameters for the STO function

These parameters are related to the STO function of the FSO module. The SLS function activates the STO function if a ramp monitoring limit is reached during deceleration. The FSO module can also 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 acknowledge-</td>
<td>Automatic</td>
<td>Sets the acknowledgement method used in the STO, SSE and SS1 functions.</td>
</tr>
<tr>
<td></td>
<td>ment</td>
<td></td>
<td><strong>Automatic:</strong> The FSO module generates the STO acknowledgement signal automatically, and the user does not have to press a reset button (see parameter FSOGEN.42 Acknowledgement button input).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The default value after factory reset is Manual. Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>STO.11</td>
<td>STO input A</td>
<td>None</td>
<td>Sets the digital input that is connected to the primary input of the STO function.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The safety option described in this manual does not use this function and the value must be None.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The default value after factory reset is DI X113:1&amp;X114:1. Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>Index</td>
<td>Name</td>
<td>Example value</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>STO.14</td>
<td>Time to zero speed with STO and mod-off</td>
<td>2000 ms</td>
<td>The time it takes for the motor to coast to a standstill from maximum process speed. This must be measured with Drive composer pro PC tool when an encoder is used for motor control (otherwise you have to make sure that the motor shaft has stopped rotating by other means, eg, visually.). Acknowledgement is allowed after coast stop in the STO, SSE and SS1 functions (when SBC is not used). If SBC is used, see parameter SBC.13 SBC time to zero speed. If an external request activates the STO function, this parameter sets the time after which the function is completed and the STO completed indication goes on. In this case, parameter STO.13 Restart delay after STO defines the time after which the acknowledgement is allowed. If the drive STO is activated or modulation stopped while a monitoring safety function is indicating &quot;unsafe&quot;, after this time acknowledgement is allowed. For example, if the drive modulation is lost during SLS deceleration ramp, SLS OK will be indicated after this time has elapsed. When an encoder is used: This parameter is relevant only if there is an encoder failure and the FSO module activates the STO function. <strong>Note:</strong> The default value after factory reset is 3,600,000 ms. Always check this parameter after factory reset.</td>
</tr>
</tbody>
</table>

**SBC usage**

| SBC.11 | STO SBC usage | None | Activates/deactivates the control of a mechanical brake of the motor. **None:** This feature is not in use. In this manual, 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. |

**Parameters for the SSE function**

These parameters are related to the Safe stop emergency (SSE) function of the FSO module. The SLS and SMS functions activate the SSE function if the motor speed reaches a trip limit during monitoring. The FSO module can activate the SSE function in internal fault situations.
Sets the type of the SSE function. *Immediate STO*: The FSO module activates the inverter unit STO function immediately after the SSE request.  
*Emergency ramp*: The FSO module first ramps down the motor speed and when the speed has reached the zero speed limit (parameter FSOGN.52), it activates the STO function. SAR0 parameters define the deceleration ramp (for more information, see the FSO module user’s manual).  
For the +Q965 option, ABB has set this parameter to value *Immediate STO* at the factory. Adjust the default value when necessary.  
**Note:** The default value after factory reset is *Emergency ramp*. Always check this parameter after factory reset.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
</table>
| SSE.13| SSE function                | Immediate STO or Emergency ramp | Sets the method used for the SSE emergency ramp monitoring. This parameter is relevant only if parameter SSE.13 SSE function is set to *Emergency ramp*.  
*Ramp*: SAR0 parameters define the emergency ramp and monitoring limits (see SAR0 ramp settings).  
*Time*: Parameter 200.102 SAR0 ramp time to zero defines the emergency ramp and it is monitored with parameter SSE.15 SSE delay for STO.  
For the +Q965 option, ABB has set this parameter to value *Ramp* at the factory. Adjust the default value when necessary.  

| SSE.14| SSE monitoring method       | Ramp or Time   | Sets the SSE monitoring time after which the FSO module activates the inverter unit STO function after the SSE request.  
This parameter is relevant only if parameter SSE.13 SSE function is set to *Emergency ramp*, time monitoring is used (SSE.14 SSE monitoring method = Time) and the motor speed does not follow the ramp.  
**Note:** This delay must be considered when the total response time for the safety function is defined.  

| SSE.15| SSE delay for STO           | 20000 ms      | Sets the method used for the SSE emergency ramp monitoring. This parameter is relevant only if parameter SSE.13 SSE function is set to *Emergency ramp*.  
This parameter is relevant only if parameter SSE.13 SSE function is set to *Emergency ramp*, time monitoring is used (SSE.14 SSE monitoring method = Time) and the motor speed does not follow the ramp.  
**Note:** This delay must be considered when the total response time for the safety function is defined. |
### SSE.16 SSE ramp zero speed delay for STO

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE.16</td>
<td>SSE ramp zero speed delay for STO</td>
<td>0 ms</td>
<td>Sets an extra delay time for the inverter unit STO activation at the zero speed in the SSE function. With this parameter, the FSO module delays the STO activation so that the inverter unit is able to reach the shaft zero speed before the FSO module activates the STO function. The delay counter starts when the motor speed reaches the zero speed limit (parameter FSOGEN.52). After this delay has elapsed, the FSO module activates the inverter unit STO function. You can use this parameter when the motor rotates a high inertia load. <strong>Note:</strong> The FSO module activates the inverter unit STO immediately if the inverter unit stops modulating before this delay has passed (that is, the motor actual speed reaches 0 rpm). This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp.</td>
</tr>
</tbody>
</table>

### SBC usage

| SBC.15 | SSE/SS1 SBC speed | 0 rpm | Sets the absolute speed below which the mechanical brake of the motor is activated while ramping. **0 rpm:** The feature is not in use. In this manual, 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. |

### SAR0 ramp settings

<table>
<thead>
<tr>
<th>200.102</th>
<th>SAR0 ramp time to zero</th>
<th>1000 ms</th>
<th>Sets the target time for the reference emergency stop ramp SAR0 (used in the SSE function). Target time = Time in which the inverter unit decelerates the motor from speed 200.202 SAR speed scaling to zero. This parameter is relevant only if parameter SSE.13 SSE function is set to Emergency ramp. Adjust the default value when necessary.</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.202</td>
<td>SAR speed scaling</td>
<td>1500 rpm</td>
<td>Sets a speed value that the FSO module uses as a reference point in ramp parameter calculations (both SAR0 and SAR1 ramps). Adjust the default value when necessary.</td>
</tr>
</tbody>
</table>
Parameters for the SLS function

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

Set these parameters for all FSO modules. Each FSO module can have different SLS1 limits, SLS1 trip limits and SAR1 ramp settings.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
</table>
| 200.21 | SLS1 activity and version           | Version 1     | Activates or deactivates the SLS1 function and shows the version of the SLS1 function.  
|        |                                     |               | Disabled: Deactivates the SLS1 function.  
|        |                                     |               | Version 1: Activates the SLS1 function.                                                |
| 200.22 | SLS1 limit negative                 | -200 rpm      | Sets the SLS1 negative speed limit for the inverter unit.  
<p>|        |                                     |               | Adjust the default value to meet the motor in use.                                           |
|        |                                     |               | <strong>Note:</strong> The difference between the SLS limit and the corresponding SLS trip limit (SLSx.13) must be at least 0.1 rpm. |
|        |                                     |               | <strong>Note:</strong> The default value after factory reset is 0 rpm. |
|        |                                     |               | Always check this parameter after factory reset.                                               |</p>
<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.23</td>
<td>SLS1 limit positive</td>
<td>200 rpm</td>
<td>Sets the SLS1 positive speed limit for the inverter unit. Adjust the default value to meet the motor in use. <strong>Note:</strong> The difference between the SLS limit and the corresponding SLS trip limit (SLSx.14) must be at least 0.1 rpm. <strong>Note:</strong> The default value after factory reset is 0 rpm. Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>SLSx.02</td>
<td>SLS acknowledgement</td>
<td>Automatic</td>
<td>Sets the acknowledgement method used in the SLS1...4 functions. <strong>Automatic:</strong> The FSO module generates the SLS acknowledgement signal automatically after the SLS request has been removed and the SLS limit has been achieved. The user does not have to press a reset button (see parameter FSOGEN.42 Acknowledge-ment button input). <strong>Note:</strong> The default value after factory reset is Manual. Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>SLSx.03</td>
<td>SLS activation monitoring</td>
<td>Time or Ramp</td>
<td>Sets the monitoring method that is used in SLS activation. <strong>Time monitoring:</strong> The inverter unit (parameter 23.13 Deceleration time 1 or 23.15 Deceleration time 2) defines the deceleration ramp and it is monitored with parameter SLSx.04 SLS time delay. <strong>Ramp monitoring:</strong> SAR1 parameters define the deceleration ramp and monitoring limits. See parameters 200.112, SARx.21, SARx.22 and SARx.02. For the option +Q965, ABB has set this parameter to value Ramp at the factory. Adjust the default value when necessary.</td>
</tr>
<tr>
<td>SLSx.04</td>
<td>SLS time delay</td>
<td>4000 ms</td>
<td>Sets the SLS monitoring time after which the FSO module activates the SLS monitoring after the SLS request. This parameter is relevant only if time monitoring is used, see parameter SLSx.03 SLS activation monitoring method. <strong>Note:</strong> With time monitoring, when Monitoring active and Modoff delay time is selected, SLSx.04 and SLSx.06 time must be set shorter than STO.14, otherwise STO is not activated due to limit hit when drive modulation is lost with SLS function.</td>
</tr>
</tbody>
</table>
### Option Description

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLSx.05</td>
<td>SLS ramp modoff reaction</td>
<td>Modoff delay time</td>
<td>Selects the fault reaction in case the drive modulation is lost during the SLS deceleration ramp, when SLS is activated from speed which is higher than SLS limit speed. For more information, see FSO module user's manual.</td>
</tr>
<tr>
<td>SLSx.06</td>
<td>SLS ramp modoff delay time</td>
<td>0 ms</td>
<td>Time to trip when modulation is lost.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> SLSx.06 time must be set shorter than STO.14, otherwise STO is not activated due to limit hit when drive modulation is lost with SLS function.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> If encoder feedback is in use, SLSx.06 parameter has no effect.</td>
</tr>
<tr>
<td>SLSx.11</td>
<td>SLS1 input A</td>
<td>DI X113:2 &amp; X114:2</td>
<td>Sets the digital input that is connected to the primary input of the SLS function with limits 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>For the option +Q965, ABB has configured the SLS request signal to these digital inputs at the factory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The default value after factory reset is <em>None</em>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>SLSx.13</td>
<td>SLS1 trip limit negative</td>
<td>-250 rpm</td>
<td>Sets the SLS1 negative speed limit that trips the inverter unit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adjust the default value to meet the motor in use.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The difference between the SLS trip limit and the corresponding SLS limit (200.22) must be at least 0.1 rpm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The default value after factory reset is 0 rpm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Always check this parameter after factory reset.</td>
</tr>
<tr>
<td>SLSx.14</td>
<td>SLS1 trip limit positive</td>
<td>250 rpm</td>
<td>Sets the SLS1 positive speed limit that trips the inverter unit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adjust the default value to meet the motor in use.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The difference between the SLS trip limit and the corresponding SLS limit (200.23) must be at least 0.1 rpm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The default value after factory reset is 0 rpm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Always check this parameter after factory reset.</td>
</tr>
</tbody>
</table>
Set the digital output that is connected to the primary output of the SLS1 function. Active when the SLS monitoring is on.

For the option +Q965, ABB has configured the SLS indication signal to this digital output at the factory.

**Note:** The default value after factory reset is *None.*

Always check this parameter after factory reset.

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLSx.15</td>
<td>SLS1 output A</td>
<td>DO X114:7</td>
<td>Sets the digital output that is connected to the primary output of the SLS1 function. Active when the SLS monitoring is on. For the option +Q965, ABB has configured the SLS indication signal to this digital output at the factory. <strong>Note:</strong> The default value after factory reset is <em>None.</em> Always check this parameter after factory reset.</td>
</tr>
</tbody>
</table>

### SAR1 ramp settings

<table>
<thead>
<tr>
<th>200.112</th>
<th>SAR1 ramp time to zero</th>
<th>2000 ms</th>
<th>Sets the target time for the stop ramp SAR1 that is used in the SLS function. Adjust the default value when necessary. Target time = The time in which the inverter unit decelerates the motor(s) from speed 200.202 SAR speed scaling to zero. <strong>Note:</strong> With value 0 ms, the inverter unit uses the emergency stop ramp set by inverter unit parameter 23.23 (see section Ramp parameters). In this case, the FSO module also monitors the actual ramp (ramp monitoring or time monitoring). <strong>Time monitoring:</strong> This value has no effect in the operation. The inverter unit (parameter 23.13 Deceleration time 1 or 23.15 Deceleration time 2) defines the deceleration ramp (see section Ramp parameters). <strong>Ramp monitoring:</strong> Adjust the default value when necessary.</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.202</td>
<td>SAR speed scaling</td>
<td>1500 rpm</td>
<td>The same value is used for SAR0 and SAR1 ramps. See section SAR0 ramp settings.</td>
</tr>
<tr>
<td>SARx.02</td>
<td>SAR initial allowed range</td>
<td>100 ms</td>
<td>The same value is used for SAR0 and SAR1 ramps. See section SAR0 ramp settings.</td>
</tr>
<tr>
<td>SARx.21</td>
<td>SAR1 min ramp time to zero</td>
<td>1000 ms</td>
<td>Sets the minimum ramp time for the SAR1 ramp monitoring. <strong>Time monitoring:</strong> This value has no effect in the operation. <strong>Ramp monitoring:</strong> Sets the minimum stop ramp time for the emergency stop. Adjust the default value when necessary. <strong>Note:</strong> With value 0 ms, the ramp is not monitored.</td>
</tr>
</tbody>
</table>
### Parameters for the SMS function

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
</table>
| 200.71| SMS activity and version          | Version 1     | Activates or deactivates the SMS function and shows the version of the SMS function.  
**Disabled:** Deactivates the SMS function (default).  
**Version 1:** Activates version 1 of the SMS function.  
**Version 2:** Activates version 2 of the SMS function (for more information, see the FSO module user’s manual).  
For the option +Q965, ABB has configured the SMS function (Version 1) at the factory. Adjust the value if necessary.  
**Note:** The default value after factory reset is **Disabled**.  
Always check this parameter after factory reset. |
Parameters for the SSM function

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Example value</th>
<th>Description</th>
</tr>
</thead>
</table>
| SSMx.01 | SSM1 activity and version         | Version 1     | Activates or deactivates the SSM1 function and shows the version of the SSM1 function.  
Disables: Deactivates the SSM1 function.  
Version 1: Activates the SSM1 function.  
For the option +Q965, ABB has activated the SSM1 function at the factory. Adjust the value if necessary. |
| SSMx.11 | SSM1 input                        | Always on     | Sets the digital input connected to the SSM1 function.  
Always on: The SSM1 function is always on. No external request signal is needed to activate the SSM1 function.  
For the option +Q965, ABB has configured the SSM1 function to be “Always on” at the factory. |
| SSMx.12 | SSM1 limit negative               | -100 rpm      | Sets the negative speed limit for the SSM1 function.                        |
| SSMx.13 | SSM1 limit positive               | 100 rpm       | Sets the positive speed limit for the SSM1 function.                        |
### FSE-31 module and safety pulse encoder related 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>200.231</td>
<td>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>200.232</td>
<td>Number of encoders</td>
<td>Single encoder CH1</td>
<td>Shows the number of safety pulse encoders connected to the FSE-31 module.</td>
</tr>
<tr>
<td>S_ENCGEN.01</td>
<td>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>S_ENCGEN.11</td>
<td>FSE diagnostic failure reaction</td>
<td>STO</td>
<td>Sets the action taken when there is a problem with the FSE-31 module. STO: The FSO module goes into Fail-safe mode and activates the drive STO function.</td>
</tr>
<tr>
<td>Index</td>
<td>Name</td>
<td>Example value</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------</td>
<td>---------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>S_ENCGEN.14</td>
<td>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. This parameter is used for the encoder diagnostic. It defines how big the difference between the speed information from channel A and B of the encoder can be. If the difference of these two values is bigger than value set to this parameter, FSO will safely stop the system (STO). The suitable value depends on the configuration (motor / load). Typically this value is 2-10 rpm, too small value will cause encoder fault (A7D8) and too big value will prevent encoder diagnostic related to this parameter.</td>
</tr>
<tr>
<td>S_ENCGEN.41</td>
<td>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>
</tbody>
</table>
| 92.17      | Accepted pulse freq of encoder 1          | 300 kHz       | 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: 
\[
r_{\text{max}} \times \text{ppr}_{\text{enc}} + 10\%\]
where 
- \(r_{\text{max}}\) = the maximum motor speed used in the application (or the motor nominal speed) 
- \(\text{ppr}_{\text{enc}}\) = Pulses/revolution of the safety pulse encoder (parameter 92.10). |
### Inverter unit parameter settings

The parameter setting in ACS880 primary control program:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.22</td>
<td>STO indication run/stop</td>
<td>Warning/Warning</td>
<td>Selects which indications are given when one or both Safe torque off (STO) signals are switched off or lost. Warning/Warning is the recommended setting.</td>
</tr>
</tbody>
</table>

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

### Ramp parameters

**Note:** You must set these parameters only for the SLS function.

When the SLS function is activated and the motor speed is above the SLS limit positive, the inverter unit ramps down the motor speed to the SLS limit.

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

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

After the SLS function has been deactivated, the inverter unit returns to normal operation and starts to follow its ordinary speed reference. The inverter unit accelerates the motor to the desired speed along its acceleration ramp. Inverter unit parameters define the acceleration ramp and it is not monitored.

For the parameter settings in the inverter unit, see the firmware manual.

### Safety pulse encoder parameters

The inverter unit parameter settings in ACS880 primary control program when you use a 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+, A-, B+, B-, Z+, Z-*.
Electrical installation

Contents of this chapter

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

Wiring

There is an extension terminal block [X68] for the connections to the FSO module inside the inverter unit cabinet. This terminal block is the user interface. The FSO module connectors [X113] and [X114] have been wired to [X68]. The tables below show the connections between the extension terminal block and the FSO module.

<table>
<thead>
<tr>
<th>FSO X113</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8, 9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13, 14, 15, 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>X68</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8, 9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15, 16</td>
</tr>
</tbody>
</table>

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

ABB installs the FSO and FSE-31 modules and the wirings between the FSO modules and the inverter units at the factory.

The user must wire the safety pulse encoders to the FSE-31 modules on site. Obey the instructions of the encoder manufacturer as well as the following rules:

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

The user must wire the SLS request signal to the FSO module on site. The user can also wire the SLS indication signal of the FSO module to the control system on site.

For the terminal designations, see the table above and the circuit diagrams delivered with the inverter unit. If you use a switch for SLS activation, obey these general rules:

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

   Note: Keep the channels separate. If you use only one channel in a two-channel implementation, 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 STO function of the inverter unit as it detects a redundancy fault.

   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.

2. Use a shielded, twisted pair cable. We recommend a double-shielded cable.

3. Make sure that the sum resistance for one channel (loop resistance) from the field to the FSO module does not exceed 1000 ohms.

4. The maximum allowed cable length between the inverter unit and the activation switch (for the whole loop) is 250 m (820 ft).

5. Obey the general control cable installation instructions given in the inverter unit hardware manual.

6. Do not use test pulses in the FSO inputs (see section I/O settings).

If the SLS activation request comes from a PLC digital transistor output (as shown in section Operation principle diagram), obey these rules:

1. Do not use test pulses in the FSO inputs (see section I/O settings).

2. The PLC must monitor the request signals. For more information, see the documentation of your PLC.

SMS function

The user does not need to make any additional wirings.

SSM function

The user must wire the SSM indication signal of the FSO module according to the application on site. See the table above and the circuit diagrams delivered with the inverter unit for the terminal designations.
Use of the safety function

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

Activating and deactivating the SLS function
To activate the SLS function, de-energize (24 V -> 0 V) the appropriate digital input of the FSO module. See the circuit diagram delivered with the drive.

When the SLS monitoring is on and the motor speed is below the SLS limit:
- the FSO module energizes a digital output and the indication connected to this output (for example, a lamp) is on. For the terminal designations, see the circuit diagram delivered with the drive.

When the inverter unit trips after an SLS trip limit hit:
- the FSO module generates a fault (see parameter FSOGEN.62 in Parameter settings)
- the inverter unit generates an event according to parameter 31.22 STO indication run/stop, see section Parameter settings.

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

To deactivate the SLS function, energize (0 V -> 24 V) the appropriate digital input of the FSO module. See the circuit diagram delivered with the inverter unit.

Activating and deactivating the SMS function
If the SMS function is activated at the start-up, it monitors the motor speed continuously. The SMS function is activated and deactivated with an FSO module parameter (200.71). To change this parameter value, a password is needed (see section Parameter settings).

When the inverter unit trips after an SMS trip limit hit:
50 Use of the safety function

- the FSO module generates a fault (see parameter FSOGEN.62)
- the inverter unit generates an event according to parameter 31.22 STO indication run/stop (see section Parameter settings).

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

Activating and deactivating the SSM function

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

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

When the motor speed is between the SSM speed limits:
- the FSO module energizes a digital output and the indication signal connected to this output is on. For the terminal designations, see the circuit diagram delivered with the inverter unit.
Start-up and acceptance test

Contents of this chapter

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

Validation of the safety functions

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

■ 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.

■ Validation procedure

You must do the acceptance test using the checklist given in section Start-up and acceptance test:

• 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 work related to the safety function.

The acceptance test must include at least the following steps:

• you must have an acceptance test plan
• you must test all commissioned functions for proper operation, from each operation location
• you must document all acceptance tests
• you must sign and store 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.

---

### Start-up and acceptance test

You need the Drive composer PC tool to perform the start-up and acceptance test. Repeat this test for every inverter unit which uses the SLS function, the SMS function (version 1), or the SSM function. Repeat the test in both operation directions of the motor.

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

**Note:** If you use SMS function, version 2: Do the acceptance test as described in FSO module user’s manual.

<table>
<thead>
<tr>
<th>Action</th>
<th>Initial status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety encoder interface:</strong></td>
<td>☐</td>
</tr>
<tr>
<td>When you use a safety pulse encoder in the safety application, validate the safety encoder interface as described in <a href="3AXD50000015614%5BEnglish%5D"><em>FSO-21 safety functions module user's manual</em></a>, chapter Verification and validation.</td>
<td>☐</td>
</tr>
<tr>
<td>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.</td>
<td>☐</td>
</tr>
</tbody>
</table>
| **Note:** When you perform the motor ID run, the SLS and SMS functions must be deactivated:  
  • **SLS function:** Make sure that the SLS request is not active (e.g., from a switch).  
  • **SMS function:** Adjust the delivered default value of the FSO module:  
    - 200.71 SMS activity and version = Disabled. | ☐ |
| After the motor ID run, activate the SLS and SMS functions. | ☐ |
| Make sure that STO function has been configured and validated.  
  Internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal. The STO function has to be validated before other safety functions. | ☐ |
| **Note:** If parameter S_ENCGEN.11 is set to Est switch not active load, both STO function with speed estimate and STO function with encoder feedback must be tested - most importantly, the value of parameter STO.14 must be set according to application needs. | ☐ |
## Action

**For SLS function and SMS function:** Make sure that SSE parameters have been set and SSE function has been validated for trip limit situations as described in FSO module user's manual.

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

## Checks and settings with no voltage connected

Stop the drive and do the steps in section *Electrical safety precautions (page 8)* before you start the work.

If you have done any connections on site, check the connections against the appropriate circuit diagrams.

## Settings with voltage connected

Close the cabinet doors and power up the drive. See the hardware manual.

Check the parameters that are relevant to the safety function. If necessary, set the parameters as defined in section Parameter settings.

### For SMS function:
- Make sure the SMS function is active (parameter SMS activity and version = Version 1).
- Set parameter SMS trip limit positive to half of the value to be used in the application and parameter SMS trip limit negative to zero.

For more information, see section Parameters for the SMS function.

### For SSM function:
For more information, see section Parameters for the SSM function.

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

We recommend that you monitor these signals with the Drive composer PC tool:

- **01.01 Motor speed used (rpm)**
- **01.02 Motor speed estimated (rpm)**
- **01.07 Motor current (A)**
- **01.10 Motor torque (%)**
- **23.01 Speed ref ramp input (rpm)**
- **23.02 Speed ref ramp output (rpm)**
- **90.01 Motor speed for control (rpm)**
- **90.10 Encoder 1 speed (rpm)**
- **200.01 FSO speed ch1 (rpm)**
- **200.02 FSO speed ch2 (rpm)**
- **200.03 FSO DI status**
- **200.04 FSO DO status**
- **200.05 FSO control word 1**
- **200.06 FSO control word 2**
- **200.07 FSO status word 1**
- **200.08 FSO status word 2**
- **200.09 Drive status word 1**
- **200.10 Drive status word 2**

Make sure that it is safe to start, run and stop the motor(s) during the test.

**For SLS function:** If it is necessary to activate STO function when drive modulation is lost during SLS deceleration ramps, follow the test procedure for SLS function described in the FSO module user's manual.
### 54 Start-up and acceptance test

<table>
<thead>
<tr>
<th>Action</th>
<th></th>
</tr>
</thead>
</table>
| Start the inverter unit and make sure that the motor is running.  
**For SLS function**: Increase the motor speed close to the maximum speed of the application (above the SLS limit).  
**For SMS function**: Increase the motor speed above the speed defined in parameter SMS trip limit positive.  
**For SSM function**: Make sure that the SSM1 indication is on. | ✔ |
| **For SLS function**: Activate the SLS request of the FSO module.  
**For SMS function**: Make sure that the inverter unit trips.  
**For SSM function**: Increase the motor speed above the speed defined in parameter SSM1 limit positive. |  |
| **For SLS function**: Make sure that the inverter unit decelerates the motor speed to the SLS limit, stays under the SLS limit, and indicates the SLS function as described in section Activating and deactivating the SLS function.  
For information on cascade connection, see FSO module user's manual.  
**For SMS function**: Reset the inverter unit if the STO indication parameter (FSOGEN.62 or 31.22) has been set so that a fault is generated. See section Parameter settings.  
**For SSM function**: Make sure that the SSM1 indication goes off. |  |
| Make sure that "STO hardware failure" (5090) is not generated. |  |
| **For SLS function**:  
When the SLS request signal is on, make sure that you cannot increase the reference speed above the SLS limit:  
• with the panel in the local control mode  
• with an external speed reference signal in the external control mode.  
The LOC and REM buttons of the control panel or the Drive composer PC tool switch between the local and external controls.  
**For SMS function**: Restart the inverter unit. Make sure that the inverter unit continues normal operation.  
**For SSM function**: Decrease the motor speed below the speed defined in parameter SSM1 limit positive. |  |
| **For SLS function**: Deactivate the SLS request of the FSO module. Make sure that the inverter unit continues normal operation.  
**For SSM function**: Make sure that the SSM1 indication goes on. |  |
| **For SLS function and SMS function**: Stop and restart the inverter units and motors and check that they operate normally. |  |
| Repeat the test in the reverse direction. |  |
| Repeat the test from each operating location. |  |
| **For SMS function**: Set the SMS parameters to suitable values to be used in the application (see section Parameters for the SMS function). |  |
| If you made any changes in the FSO parameters, save the FSO safety file (button **Save safety file** in the Drive composer pro PC tool). |  |
| Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted for operation. |  |
Contents of this chapter

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

Safety circuit maintenance

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

It is a good practice to check the operation of the safety function when other maintenance routines are carried out on the machinery. Include this check in the routine maintenance program of the machinery that the drive runs.

If you change any wiring or component after the start-up, replace the FSO or FSE-31 module, modify FSO module parameters, or restore parameters to their factory default values:

- Use only ABB-approved spare parts.
- Register the change to the change log for the safety circuit.
- Test the safety function again after the change. Do the start-up and acceptance test of the safety function.
- 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 operation of the safety function must be ensured 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 by doing the start-up and acceptance test of the safety function.
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 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-31 modules and the STO circuit of the inverter unit do not contain electromechanical outputs.

**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 operators.

**Intentional misuse**

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

**Decommissioning**

When you decommission a safety function network or a part of it, or an inverter unit, make sure that the safety of the machine is maintained until the decommissioning is complete.
Technical data

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

Safety data

- **Safety performance with different safety pulse encoders**
  See *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

- **Safety data values**
  Each multidrives delivery is unique. If included in the customer order, ABB calculates the safety data for the safety function, and delivers the data separately to the customer.
  For the safety data of the FSO-21 and FSE-31 modules, see *FSO-21 safety functions module user’s manual* (3AXD50000015614 [English]).

- **Safety component types**
  Safety component types as defined in IEC 61508-2:
  - safety relay(s): type A
  - FSO module: type B
  - FSE module: type B
  - inverter unit STO circuit:
    - frame sizes R1...R9 and drives with R1i...R7i inverter modules: type A
    - frame sizes R10 and R11 and drives with R8i inverter modules: type B.
Safety block diagrams
Each multidrives delivery is unique. If included in the customer order, ABB defines the safety block diagram for the safety function and delivers the diagram separately to the customer.

Relevant failure modes
Relevant failure modes are:
• internal failures of the FSO and FSE modules and the STO function in the inverter unit.
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
• any short and open circuits in the cabinet terminal blocks of the safety circuits.

Operation delays
Total delay: (less than) 500 ms (includes the response time of the inverter unit STO).
Note: When using a safety pulse encoder, you must add the delays of the encoder when defining the total response time for the safety function and the fault reaction function.

Ambient conditions
For the environmental limits for the safety functions and the drive, refer to the hardware manual of your drive, and to FSO and FSE-31 module user's manuals.

Related standards and directives

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<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 60204-1:2016</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>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>
</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 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.

Providing feedback on ABB manuals
Your comments on our manuals are welcome. Navigate to new.abb.com/drives/manuals-feedback-form.

Document library on the Internet
You can find manuals and other product documents in PDF format on the Internet at www.abb.com/drives/documents.