OPTIONS FOR ABB DRIVES

Emergency stop, stop category 1 (option +Q964) for ACS880-07/17/17LC/37/37LC drives

User's manual
Emergency stop, stop category 1 (option +Q964) for ACS880-07/17/17LC/37/37LC drives

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 electrician, 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 electrician, do not do installation or maintenance work.

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

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Make sure that re-connection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - If you have a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Disconnect 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.
• If you have a permanent magnet motor connected to the drive, 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 ACS880-07/17/17LC/37/37LC drives which have the option: Emergency stop, stop category 1 with STO, with safety relays (option +Q964).
In this emergency stop option, the main contactor/breaker of the drive is not opened.
For the option +Q964, ABB installs the FIO-01 digital I/O extension module (option +L501) to the drive.

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>
</tr>
</tbody>
</table>

Related manuals

<table>
<thead>
<tr>
<th>Manual</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drive hardware</strong></td>
<td></td>
</tr>
<tr>
<td>ACS880-07 drives (560 to 2800 kW) hardware manual</td>
<td>3AU0000143261</td>
</tr>
<tr>
<td>ACS880-07 drives (45 to 710 kW, 50 to 700 hp) hardware manual</td>
<td>3AU0000105718</td>
</tr>
<tr>
<td>ACS880-17 drives (160 to 3200 kW) hardware manual</td>
<td>3AXD5000020436</td>
</tr>
<tr>
<td>ACS880-17 drives (45 to 400 kW) hardware manual</td>
<td>3AXD5000035158</td>
</tr>
<tr>
<td>ACS880-17LC hardware manual</td>
<td>3AXD5000250295</td>
</tr>
<tr>
<td>ACS880-37 drives (160 to 3200 kW) hardware manual</td>
<td>3AXD5000020437</td>
</tr>
<tr>
<td>ACS880-37 drives (45 to 400 kW) hardware manual</td>
<td>3AXD5000035159</td>
</tr>
<tr>
<td>ACS880-37LC hardware manual</td>
<td>3AXD50000251407</td>
</tr>
<tr>
<td><strong>Drive firmware</strong></td>
<td></td>
</tr>
<tr>
<td>ACS880 primary control program firmware manual</td>
<td>3AU0000085967</td>
</tr>
<tr>
<td>ACS880 primary control program quick start-up guide</td>
<td>3AU0000098062</td>
</tr>
<tr>
<td>ACS880 diode supply control program firmware manual</td>
<td>3AU000103295</td>
</tr>
<tr>
<td>ACS880 IGBT supply control program firmware manual</td>
<td>3AU000131562</td>
</tr>
<tr>
<td><strong>PC tools</strong></td>
<td></td>
</tr>
<tr>
<td>Drive composer start-up and maintenance PC tool user's manual</td>
<td>3AU0000094606</td>
</tr>
<tr>
<td>Functional safety design tool user's manual</td>
<td>3AXD1000102417</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td></td>
</tr>
<tr>
<td>Functional safety; Technical guide No. 10</td>
<td>3AU0000048753</td>
</tr>
<tr>
<td>Safety and functional safety; A general guide</td>
<td>1SFC001008B0201</td>
</tr>
<tr>
<td>ABB Safety information and solutions</td>
<td><a href="http://www.abb.com/safety">www.abb.com/safety</a></td>
</tr>
<tr>
<td><strong>Options</strong></td>
<td></td>
</tr>
<tr>
<td>ACX-AP-x assistant control panels user’s manual</td>
<td>3AU0000085685</td>
</tr>
<tr>
<td>Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Other documents</strong></td>
<td></td>
</tr>
<tr>
<td>Circuit diagrams</td>
<td>Delivered with the drive</td>
</tr>
<tr>
<td>Part lists</td>
<td>Delivered with the drive</td>
</tr>
</tbody>
</table>
You can find manuals and other product documents in PDF format on the Internet. See [Document Library](http://www.abb.com/safety). For manuals not available in the Document library, contact your local ABB representative.


<table>
<thead>
<tr>
<th>Manual</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety data report (if the safety circuit is application-engineered)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACS880-07 (45 to 710 kW) manuals</th>
<th>ACS880-07 (560 to 2800 kW) manuals</th>
<th>ACS880-17 (45 to 400 kW) manuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS880-17 (160 to 3200 kW) manuals</td>
<td>ACS880-17LC manuals</td>
<td>ACS880-37 (45 to 400 kW) manuals</td>
</tr>
<tr>
<td>ACS880-37 (160 to 3200 kW) manuals</td>
<td>ACS880-37LC manuals</td>
<td></td>
</tr>
</tbody>
</table>
# Terms and abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</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>CCF</td>
<td>Common cause failure (%) (EN ISO 13849-1)</td>
</tr>
<tr>
<td>D8T</td>
<td>Frame size designation of the diode supply module</td>
</tr>
<tr>
<td>DC</td>
<td>Diagnostic coverage (EN ISO 13849-1)</td>
</tr>
<tr>
<td>DI</td>
<td>Digital input</td>
</tr>
<tr>
<td>DIIL</td>
<td>Digital input interlock</td>
</tr>
<tr>
<td>E-stop</td>
<td>Emergency stop</td>
</tr>
<tr>
<td>FIO-01</td>
<td>Optional digital I/O extension module</td>
</tr>
<tr>
<td>Frame, frame size</td>
<td>Physical size of the drive or power module</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>PFD_{avg}</td>
<td>Average probability of dangerous failure on demand (IEC 61508)</td>
</tr>
<tr>
<td>PFH</td>
<td>Average frequency of dangerous failures per hour (IEC 61508)</td>
</tr>
<tr>
<td>PL</td>
<td>Performance level. Levels a...e correspond to SIL (EN ISO 13849-1)</td>
</tr>
<tr>
<td>RO</td>
<td>Relay output</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>SS1</td>
<td>Safe stop 1 (IEC/EN 61800-5-2)</td>
</tr>
<tr>
<td>STO</td>
<td>Safe torque off (IEC/EN 61800-5-2)</td>
</tr>
<tr>
<td>T1</td>
<td>Proof test interval. Defines the probabilistic failure rate (PFH or PFD) for the safety function or subsystem. Performing a proof test at a maximum interval of T1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. Note that any T1 values given cannot be regarded as a guarantee or warranty.</td>
</tr>
</tbody>
</table>
Option description

Contents of this chapter
This chapter describes the +Q964 emergency stop option and its settings.

Overview
The option +Q964 corresponds to a controlled stop in accordance with stop category 1 (EN/IEC 60204-1). The option corresponds to the Safe Stop 1 (SS1) function. After the user has given the emergency stop command, the drive first decelerates the motor(s) to zero speed according to a preset ramp time. Then, the option activates the Safe torque off (STO) function which disables the control voltage of the power semiconductors of the drive output stage. This prevents the drive from generating the torque required to rotate the motor(s). The main contactor/breaker of the drive is not opened.

For the option +Q964, ABB installs the FIO-01 digital I/O extension module (option +L501) to the drive control unit (Slot 1).

For a detailed description of the Safe torque off function, see the appropriate hardware manual.
**Note:** Drives with the Prevention of unexpected start-up (POUS) option (+Q957): If the user activates the POUS function during the emergency stop deceleration ramp, it overrides the emergency stop function. This activates the Safe torque off (STO) function of the drive immediately and the motor coasts to a stop. For more information on the POUS safety function, see *Prevention of unexpected start-up (option +Q957)* for ACS880-07/17/17LC/37/37LC drives (3AUA00000119910 [English]).

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

The SS1 and STO functions comply with EN/IEC 61800-5-2:2007.

The design principles of the option +Q964 comply with EN ISO 13850.

For a complete list of related standards and European directives, see section Related standards and directives.

**Operation principle**

The figure shows a simplified operation principle. For a more detailed description, see the circuit diagrams delivered with the drive.
<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>A61</td>
</tr>
<tr>
<td>A62</td>
</tr>
<tr>
<td>A412.X</td>
</tr>
<tr>
<td>S61</td>
</tr>
<tr>
<td>S62</td>
</tr>
<tr>
<td>K61</td>
</tr>
<tr>
<td>K63</td>
</tr>
<tr>
<td>X969</td>
</tr>
<tr>
<td>T11.x</td>
</tr>
</tbody>
</table>

**Step** | **Operation**
---|---
Initial status: The drive is in operation and the motor is running.
1 | The user activates emergency stop with the emergency stop button [S61].

2 The emergency stop safety relay [A61] switches off the digital input on the inverter control unit [A41] giving the emergency stop command.  
The emergency stop safety relay [A61] switches off the power supply for the timer relay [K61].  
The break delay counter of the emergency stop safety relay [A61] starts (user-adjustable delay).  
The break delay counter of the timer relay [K61] starts (non-user-adjustable delay).

3 The drive acknowledges the emergency stop command by energizing the relay output RO1 of the digital I/O extension module [A412.X].  
The relay output of the digital I/O extension module [A412.X] re-energizes the timer relay [K61] resetting its break delay counter. The relay keeps its delayed break contact closed.  
**Note:** If the drive fails to acknowledge the reception of the emergency stop command in 2 seconds, the STO cuts off the drive control pulses preventing motor control and rotation.

4 The drive decelerates the motor to zero speed in emergency stop deceleration time (parameter setting).

5 The break delay counter of the emergency stop safety relay [A61] trips and the relay switches off the power supply for the extension safety relay [A62].  
The extension safety relay [A62] switches off the Safe torque off (STO) control signals on the inverter control unit [A41]. The STO cuts off the drive control pulses preventing motor control and rotation.

6 The contact of the auxiliary relay [K63] energizes the emergency stop reset button indicator light [S62].

7 Normal operation resumes after the user:  
- releases the emergency stop button [S61] to normal (up) position  
- resets the emergency stop circuit with the emergency stop reset button [S62] (the user must push the button for 0.1 - 3 seconds)  
- resets the drive (if the drive tripped on a fault).  
- makes sure that the drive has received the start signal (depends on the configuration, see the firmware manual).
Fault reaction function

**Definition:** A safety function requires a “fault reaction function” that attempts to initiate a safe state if the safety function’s diagnostics detect a fault within the hardware/software that performs the safety function.

The fault reaction function of the emergency stop safety relay trips the system if it detects a failure (short circuit between signals, open circuits, redundancy fault when the emergency stop button is pressed) in the safety circuit consisting of, for example, emergency stop button and the contacts wired to it.

The fault reaction function shifts the system immediately into safe state by switching on the emergency stop command, activating the STO function, and keeping safe state activated and the emergency stop reset button indicator light lit until the detected fault has been fixed and safety function has been reset.

**Note:** Resetting the safety function is not possible, if the reset circuit in the emergency stop safety relay is open.

The user must reset the safety relay, see section Fault tracing. For a detailed description of the emergency stop safety relay [A61], see section Hardware settings.

The STO function has its own internal fault diagnostics and fault reaction function.

Parameter settings

- **Drive parameter settings**

The parameter settings 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>14.01</td>
<td>Module 1 type</td>
<td>FIO-01</td>
<td>Activates (and specifies the type of) I/O extension module 1.</td>
</tr>
<tr>
<td>14.02</td>
<td>Module 1 location</td>
<td>Slot 1</td>
<td>Specifies the slot (1…3) on the control unit of the drive into which the I/O extension module is installed.</td>
</tr>
<tr>
<td>14.09</td>
<td>DIO 1 function</td>
<td>Input</td>
<td>Selects whether DIO1 of the extension module is used as a digital input or output.</td>
</tr>
<tr>
<td>14.14</td>
<td>DIO 2 function</td>
<td>Input</td>
<td>Selects whether DIO2 of the extension module is used as a digital input or output.</td>
</tr>
<tr>
<td>14.34</td>
<td>RO1 source</td>
<td>P.14.5.1-</td>
<td>Selects a drive signal to be connected to relay output RO1. In this case, the RO1 is energized by the status of DIO2 of the FIO module (inverted value).</td>
</tr>
<tr>
<td>21.04</td>
<td>Emergency stop mode</td>
<td>Eme ramp stop (Off3)</td>
<td>Selects the way the motor is stopped when an emergency stop command is received.</td>
</tr>
<tr>
<td>21.05</td>
<td>Emergency stop source</td>
<td>P.14.5.1</td>
<td>Selects the source of the emergency stop signal. In this case, the source is DI02 of the FIO module.</td>
</tr>
<tr>
<td>23.23</td>
<td>Emergency stop time</td>
<td>User-defined</td>
<td>Select a suitable value. See the firmware manual and section Hardware settings.</td>
</tr>
<tr>
<td>31.03</td>
<td>External event 2 source</td>
<td>P.14.5.0</td>
<td>Selects the source of external event 1. In this case, the source is DI01 of the FIO module.</td>
</tr>
<tr>
<td>31.04</td>
<td>External event 2 type</td>
<td>Warning/Fault</td>
<td>Selects the type of external event 2.</td>
</tr>
</tbody>
</table>
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.

Selects the maximum speed value used to define the initial speed value used to define the deceleration ramp rate. Select a suitable value. See the firmware manual and section Hardware settings.

**Additional parameter settings for ACS880-07 drives, frames nxDXT + nxR8i and ACS880-17/17LC/37/37LC drives, frames nxR8i + nxR8i**

**Note:** ACS880 primary control program controls the inverter unit by default. There are dedicated control units for the supply and inverter units.

The supply unit parameter settings in the ACS880 supply control programs:
- parameter 121.05 **Emergency stop source** is set to value *Inactive*.

For more information, see the firmware manuals.

**Hardware settings**

Set the time delay of the emergency stop safety relay [A61] according to the application needs with the rotary switches on the safety relay.

<table>
<thead>
<tr>
<th>Switch</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{Fkt} )</td>
<td>1</td>
<td>Selects the delay mode. Must be 1.</td>
</tr>
<tr>
<td>( t_{\text{max}} )</td>
<td>User-defined</td>
<td>Selects the time range (in seconds) for the delayed contacts. Value range: 1-300 s.</td>
</tr>
<tr>
<td>( t )</td>
<td>User-defined</td>
<td>Adjusts the time within the selected range in 10% steps. Value range: 0.1-1.</td>
</tr>
</tbody>
</table>

Example: Required time \( t_v \) = 30 s, set:
- \( t_{\text{max}} = 30 \text{ s} \) and \( t = 1 \) \( (t_v = t_{\text{max}} \times t = 30 \text{ s} \times 1 = 30 \text{ s}) \), or
- \( t_{\text{max}} = 300 \text{ s} \) and \( t = 0.1 \) \( (t_v = t_{\text{max}} \times t = 300 \text{ s} \times 0.1 = 30 \text{ s}) \).

Tune the delay for the emergency stop safety relay [A61] a little longer than the emergency stop deceleration time defined by drive parameters 23.23 and 46.01 (see section Parameter settings).
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

One emergency stop button and one reset button are installed on the cabinet door and wired to the drive at the factory. There are double contacts in the emergency stop button and double wiring (redundant two-channel connection) between the button and the emergency stop safety relay [A61]. The safety relay detects cross faults and faults across one contact from the emergency stop button.

If needed, install additional emergency stop buttons on site and wire them to the appropriate terminal block inside the drive cabinet. See the circuit diagrams delivered with the drive.

Obey these general rules:

1. Use only double-contact buttons approved for the emergency stop circuits.
2. Connect the emergency stop buttons with two conductors (two-channel connection).
   
   **Note:** Keep the channels separate. If you use only one channel, or if the first and second channels are connected together (for example, in a chain), the cross-fault detection of the emergency stop safety relay trips and activates the emergency stop command of the drive as it detects a redundancy fault.
3. Use shielded, twisted pair cables. We recommend a double-shielded cable and gold-plated contacts in the emergency stop button.
4. Make sure that the sum resistance for one channel (loop resistance) does not exceed 1 kohm.
5. Obey the general control cable installation instructions given in the drive hardware manual.
You can also install additional reset buttons and indication lamps for the emergency stop circuit on site. We recommend gold-plated contacts in the reset button. Wire the buttons to the appropriate terminal block inside the drive cabinet. See the circuit diagrams delivered with the drive. Obey the rules below:

1. Sum resistance of the external reset circuit may not exceed 1 kohm.
2. Obey the general control cable installation instructions given in the drive hardware manual.
Use of the safety function

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

Activating the safety function
1. Push the emergency stop button [S61]. The emergency stop is activated and the button locks in the “ON” (open) position.
   When the emergency stop is on, the following indications are shown:
   • the drive control program has the warning Safe torque off and warning Emergency stop (off1 or off3) active,
   • the emergency stop reset button indicator light [S62] on cabinet door is lit after the emergency stop deceleration ramp time has passed
   • the ON LED of the emergency stop safety relay [A61] is green and steady.

A5A0 Safe torque off is indicated when drive STO is activated.

Resetting the safety function
1. Turn the emergency stop button [S61] until it releases.
2. Push the emergency stop reset button [S62] on the cabinet door. The emergency stop reset button indicator light [S62] goes out, the emergency stop is deactivated.
   Note: You must push the reset button [S62] for 0.1 - 3 seconds.
3. Reset the drive if necessary.
4. Make sure that the drive has received the start signal (depends on the configuration, see the firmware manual).
5. You can now restart the drive.
24 Use of the safety function

**Note:** You have to reset the emergency stop circuit with the reset button [S62] also after you have powered up the drive.
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 or a control panel to perform the start-up and acceptance test.

<table>
<thead>
<tr>
<th>Action</th>
<th>Initial status</th>
<th>Checks and settings with no voltage connected</th>
<th>Settings with voltage connected</th>
<th>Acceptance test</th>
</tr>
</thead>
<tbody>
<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>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>WARNING! Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Stop the drive and do the steps in section Electrical safety precautions (page 8) before you start the work.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>If you have done any connections for the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the appropriate circuit diagrams.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Inverter units with parallel R8i inverter modules: Check that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Check that the hardware settings relevant to the safety function are set as defined in section Hardware settings.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Close the cabinet doors and power up the drive. See the hardware manual.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Check the parameters that are relevant to the safety function. If necessary, set the parameters as defined in section Parameter settings.</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
</tbody>
</table>
## Action

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)
- *When using an encoder, also: 90.10 Encoder 1 speed (rpm)*

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

Start the drive and make sure that the motor is running. If possible, use a motor speed close to the maximum speed of the application.

Push the emergency stop button [S61].

Make sure that the drive stops the motor by decelerating and the control panel displays a related warning. See sections Operation principle and Activating the safety function.

Make sure that the emergency stop reset button indicator light [S62] switches on.

Make sure that "STO hardware failure" (5090) is not generated. If the failure occurs, see section Fault tracing.

Make sure that you cannot start the drive and motor from any control location: make sure that the motor does not start even if you switch the start signal off and on or push the start key of the panel.

Turn the emergency stop button [S61] until it releases and returns to the up position.

Reset the emergency stop circuit by pushing the emergency stop reset button [S62].

Make sure that the emergency stop reset button indicator light [S62] switches off.

Switch off the drive start signal. If the drive generates a fault message, reset the drive.

Power up the drive (see the hardware manual).

Restart the drive and ensure that the drive and the motor operate normally.

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

Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted for operation.
Fault tracing

Contents of this chapter
This chapter provides general diagnostics and troubleshooting tips.

Fault tracing
This table describes the status LEDs of the emergency stop safety relay [A61].

<table>
<thead>
<tr>
<th>LED</th>
<th>Color</th>
<th>LED is lit and steady</th>
<th>LED is lit and flashing</th>
<th>LED is not lit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>Green</td>
<td>Power supply is connected.</td>
<td>-</td>
<td>Power supply is not connected.</td>
</tr>
<tr>
<td>ERR</td>
<td>Red</td>
<td>System error. Replace the unit if the error is not removed after re-start.</td>
<td>During external errors. See the figure below for details.</td>
<td>-</td>
</tr>
<tr>
<td>K1/K2</td>
<td>Green</td>
<td>Relays K1 and K2 are energized (instantaneous contact).</td>
<td>During external errors.</td>
<td>-</td>
</tr>
<tr>
<td>K3/K4</td>
<td>Green</td>
<td>Relays K3 and K4 are energized (delayed contacts).</td>
<td>During the time delay.</td>
<td>-</td>
</tr>
</tbody>
</table>

This figure describes the ERR LED indications in fault situations.
To reset the emergency stop safety relay [A61] after fault situations, switch off the external power supply of the safety relay. If the emergency stop safety relay cannot be reset, check the reset circuit connections.

If STO hardware failure (5090) is generated, check STO wiring against the circuit diagrams. See drive hardware manual for more information.

This table describes the status LEDs of the extension safety relay [A62].

<table>
<thead>
<tr>
<th>LED</th>
<th>LED is lit and steady</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>Power supply is connected. Relay K1 is energized.</td>
</tr>
<tr>
<td>K2</td>
<td>Power supply is connected. Relay K2 is energized.</td>
</tr>
</tbody>
</table>

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

**Reporting problems and failures related to safety functions**

Contact ABB.
Maintenance

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 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, safety relays, contactor relays, emergency stop buttons, switches, etc. are typically safety devices which contain electromechanical outputs. The STO circuit of the drive does not contain any electromechanical components.

**Competence**

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

**Residual risk**

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

**Intentional misuse**

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

**Decommissioning**

When you decommission an emergency stop circuit or a drive, make sure that the 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 data values

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

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

<table>
<thead>
<tr>
<th>Drive module frame size</th>
<th>SIL / SILCL</th>
<th>SC</th>
<th>PL</th>
<th>PFH(^1) ([1/h])</th>
<th>PFD(_{av}) (T(_1)=2a)</th>
<th>PFD(_{av}) (T(_1)=5a)</th>
<th>DC(^2) [%]</th>
<th>Cat.</th>
<th>HFT</th>
<th>CCF</th>
<th>Mission time ([a])</th>
<th>(T_1^{3,4} ) ([a])</th>
</tr>
</thead>
<tbody>
<tr>
<td>R6, R7</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.7E-08</td>
<td>3.8E-04</td>
<td>4.2E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>R8, R9</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.7E-08</td>
<td>3.8E-04</td>
<td>4.2E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>R10, R11</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.7E-08</td>
<td>3.9E-04</td>
<td>4.4E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>1×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>2×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>3×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>4×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
</tbody>
</table>
### Technical data

<table>
<thead>
<tr>
<th>Drive module frame size</th>
<th>SIL / SIL CL</th>
<th>SC</th>
<th>PL</th>
<th>PFH 1) [1/h]</th>
<th>PFD(_{avg}) (T(_1)=2a)</th>
<th>PFD(_{avg}) (T(_1)=5a)</th>
<th>DC 2) [%]</th>
<th>Cat.</th>
<th>HFT</th>
<th>CCF</th>
<th>Mission time [a]</th>
<th>T(_1) 3) 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
<tr>
<td>6-8×R8i</td>
<td>3</td>
<td>3</td>
<td>e</td>
<td>4.4E-08</td>
<td>3.6E-04</td>
<td>3.6E-04</td>
<td>&gt;90</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>20/5/2</td>
</tr>
</tbody>
</table>

1) PFH values are according to EN ISO 13849.
2) DC for low demand mode is 90% (determined by the DC of the worst component in the subsystem).
3) See the Recommendation of Use CNB/M/11.050 published by the European co-ordination of notified bodies for lower T\(_1\) requirement.
4) T\(_1\) = 20a is used with high demand mode of operation. T\(_1\) = 2a/5a is used with low demand mode of operation. See also section Proof test interval.

#### Safety component types

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

#### Safety block diagrams

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

#### Relevant failure modes

Relevant failure modes are:
- internal failures of safety relays, STO and the emergency stop button. These failures are included in the PFH 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

Emergency stop total delay: emergency stop deceleration ramp time + 500 ms.
**Ambient conditions**

For the environmental limits for the safety functions and the drive, refer to the hardware manual of your drive.

- **ACS880-07 drives, frames R6 to R11**

The maximum ambient temperature for the drive with safety relays is 45 °C (113 °F). In the temperature range +40…45 °C (+104…113 °F), the rated output current must be derated by 2% for every added 1 °C (1.8 °F). The output current can be calculated by multiplying the current given in the rating table by the derating factor ($k$):

\[ k = \begin{cases} 1.00 & \text{for } T \leq 40°C \text{ (104°F)} \\ 0.80 & \text{for } T = 45°C \text{ (113°F)} \end{cases} \]

---

### 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>Safety of machinery – Electrical equipment of machines – Part 1: General requirements</td>
</tr>
<tr>
<td>IEC 61326-3-1:2017</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>
<tr>
<td>EN 61800-5-2:2007</td>
<td>Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional</td>
</tr>
<tr>
<td>IEC 61800-5-2:2016</td>
<td>Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional</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.