OPTIONS FOR ABB DRIVES

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

User's manual

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

User's manual




3AUA0000119909 Rev J
EN
EFFECTIVE: 2020-09-30

# Table of contents

1

# Safety instructions

## Contents of this chapter

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

## Use of warnings and notes

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

The manual uses these warning symbols:

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

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

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

# Instructions for functional safety circuits

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

Only a qualified electrical professional who has sufficient knowledge about functional, machine, and process safety is permitted to install, start up and maintain the safety circuit. All user-made changes are on the user's responsibility.

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

**WARNING!**
(With permanent magnet or synchronous reluctance [SynRM] motors only)

In case of a multiple IGBT power semiconductor failure, the drive system can produce an alignment torque which maximally rotates the motor shaft by 180/*p* (with permanent magnet motors) or 180/2*p* (with synchronous reluctance [SynRM] motors) degrees regardless of the activation of the Safe torque off function. *p* denotes the number of pole pairs.

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

**WARNING!**
Make sure that the functional safety of the machine is maintained in situations where the safety option does not provide protection, for example, during commissioning, system maintenance, fault tracing, or decommissioning.

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

# Electrical safety precautions

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

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

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

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

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

2

# Introduction to the manual

## Contents of this chapter

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

## Applicability

This manual is applicable to ACS880-07/07LC/17/17LC/37/37LC drives which have the option: Emergency stop, stop category 1 with STO, with safety relays (option +Q964).

This manual shows the default design of the safety circuit ordered with option code +Q964. The actual design can be different from the default design because of customer-defined modifications. Always refer to the documentation delivered with the drive.

## Target audience

This manual is intended for people who install, commission, use and service the safety function. Read the manual before working on the unit. You are expected to know the fundamentals of electricity, wiring, electrical components, electrical schematic symbols, and functional safety.

## Exclusion of liability

ABB is not responsible for the implementation, verification and validation of the overall safety system. It is the responsibility of the system integrator (or other party) who is responsible for the overall system and system safety.

The system integrator (or other responsible party) must make sure that the entire implementation complies with the instructions in this manual, all relevant standards, directives and local electrical code, and that the system is tested, verified and validated correctly.

# Quick reference guide for taking a safety function into use

| Task | ☑ |
|---|---|
| Connect the user-defined wiring (if any). See the wiring instructions in this manual and the circuit diagrams delivered with the drive. | ☐ |
| Check and/or set the safety function related parameters (as listed in this manual). | ☐ |
| Do the validation test to make sure that the implemented system meets the safety requirements. You can find the instructions for the validation test in this manual. | ☐ |
| Document the validation test procedure. You can find the guidelines for the validation test report in this manual. | ☐ |

# Terms and abbreviations

| Term | Description |
|---|---|
| Cat. | Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. The categories are: B, 1, 2, 3 and 4. (EN ISO 13849-1) |
| CCF | Common cause failure (%) (EN ISO 13849-1) |
| D8T | Frame size designation of the diode supply module |
| DC | Diagnostic coverage (EN ISO 13849-1) |
| DI | Digital input |
| DIIL | Digital input interlock |
| E-stop | Emergency stop |
| FIO-01 | Optional digital I/O extension module |
| Frame, frame size | Physical size of the drive or power module |
| HFT | Hardware fault tolerance (IEC 61508) |
| IGBT | Insulated gate bipolar transistor |
| $PFD_{avg}$ | Average probability of dangerous failure on demand (IEC 61508) |
| PFH | Average frequency of dangerous failures per hour (IEC 61508) |
| PL | Performance level. Levels a...e correspond to SIL (EN ISO 13849-1) |
| RO | Relay output |
| SC | Systematic capability (IEC 61508) |
| SIL | Safety integrity level (1...3) (IEC 61508) |
| SILCL | Maximum SIL (level 1...3) that can be claimed for a safety function or subsystem (IEC/EN 62061) |
| SS1 | Safe stop 1 (IEC/EN 61800-5-2) |
| STO | Safe torque off (IEC/EN 61800-5-2) |
| Stop category | There are three categories of stop functions defined by IEC/EN 60204-1:<br>• stop category 0: an uncontrolled stop where power to the machine actuators is removed immediately (for example, STO)<br>• stop category 1: a controlled stop where the machine actuators have power for stopping, after which the power is removed (SS1)<br>• stop category 2: a controlled stop where the machine actuators continue to have power (SS2). |
| $T_1$ | Proof test interval. Defines the probabilistic failure rate (PFH or $PFD_{avg}$) for the safety function or subsystem. Performing a proof test at a maximum interval of $T_1$ is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. Note that any $T_1$ values given cannot be regarded as a guarantee or warranty. |

3

# Option description

## Contents of this chapter

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

## Overview

Option +Q964 corresponds to a controlled stop in accordance with stop category 1 (IEC/EN 60204-1) and to the Safe Stop 1 time controlled function (SS1-t). When the user gives the emergency stop command, the drive decelerates the motor to zero speed according to a user-defined ramp time. Then, the Safe torque off (STO) function is activated, which prevents the drive from generating the torque required to rotate the motor. The main contactor/breaker of the drive is not opened.

For 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 drive 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 ACS880-07/07LC/17/17LC/37/37LC drives* (3AUA0000119910 [English]).

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

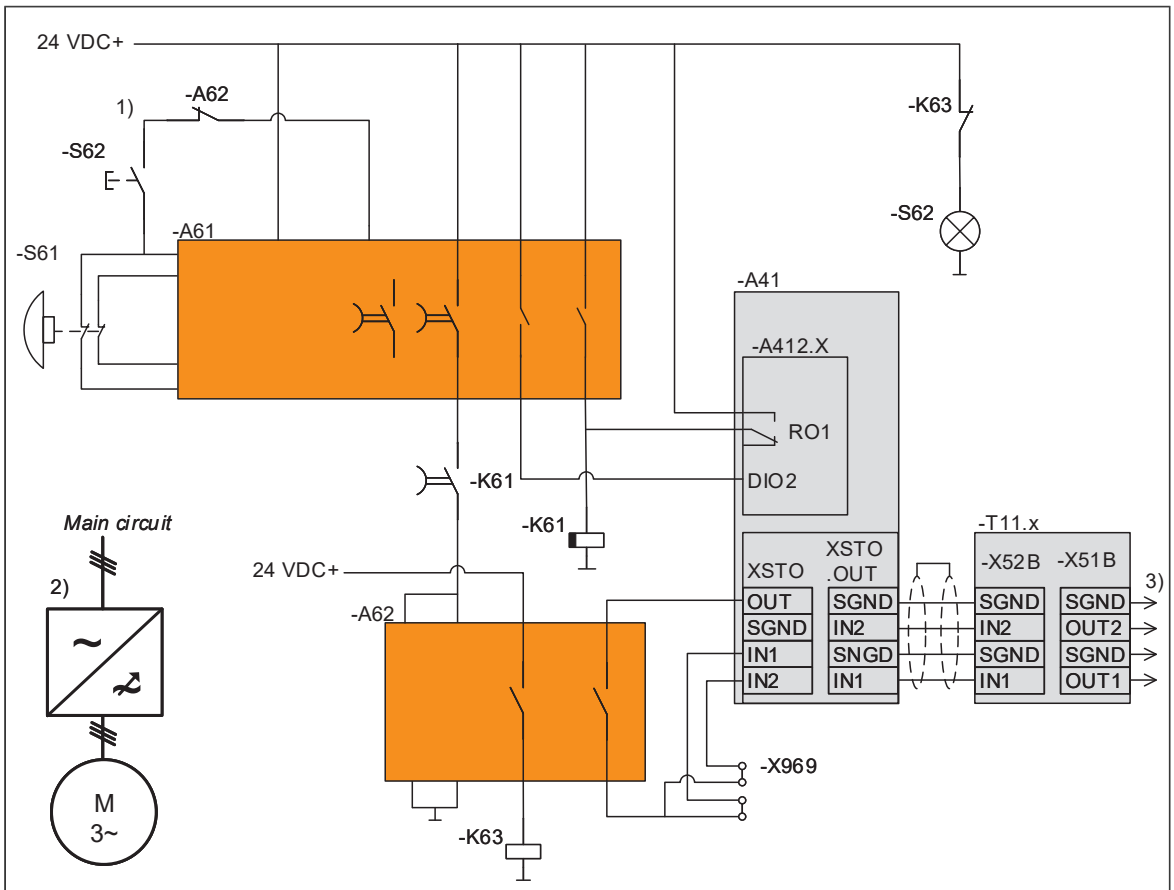
The SS1 and STO functions comply with IEC/EN 61800-5-2.

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 (page 33)*.

# Operation principle

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




| | |
|---|---|
| A41 | Inverter control unit |
| A61 | Emergency stop safety relay with delay contacts |
| A62 | Extension safety relay |
| A412.X | Digital I/O extension module |
| S61 | Emergency stop button |
| S62 | Emergency stop reset button with indicator light |
| K61 | Timer relay |
| K63 | Safety relay |
| X969 | STO terminal block |
| T11.x | Inverter module(s) under inverter unit T11 (only for R8i) |
| 1) | Reset circuit |
| 2) | Drive module |
| 3) | To parallel R8i modules (if any) |

| 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] de-energizes the digital input on the digital I/O extension module [A412.X] of the drive. This gives the emergency stop command to the drive.<br>The emergency stop safety relay [A61] de-energizes the timer relay [K61].<br>The break delay counter of the emergency stop safety relay [A61] starts (user-adjustable delay).<br>The break delay counter of the timer relay [K61] starts (non-user-adjustable delay). |
| 3 | The drive acknowledges the reception of the emergency stop command by energizing the relay output (RO1) of the digital I/O extension module [A412.X].<br>The relay output of the extension module [A412.X] energizes the timer relay [K61], resetting its break delay counter. The relay keeps its delayed break contact closed.<br>**Note:** If the drive does not acknowledge the reception of the emergency stop command in 2 seconds, the drive STO function is activated. |
| 4 | The drive decelerates the motor to zero speed in emergency stop deceleration time (user-defined drive parameter). |
| 5 | The break delay counter of the emergency stop safety relay [A61] trips and the delay contact de-energizes the extension safety relay [A62].<br>The extension safety relay [A62] de-energizes XSTO inputs IN1 and IN2 of the inverter control unit [A41], which activates the drive STO function.<br>The extension safety relay [A62] de-energizes safety relay [K63]. |
| 6 | The contact of the safety relay [K63] energizes the emergency stop reset button indicator light [S62]. |
| 7 | Normal operation resumes after the user:<br>• releases the emergency stop button [S61] to normal (up) position<br>• pushes the emergency stop reset button [S62] for 0.1 … 3 seconds to reset the emergency stop circuit<br>• resets the drive (if the drive tripped on a fault)<br>• makes sure that the drive has received the start signal (depends on the configuration, see the firmware manual). |

# Fault reaction function

**Definition:** A safety function requires a “fault reaction function” that tries to initiate a safe state if it detects a failure in the safety system.

The fault reaction function of the emergency stop safety relay trips the system, if it detects a failure in the safety circuit (for example, short circuit between signals, open circuit, or redundancy fault).

If a fault is detected, the fault reaction function:

- activates the emergency stop command
- activates the drive STO function
- keeps the safe state activated and the emergency stop reset button indicator light on until the fault is repaired and the safety function is 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 (page 27)*.

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

# Hardware settings

The time delay on the emergency stop safety relay [A61] is adjustable. Set the delay according to the application requirements. Make sure that the delay is slightly longer than the emergency stop deceleration time defined by drive parameters *23.23 Emergency stop time*, and *46.01 Speed scaling* or *46.02 Frequency scaling*. See chapter *Parameter settings (page 19)*.

Use the rotary switches on the relay to set the time delay. Refer to the table that follows:

| Switch | Value | Description |
|---|---|---|
| $t_{Fkt}$ | 1 | Selects the delay mode. Must be 1. |
| $t_{max}$ | User-defined | Selects the time range (in seconds) for the delayed contacts.<br>Value range: 1 … 300 s. |
| t | User-defined | Adjusts the time within the selected range in 10% steps.<br>Value range: 0.1…1. |

**Example:** If the required time ($t_v$) is 30 s, set:

- $t_{max}$ = 30 s and t = 1 ($t_v = t_{max} \cdot t = 30\ s \cdot 1 = 30\ s$), or
- $t_{max}$ = 300 s and t = 0.1 ($t_v = t_{max} \cdot t = 300\ s \cdot 0.1 = 30\ s$).

4

# Electrical installation

## Contents of this chapter

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

## Wiring

One emergency stop button and one reset button are installed on the cabinet door and wired to the 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 necessary, install additional emergency stop buttons on site and connect them to the applicable terminal block inside the drive cabinet. Refer to the circuit diagrams delivered with the drive. Obey these general rules:

1. Use only double-contact buttons approved for emergency stop circuits.
2. Connect the emergency stop buttons with two conductors (two-channel connection). Keep the channels separate.

   **Note:** If you use only one channel in a two-channel implementation, or if the channels are connected together, the cross fault detection of the emergency stop relay detects a redundancy fault and activates the fault reaction function.

   **Note:** The safety circuit design can be different when modified according to the customer's safety requirements. Refer to the circuit diagrams delivered with the drive.
3. Use shielded, twisted pair cables. ABB recommends double-shielded cable and gold-plated contacts in the emergency stop button.

4. Make sure that the sum resistance for one channel (loop resistance) is not more than 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. ABB recommends gold-plated contacts in the reset button. Connect the buttons to the applicable terminal block inside the drive cabinet. Refer to the circuit diagrams delivered with the drive. Obey the rules below:

1. Sum resistance of the external reset circuit must not be more than 1 kohm.
2. Obey the general control cable installation instructions given in the drive hardware manual.

5

# Parameter settings

## Contents of this chapter

This chapter contains the parameter settings related to the safety function.

## Drive parameter settings

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

The table that follows shows the parameters that are set at the factory.

| No. | Name | Default value [1)] | Description |
|---|---|---|---|
| 14.01 | Module 1 type | FIO-01 | Activates (and specifies the type of) I/O extension module 1. |
| 14.02 | Module 1 location | Slot 1 | Specifies the slot (1…3) on the control unit of the drive into which the I/O extension module is installed. |
| 14.09 | DIO 1 function | Input | Selects whether DIO1 of the extension module is used as a digital input or output. |
| 14.14 | DIO 2 function | Input | Selects whether DIO2 of the extension module is used as a digital input or output. |
| 14.34 | RO1 source | P.14.5.1- | 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). |
| 21.04 | Emergency stop mode | Eme ramp stop (Off3) | Selects the way the motor is stopped when an emergency stop command is received. |
| 21.05 | Emergency stop source | P.14.5.1 | Selects the source of the emergency stop signal. In this case, the source is DIO2 of the FIO module. |
| 31.03 | External event 2 source | P.14.5.0 | Selects the source of external event 1. In this case, the source is DIO1 of the FIO module. |
| 31.04 | External event 2 type | Warning/Fault | Selects the type of external event 2. |

| No. | Name | Default value [1)] | Description |
|---|---|---|---|
| 31.22 | STO indication run/stop | Warning/Warning | Selects which indications are given when one or both Safe torque off (STO) signals are switched off or lost. *Warning/Warning* is the recommended setting. |

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

The table that follows shows the parameters that you must set according to application requirements. Make sure that the selected values agree with the time delay settings of the emergency stop safety relay. See section *Hardware settings (page 16)*.

| No. | Name | Value | Description |
|---|---|---|---|
| 23.23 | Emergency stop time | User-defined | In speed control mode, this parameter defines the deceleration rate for emergency stop Off3 as the time it would take for the speed to decrease from the value of parameter *46.01 Speed scaling* to zero. This also applies to torque control because the drive switches to speed control on receiving an emergency stop Off3 command. In frequency control mode, this parameter specifies the time it would take for the frequency to decrease from the value of *46.02 Frequency scaling* to zero. |
| 46.01 | Speed scaling | User-defined | Selects the maximum speed value used to define the initial speed value that defines the deceleration ramp rate. Set this parameter if you use the speed control mode or torque control mode. |
| 46.02 | Frequency scaling | User-defined | Selects the maximum frequency value used to define the initial frequency value that defines the deceleration ramp rate. Set this parameter if you use the frequency control mode. |

# Additional parameter settings for ACS880-07/07LC drives, frames n×DXT + n×R8i and ACS880-17/17LC/37/37LC drives, frames n×R8i + n×R8i

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

The parameters are set at the factory. 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.

6

# Use of the safety function

## Contents of this chapter

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

## Activating the safety function

Activation procedure:

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

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

# Resetting the safety function

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

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

You must also reset the emergency stop safety relay [A61] with the emergency stop reset button [S62] each time after you energize the relay.

7

# Start-up and validation test

## Contents of this chapter

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

## Validation of the safety functions

You must do a validation test to validate the correct operation of safety functions.

### Competence

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

### Validation procedure

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

- at the initial start-up of the safety function
- after changes related to the safety function (wiring, components, safety function -related parameter settings, etc.)
- after maintenance work related to the safety function.

The validation test must include at least the following steps:

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

### Validation test reports

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

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

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

## Start-up and validation test

You must use the Drive composer PC tool or a control panel to do the start-up and validation test.

| **Action** | ☑ |
|---|---|
| **WARNING!**<br>Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur. | ☐ |
| **Initial status** | |
| Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. See the hardware manual. | ☐ |
| Make sure that the STO function is configured and validated. | ☐ |
| **Checks and settings with no voltage connected** | |
| Stop the drive and do the steps in section *Electrical safety precautions (page 9)* before you start the work. | ☐ |
| If you have done any connections for the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the applicable circuit diagrams. | ☐ |
| Inverter units with parallel R8i inverter modules:<br>Make sure that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules. | ☐ |
| Make sure that the hardware settings of the safety function are set as defined in section *Hardware settings (page 16)*. | ☐ |
| **Settings with voltage connected** | |
| Close the cabinet doors and power up the drive. See the hardware manual. | ☐ |
| Make sure that the parameter settings related to the safety functions are correct. See chapter *Parameter settings*. | ☐ |

| **Action** | ☑ |
|---|---|
| **Validation test** | |
| ABB recommends that you monitor these signals with the Drive composer PC tool:<br>• 01.01 Motor speed used (rpm)<br>• 01.02 Motor speed estimated (rpm)<br>• 01.07 Motor current (A)<br>• 01.10 Motor torque (%)<br>• 06.18 Start inhibit status word<br>• 23.01 Speed ref ramp input (rpm)<br>• 23.02 Speed ref ramp output (rpm)<br>• 90.01 Motor speed for control (rpm)<br>• 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. | ☐ |
| Make sure that the emergency stop reset button indicator light [S62] comes on. | ☐ |
| Make sure that the drive generates none of these faults:<br>• STO hardware failure (5090)<br>• Safe torque off 1 loss (FA81)<br>• Safe torque off 2 loss (FA82)<br>If the drive generates one or more of these faults, see section *Fault tracing (page 27)*. | ☐ |
| Make sure that you cannot start the drive or motor from any control location. Make sure that the drive or motor does not start when you switch the start signal off and on, or push the start key of the panel when the panel is in local control mode. | ☐ |
| Switch off the drive start signal. | ☐ |
| Turn the emergency stop button [S61] until it releases and returns to the up position. | ☐ |
| Push the emergency stop reset button [S62] to reset the emergency stop circuit. | ☐ |
| Make sure that the emergency stop reset button indicator light [S62] goes off. | ☐ |
| Power up the drive:<br>• If the drive tripped on a fault, reset the faults from the drive<br>• Make sure that the operating switch is set to ON (1)<br>• Switch on the drive start signal.<br>For more information, see the hardware manual. | ☐ |
| Restart the drive and make sure that the drive and the motor operate normally. | ☐ |
| Do the test again from each operating location (for every emergency stop button and reset button). | ☐ |
| Fill in and sign the validation test report. Store the report in the logbook of the machine. | ☐ |

8

# Fault tracing

## Contents of this chapter

This chapter provides general diagnostics and troubleshooting tips.

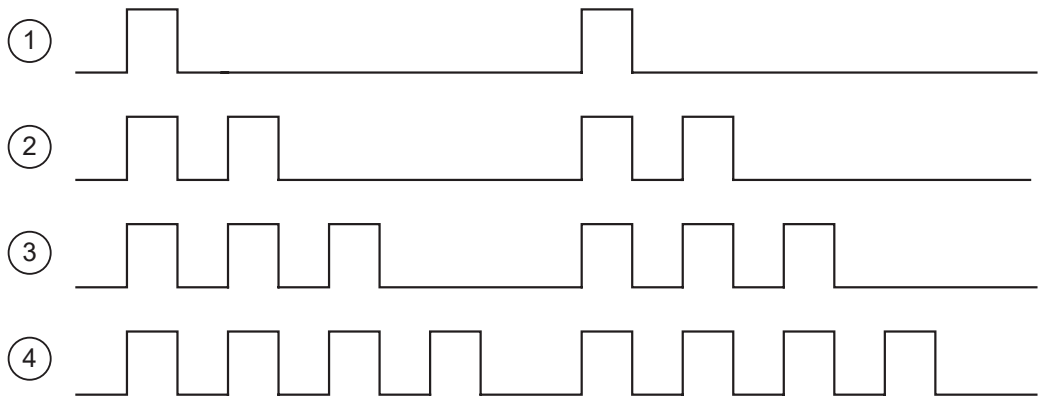
## Fault tracing

The emergency stop safety relay [A61] type is DOLD UG 6960.

This table gives the indications of the DOLD UG 6960 relay:

| LED | Color | LED is on | LED is flashing | LED is off |
|---|---|---|---|---|
| ON | Green | Power supply is connected. | - | Power supply is not connected. |
| ERR | Red | System error. Replace the unit if the error is not removed after restart. | When flashing in 1:1 relation: Power supply undervoltage or overvoltage.<br>When flashing in 4:1 relation: There is an external error. | - |
| K1/K2 | Green | Relays K1 and K2 are energized (instantaneous contact). | There is an external error. See the figure below for the indications of the LED. | - |
| K3/K4 | Green | Relays K3 and K4 are energized (delayed contacts). | During the time delay. | - |

If there are external errors, the K1/K2 LED shows an error code by flashing. This figure describes the K1/K2 LED indications.




| | |
|---|---|
| 1 | Potentiometer or adjustment failure |
| 2 | Line fault across start button |
| 3 | Cross fault or wiring fault |
| 4 | Simultaneity error |

For more information, see the data sheet of the relay (www.dold.com).

If there is a fault, the emergency stop safety relay [A61] can go into a fault mode. If this occurs, you must restart the relay. Switch off the external power supply of the relay and then switch it back on.

If you cannot reset the emergency stop function with the emergency stop reset button [S62], check the reset circuit connections. Refer to the circuit diagrams delivered with the drive.

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

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

Refer to the circuit diagrams delivered with the drive.

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

| **LED** | **LED is on** |
|---|---|
| K1 | Power supply is connected. Relay K1 energized. |
| K2 | Power supply is connected. Relay K2 energized. |

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

# Reporting problems and failures related to safety functions

Contact ABB.

9

# Maintenance

## Contents of this chapter

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

## Safety circuit maintenance

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

If you change the wiring or a component after the start-up, or restore parameters to their factory default values:

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

## Proof test interval

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

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

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

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

## Competence

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

## Residual risk

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

## Intentional misuse

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

## Decommissioning

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

10

# Technical data

## Contents of this chapter

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

## Safety data

### Safety data values

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

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

| Drive module frame size | SIL / SIL-CL | SC | PL | PFH [1/h] [1)] | $PFD_{avg}$ ($T_1$=2a) | $PFD_{avg}$ ($T_1$=5a) | DC [%] [2)] | Cat. | HFT | CCF | Mission time [a] | T1 [a] [3) 4)] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R6, R7 | 3 | 3 | e | 4.7E-08 | 3.8E-04 | 4.2E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| R8, R9 | 3 | 3 | e | 4.7E-08 | 3.8E-04 | 4.2E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| R10, R11 | 3 | 3 | e | 4.7E-08 | 3.9E-04 | 4.4E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 1×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 2×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 3×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 4×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| 5×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |

| Drive module frame size | SIL / SIL-CL | SC | PL | PFH [1)] [1/h] | $PFD_{avg}$ ($T_1$=2a) | $PFD_{avg}$ ($T_1$=5a) | DC [2)] [%] | Cat. | HFT | CCF | Mission time [a] | T1 [3) 4)] [a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6…8×R8i | 3 | 3 | e | 4.4E-08 | 3.6E-04 | 3.6E-04 | ≥90 | 3 | 1 | 80 | 20 | 20/5/2 |
| | | | | | | | | | | | | 3AXD10000097591 J |

1) PFH values are according to EN ISO 13849.
2) DC for low demand mode is 90% (determined by the DC of the worst component in the subsystem).
3) See the Recommendation of Use CNB/M/11.050 published by the European coordination 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.

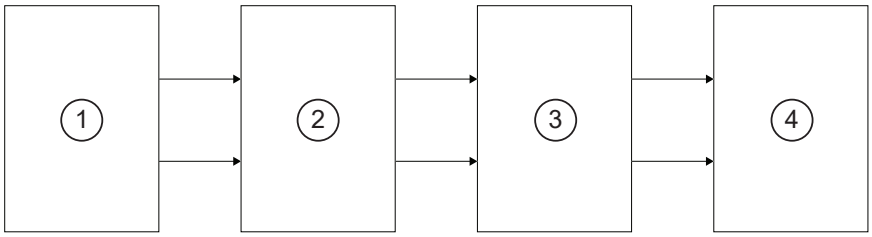
## Safety component types

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). The components not included in the delivery are not included in the safety data calculations.




| | |
|---|---|
| 1 | Emergency stop button |
| 2 | Emergency stop safety relay |
| 3 | Extension safety relay |
| 4 | Drive STO |

## 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):

- short and open circuits in the cables of the safety circuit
- short and open circuits in the cabinet terminal blocks of the safety circuits.

### Operation delays

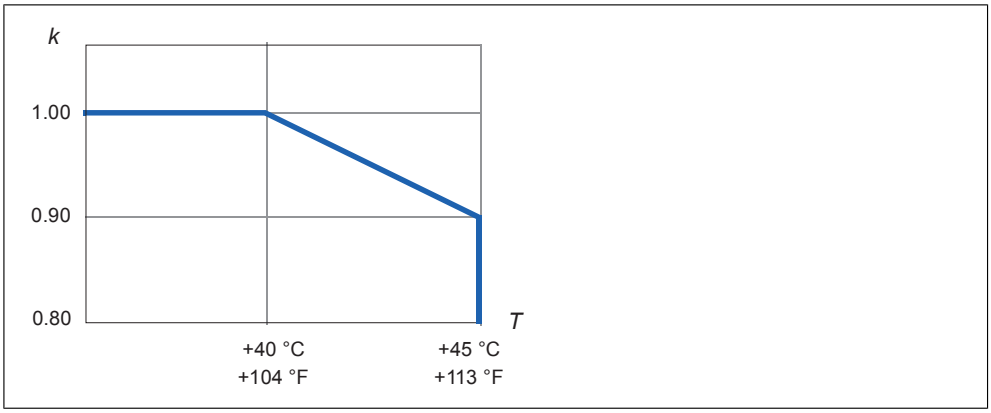
Emergency stop total delay: emergency stop deceleration ramp time + 500 ms.

## Ambient conditions

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

### ACS880-07 drives, frames R6…R11

The maximum surrounding air 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*):




## Related standards and directives

| Standard | Name |
|---|---|
| EN ISO 12100:2010 | Safety of machinery – General principles for design – Risk assessment and risk reduction |
| EN ISO 13849-1:2015 | Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design |
| EN ISO 13849-2:2012 | Safety of machinery – Safety-related parts of control systems – Part 2: Validation |
| EN ISO 13850:2015 | Safety of machinery. Emergency stop. Principles for design. |
| EN 60204-1:2018<br>IEC 60204-1:2016 | Safety of machinery – Electrical equipment of machines – Part 1: General requirements |
| IEC 61326-3-1:2017 | Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications |
| IEC 61508-1:2010 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements |
| IEC 61508-2:2010 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems |
| IEC 61511-1:2016 | Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements |

| Standard | Name |
|---|---|
| EN 61800-5-2:2007<br>IEC 61800-5-2:2016 | Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional |
| EN 62061:2005<br>+ AC:2010<br>+ A1:2013<br>+ A2:2015<br>IEC 62061:2015 Ed. 1.2 | Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems |
| 2006/42/EC | European Machinery Directive |
| Other | Machine-specific C-type standards |

# Compliance with the European Machinery Directive

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

# Further information

## Product and service inquiries

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

## Product training

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

## 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.

a2 (frozen)
PDF-A4
Created 2020-09-29, 15:07:21

**www.abb.com/drives**

3AUA0000119909J



3AUA0000119909 Rev J (EN) EFFECTIVE 2020-09-30