
OPTIONS FOR ABB DRIVES

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

User's manual



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

User's manual

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Safety instructions

Contents of this chapter

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

Safety messages

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

The manual uses these warning symbols:



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



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



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

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



Instructions for functional safety circuits

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



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

- Only a qualified electrical professional who has sufficient knowledge about functional, machine, and process safety is permitted to install, start up and maintain the safety circuit. All user-made changes are on the user's responsibility.
- The safety function described in this manual does isolate the main or auxiliary circuits from the power supply. Before you do work on the drive, or its main or auxiliary circuits, do the steps in section [Electrical safety precautions \(page 9\)](#).
- (With permanent magnet or synchronous reluctance [SynRM] motors only)
In case of a multiple IGBT power semiconductor failure, the drive system can produce an alignment torque which maximally rotates the motor shaft by $180/p$ (with permanent magnet motors) or $180/2p$ (with synchronous reluctance [SynRM] motors) degrees regardless of the activation of the Safe torque off function. p denotes the number of pole pairs.
- Do the validation test of the safety function at the start-up and also after you make changes to the safety circuit.
- Make sure that the functional safety of the machine is maintained in situations where the safety option does not provide protection, for example, during commissioning, system maintenance, fault tracing, or decommissioning.



Electrical safety precautions

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



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

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





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

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





Introduction to the manual

Contents of this chapter

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

Applicability

This manual is applicable to ACS880-07, -07LC, -17, -17LC, -37, and -37LC drives which have the option: 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	<input checked="" type="checkbox"/>
Connect the customer-defined wiring (if any). Refer to the wiring instructions in this manual and the circuit diagrams delivered with the drive.	<input type="checkbox"/>
Check and/or set the safety function related parameters (as listed in this manual).	<input type="checkbox"/>
Do the validation test to make sure that the implemented system meets the safety requirements. You can find the instructions for the validation test in this manual.	<input type="checkbox"/>
Document the validation test procedure. You can find the guidelines for the validation test report in this manual.	<input type="checkbox"/>

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, IEC 62061, IEC 61800-5-2)
SS1	Safe stop 1 (IEC/EN 61800-5-2)
STO	Safe torque off (IEC/EN 61800-5-2)

Term	Description
Stop category	<p>There are three categories of stop functions defined by IEC/EN 60204-1:</p> <ul style="list-style-type: none"> • stop category 0: an uncontrolled stop where power to the machine actuators is removed immediately (for example, STO) • stop category 1: a controlled stop where the machine actuators have power for stopping, after which the power is removed (SS1) • stop category 2: a controlled stop where the machine actuators continue to have power (SS2).
T_1	<p>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.</p>
T_M	<p>Mission time: the period of time covering the intended use of the safety function/device. After the mission time elapses, the safety device must be replaced. Note that any T_M values given cannot be regarded as a guarantee or warranty. (EN ISO 13849-1)</p>

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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, refer to the drive hardware manual.

Note: Drives with 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, and -37LC drives \(3AUA0000119910 \[English\]\)](#).

Note: ACS880-07 and -07LC drives with frame size nxDxT + n×R8i with main contactor/breaker (option +F250/+F255), ACS880-17, -17LC, -37, and -37LC drives with frame size n×R8i + n×R8i, and ACS880-17 and -37 drives with frame size R8, R11, R6i + R6i, or R7i + R7i: When the inverter unit STO is activated, the main contactor/breaker is opened after a user-defined delay (defined with parameter 94.11, the default value is 600 s). Refer to the hardware and firmware manuals for more information.

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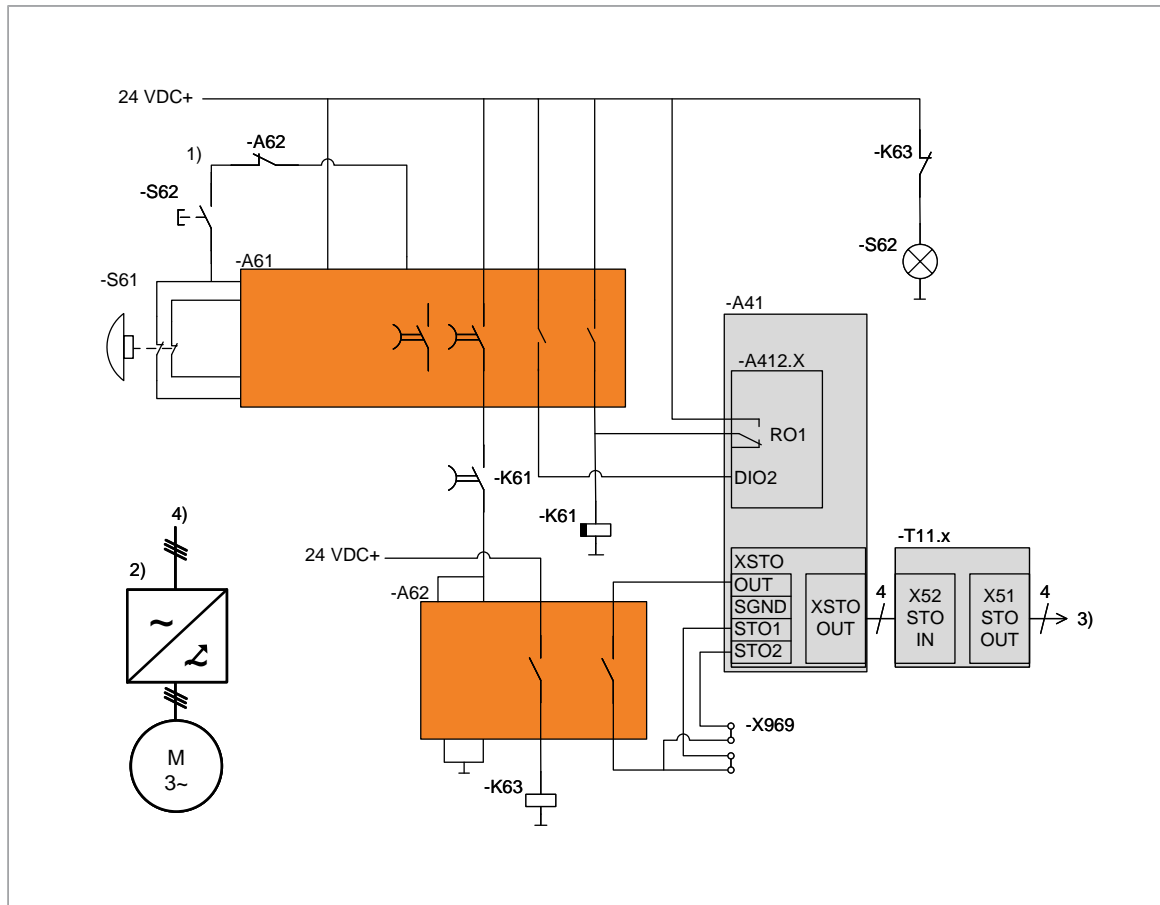
The SS1 and STO functions comply with IEC/EN 61800-5-2.

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

For a complete list of related standards and European directives, refer to section [Related standards and directives \(page 39\)](#).

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)
4)	Main circuit

Step	Operation
	Initial status: The drive is in operation and the motor is running.
1	The user activates emergency stop with the emergency stop button [S61].
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. The emergency stop safety relay [A61] de-energizes 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 reception of the emergency stop command by energizing the relay output (RO1) of the digital I/O extension module [A412.X]. 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. 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]. The extension safety relay [A62] de-energizes XSTO inputs STO1 and STO2 of the inverter control unit [A41], which activates the drive STO function. 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: <ul style="list-style-type: none"> • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62] for 0.1 ... 3 seconds to reset the emergency stop circuit • 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 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).

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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. Refer to section [Fault tracing \(page 29\)](#).

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

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Electrical installation

Contents of this chapter

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

Wiring



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

One emergency stop button and one reset button are installed on the cabinet door and connected to the drive at the factory. There are double contacts in the emergency stop button and double wiring (redundant two-channel connection) between the button and the 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 these rules:

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.

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 parameter 23.23 Emergency stop time. Refer to chapter [Parameter settings \(page 21\)](#).

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. Value range: 1 ... 300 s.
t	User-defined	Adjusts the time within the selected range in 10% steps. Value range: 0.1...1.

Multiply the values of t_{max} and t to get the time delay ($t_v = t_{max} \cdot t$). For example, if the required time is 30 s, you can set the switches as follows:

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



Parameter settings

Contents of this chapter

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

Drive parameter settings

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

No.	Name	Default value ¹⁾	Description
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.

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No.	Name	Default value ¹⁾	Description
31.22	STO indication run/stop	Warning/Warning	Selects which indications are given when the Safe torque off (STO) function is activated. Warning/Warning is the recommended setting.

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

The table that follows gives 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 \(page 20\)](#).

No.	Name	Value	Description
21.06	Zero speed limit	User-defined	Defines the zero speed limit. The motor is stopped along a speed ramp until this limit is reached. After the zero speed delay (parameter 21.07, default value 0 ms), the motor coasts to a stop.
23.23	Emergency stop time	User-defined	Defines the deceleration time for emergency stop Off3. The deceleration time is the time it takes to decelerate the motor from the maximum process speed defined by parameter 46.01 or 46.02 to the zero speed limit defined by parameter 21.06.
46.01	Speed scaling	User-defined	Defines the maximum motor speed used in the application. Set this parameter if you use the speed control mode or torque control mode.
46.02	Frequency scaling	User-defined	Defines the maximum motor frequency used in the application. Set this parameter if you use the frequency control mode.

Supply unit parameter settings

This section is applicable to:

- ACS880-07 and -07LC drives with frame size nxDxT + n×R8i
- ACS880-17 and -37 drives with frame size R6i + R6i or R7i + R7i
- ACS880-17, -17LC, -37, and -37LC drives with frame size n×R8i + n×R8i

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

No.	Name	Default value ¹⁾	Description
121.05	Emergency stop source	Inactive	Selects the source of the emergency stop signal. This parameter cannot be changed while the supply unit is running.

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

For more information, refer to the applicable firmware manual.

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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, these indications are shown:

- the drive control program has the indication Safe torque off 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.
-

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4. Make sure that the drive receives the start signal.
5. You can now restart the drive.

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

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

■ **Competence**

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

■ **Validation procedure**

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

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



The validation test must include at least the following steps:

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

■ **Validation test reports**

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


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

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

Start-up and validation test



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

Action	<input checked="" type="checkbox"/>
 ▲WARNING Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.	<input type="checkbox"/>
Initial status	
Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. Refer to the hardware manual.	<input type="checkbox"/>
Make sure that the STO function is configured and validated. Refer to the drive hardware manual.	<input type="checkbox"/>
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.	<input type="checkbox"/>
If you made connections to the emergency stop circuit on site (for example, added emergency stop buttons), do a check of the connections against the applicable circuit diagrams.	<input type="checkbox"/>
Make sure that the hardware settings of the safety function are set as defined in this manual.	<input type="checkbox"/>
Settings with voltage connected	
Close the cabinet doors and power up the drive. Refer to the hardware manual.	<input type="checkbox"/>
Make sure that the parameter settings related to the safety functions are correct. Refer to chapter Parameter settings .	<input type="checkbox"/>

Action	<input checked="" type="checkbox"/>
Validation test	
ABB recommends that you monitor at least these signals with the Drive Composer PC tool: <ul style="list-style-type: none"> • 01.01 Motor speed used (rpm) • 01.02 Motor speed estimated (rpm) • 01.07 Motor current (A) • 01.10 Motor torque (%) • 06.18 Start inhibit status word • 23.01 Speed ref ramp input (rpm) • 23.02 Speed ref ramp output (rpm) • 90.01 Motor speed for control (rpm) • <u>When using an encoder, also:</u> 90.10 Encoder 1 speed (rpm) 	<input type="checkbox"/>
Make sure that it is safe to start, run and stop the motor during the test.	<input type="checkbox"/>
Start the drive and make sure that the motor is running. If possible, use a motor speed close to the maximum speed of the application.	<input type="checkbox"/>
Push the emergency stop button [S61].	<input type="checkbox"/>
Make sure that the drive stops the motor by decelerating. Make sure that the correct warnings and indications are shown.	<input type="checkbox"/>
Make sure that the emergency stop reset button indicator light [S62] comes on.	<input type="checkbox"/>
Make sure that the STO function is activated.	<input type="checkbox"/>
Make sure that the correct indications for STO activation are shown (as defined by parameter 31.22).	<input type="checkbox"/>
Make sure that the drive generates none of these faults: <ul style="list-style-type: none"> • STO hardware failure (5090) • Safe torque off 1 loss (FA81) • Safe torque off 2 loss (FA82) If the drive generates these faults, refer to the fault tracing instructions in this manual.	<input type="checkbox"/>
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.	<input type="checkbox"/>
Switch off the drive start signal.	<input type="checkbox"/>
Turn the emergency stop button [S61] until it releases and returns to the up position.	<input type="checkbox"/>
Push the emergency stop reset button [S62] to reset the emergency stop circuit. Make sure that the emergency stop reset button indicator light goes off.	<input type="checkbox"/>
Power up the drive: <ul style="list-style-type: none"> • If the drive tripped on a fault, reset the faults from the drive • Make sure that the operating switch is set to ON (1) • Switch on the drive start signal. For more information, see the hardware manual.	<input type="checkbox"/>
Restart the drive and motor. Make sure that they operate normally.	<input type="checkbox"/>
Do the test again from each operating location (for each emergency stop button and reset button).	<input type="checkbox"/>
Create a backup file of the drive parameters with the Drive Composer PC tool or control panel.	<input type="checkbox"/>
Fill in and sign the validation test report. Store the report in the logbook of the machine.	<input type="checkbox"/>





Fault tracing

Contents of this chapter

This chapter provides general diagnostics and troubleshooting tips.

Fault tracing

- **Emergency stop safety relay**

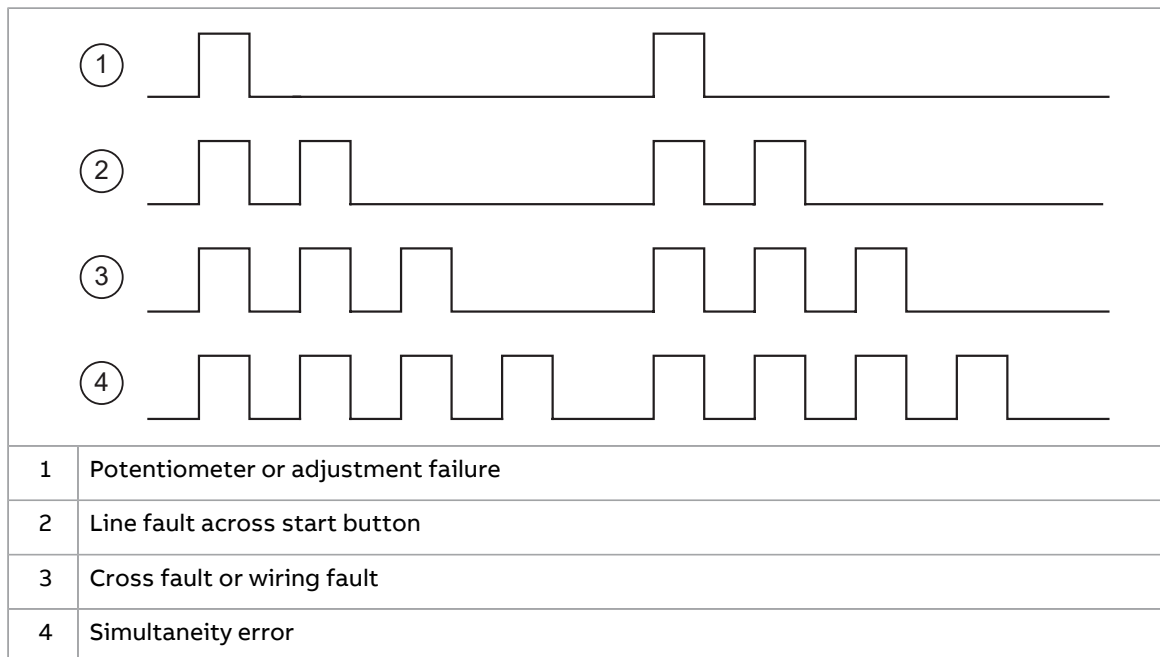
The emergency stop safety relay [A61] type is DOLD UG 6960.

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. 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.	-

30 Fault tracing

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



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], examine the reset circuit connections. Refer to the circuit diagrams delivered with the drive.

■ Extension safety relay

This table gives information on 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.

■ STO circuit connections

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

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

Refer to the circuit diagrams delivered with the drive.

Stop the drive and do the steps in section [Electrical safety precautions \(page 9\)](#) before you start the work.

■ **Other**

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

Reporting problems and failures related to safety functions

Contact ABB.

A large, bold, black number '9' is centered within a light grey square with rounded corners.

Maintenance

Contents of this chapter

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

Safety circuit maintenance

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

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

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

Proof test interval

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

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

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

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

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

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

Functional safety components

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

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

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

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

Contact your local ABB service representative for more information.

Competence

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

Residual risk

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

Intentional misuse

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

Decommissioning

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

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Technical data

Contents of this chapter

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

Safety data

■ Safety data values

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

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

Frame size	SIL	SC	PL	PFH ¹⁾ [1/h]	PFD _{avg} (T ₁ =2a)	PFD _{avg} (T ₁ =5a)	DC ²⁾ [%]	Cat.	HFT	CCF	T _M [a]	T ₁ ^{3) 4)} [a]
R6...R8	3	3	e	4.7E-08	2.9E-04	3.3E-04	≥90	3	1	80	20	20/5/2
R9	3	3	e	4.7E-08	2.9E-04	3.4E-04	≥90	3	1	80	20	20/5/2
R10...R11	3	3	e	4.7E-08	2.9E-04	3.4E-04	≥90	3	1	80	20	20/5/2
R6i...R7i	3	3	e	4.7E-08	2.9E-04	3.4E-04	≥90	3	1	80	20	20/5/2
1×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
2×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
3×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
4×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
5×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
6×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2

Frame size	SIL	SC	PL	PFH ¹⁾ [1/h]	PFD _{avg} (T ₁ =2a)	PFD _{avg} (T ₁ =5a)	DC ²⁾ [%]	Cat.	HFT	CCF	T _M [a]	T ₁ ^{3) 4)} [a]
7×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
8×R8i	3	3	e	4.4E-08	2.6E-04	2.7E-04	≥90	3	1	80	20	20/5/2
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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 T₁ requirement.

4) T₁ = 20a is used with high demand mode of operation. T₁ = 2a/5a is used with low demand mode of operation.

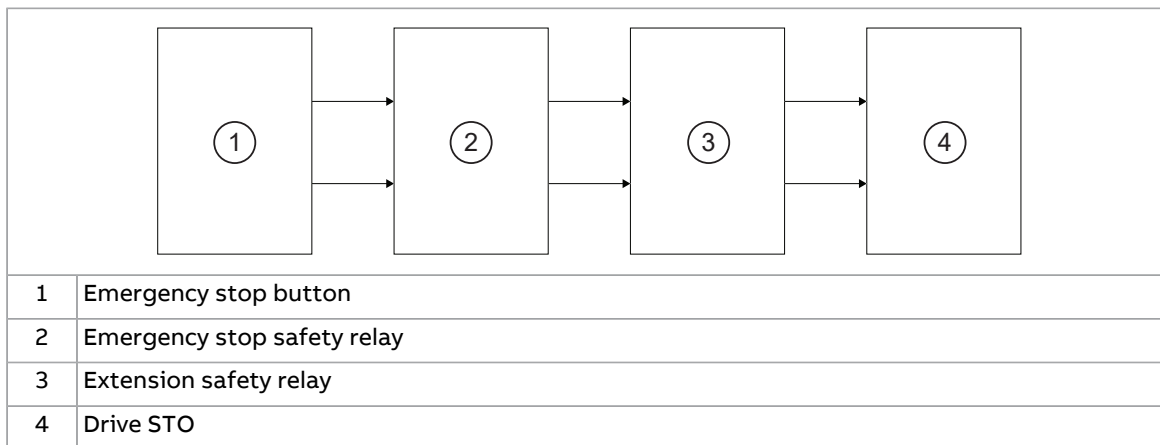
■ Safety component types

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

■ Safety block diagrams

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



■ Relevant failure modes

Relevant failure modes are:

- internal failures of safety relays, STO and the emergency stop button. These failures are included in the failure rate 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**

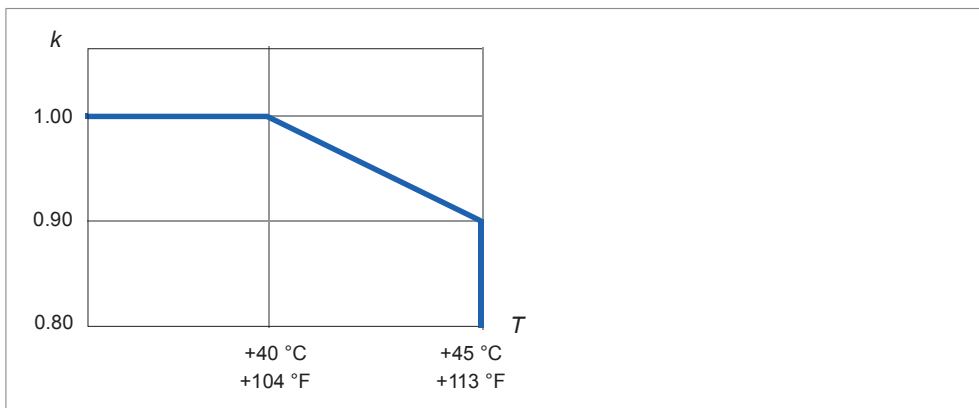
Emergency stop total delay: emergency stop deceleration ramp time + 500 ms.

Ambient conditions

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

■ **ACS880-07 drives with frame size 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
IEC 61800-5-2:2016 EN 61800-5-2:2007	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements – Functional
IEC 62061:2021 + AMD1:2024 EN IEC 62061:2021	Safety of machinery – Functional safety of safety-related control systems
EN ISO 13849-1:2023	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems - Part 2: Validation
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronics safety related systems – Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronics safety related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61511-1:2016 + AMD1:2017	Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements

Standard	Name
IEC 61000-6-7:2014	Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
IEC 61326-3-1:2017	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications
EN ISO 13850:2015	Safety of machinery – Emergency stop – Principles for design
2006/42/EC	European Machinery Directive
	Supply of Machinery (Safety) Regulations 2008 (UK)
Other	Machine-specific C-type standards

Compliance with the European Machinery Directive

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



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

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

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



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

Further information

Product and service inquiries

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

Product training

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

Providing feedback on ABB manuals

Your comments on our manuals are welcome. Navigate to forms.abb.com/form-26567.

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