Options for ABB drives

User’s manual
Emergency stop, stop category 0 (option +Q963) for ACS880 multidrives
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<th>Code (English)</th>
</tr>
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<tbody>
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</tr>
<tr>
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<td>3AXD10000102417</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Code (English)</th>
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<td>Safety and functional safety; A general guide</td>
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</tr>
<tr>
<td>ABB Safety information and solutions</td>
<td><a href="http://www.abb.com/safety">www.abb.com/safety</a></td>
</tr>
</tbody>
</table>

You can find manuals and other product documents in PDF format on the Internet. See section [Document library on the Internet](#) on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.
User’s manual

Emergency stop, stop category 0 (option +Q963) for ACS880 multidrives
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Introduction to the manual

Contents of this chapter

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

Applicability

The manual applies to ACS880 multidrives which have the option: Emergency stop, stop category 0 with STO, with safety relays (option+Q963). In this emergency stop option, the main contactor/circuit breaker of the drive is not opened.

Safety instructions

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

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

WARNING! After you have made additions to the drive safety circuit or modified it, changed circuit boards inside the drive, always test the operation of the safety circuit according to its acceptance test procedure. The change can affect unexpectedly. All customer-made changes are on the customer's responsibility.
WARNING! The Safe torque off functionality is only achieved through the XSTO connector of the inverter control unit. True Safe torque off functionality is not achieved through the XSTO connectors of other control units (such as the supply control unit or the brake control unit). In the supply and brake units, the XSTO input must not be used for any safety function purposes to ensure personnel safety. The Safe torque off function is supported by any ACS880 inverter or drive firmware. It is not supported by supply or brake firmware.

WARNING! Read and obey all safety instructions given for the drive in ACS880 multidrive cabinets and modules safety instructions (3UA0000102301 [English]). If you ignore them, injury or death, or damage to the equipment can occur.

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

Target audience

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

Contents

The chapters of this manual are briefly described below.

Introduction to the manual (this chapter) introduces this manual.

Option description and instructions describes the safety option and instructs how to wire, start up, test, validate, use and maintain it.

Related documents

- Product manuals (see the inside of the front cover)
- Circuit diagrams delivered with the drive
- Part lists delivered with the drive
- Safety data report
Abbreviations

Abbreviations used in this manual are listed below.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat.</td>
<td>Category&lt;br&gt;1. Stop category according to EN/IEC 60204-1&lt;br&gt;2. 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.</td>
<td>EN/IEC 60204-1, EN ISO 13849-1</td>
</tr>
<tr>
<td>DI</td>
<td>Digital input</td>
<td>DI</td>
</tr>
<tr>
<td>DIIL</td>
<td>Digital input interlock</td>
<td>DIIL</td>
</tr>
<tr>
<td>E-stop</td>
<td>Emergency stop</td>
<td></td>
</tr>
<tr>
<td>HFT</td>
<td>Hardware fault tolerance</td>
<td>IEC 61508, EN/IEC 62061</td>
</tr>
<tr>
<td>IGBT</td>
<td>Insulated gate bipolar transistor</td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>Performance level (levels are: a, b, c, d and e). Corresponds to SIL.</td>
<td>EN ISO 13849-1</td>
</tr>
<tr>
<td>SIL</td>
<td>Safety integrity level</td>
<td>IEC 61508, IEC 61511, EN/IEC 62061, EN/IEC 61800-5-2</td>
</tr>
<tr>
<td>STO</td>
<td>Safe torque off</td>
<td>EN/IEC 61800-5-2</td>
</tr>
</tbody>
</table>

Exclusion of liability

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

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

Quick reference guide for implementing a safety system

| Task                                                                 | ☑   |
|                                                                     |     |
| Select the appropriate functional safety standard for the implementation: EN ISO 13849-1, EN/IEC 62061, IEC 61511 or other. |     |
| If you select EN/IEC 62061 or IEC 61511, make a safety plan. See EN/IEC 62061 or IEC 61511. |     |
| Assess safety: analyze and evaluate risks (estimate SIL/PL) and define risk reduction strategies. Define the safety requirements. |     |
| Design the safety system. The part of the design made by ABB is described in chapter **Option description and instructions** on page 11. |     |
| Verify the achieved SIL/PL with, for example, FSDT-01 Functional safety design tool or similar. See **Functional safety design tool user’s manual** (3AXD10000102417 [English]). |     |
| Connect the wiring. See section **Wiring** on page 15. |     |
| Set the parameters. See section **Parameter settings** on page 14. |     |
### Task

<table>
<thead>
<tr>
<th>Task</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Validate that the implemented system meets the safety requirements:</td>
<td>√</td>
</tr>
<tr>
<td>• Do the acceptance test. See section <em>Start-up and acceptance test</em> on page 16.</td>
<td></td>
</tr>
<tr>
<td>Write the necessary documentation.</td>
<td></td>
</tr>
</tbody>
</table>
Option description and instructions

Contents this chapter

This chapter describes the +Q963 emergency stop option and instructs how to wire, start up, test, validate, use and maintain it.

Description

The option +Q963 corresponds to an uncontrolled stop in accordance with stop category 0 (EN/IEC 60204-1). 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 inverter units from generating the torque required to rotate the motor(s). The motor(s) coasts to a stop. The main contactor/breaker of the drive is not opened.

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


The design principles of the option +Q963 comply with EN ISO13850.

For a complete list of related standards and European directives, see section Related standards and directives on page 22.
12 Option description and instructions

Operation principle

1) Emergency stop signal
2) To the next drive unit
3) STO signals to the inverter IGBTs
A41 Control board (inverter unit)
A51 Control board (supply unit)
A61 Emergency stop safety relay
A62 Emergency stop extension safety relay
F61 Protection switch
P61 Emergency stop indication (optional or user-defined)
S61 Emergency stop button (optional or user-defined)
S62 Emergency stop reset button
T11...TXX Inverter units
T61 24 V power supply
T62 24 V power supply for Safe torque off

The dash-dot line (---) in the figure indicates a user-defined installation.
Initial status: The drive is in operation and the motor is running.

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The user activates emergency stop by pushing the emergency stop button [S61].</td>
</tr>
</tbody>
</table>
| 2.   | The emergency stop safety relay [A61]:  
      • switches off digital input on the inverter control boards [A41] giving emergency stop command.  
      • switches off power for the extension safety relay [A62].  
      The extension safety relay [A62] switches off the Safe torque off (STO) control signals on the inverter control boards [A41]. |
| 3.   | The emergency stop safety relay [A61] energizes the indication lamp [P62] of the emergency stop reset button [S62]. |
| 4.   | The motors coast to zero speed and remain at zero speed while the emergency stop is active. |
| 5.   | Normal operation resumes after the user:  
      • releases the emergency stop button [S61] to normal (up) position  
      • resets the emergency stop safety relay [A61] with the emergency stop reset button [S62]  
      • resets the inverter units (if the STO indication parameter 31.22 has been set so that a fault is generated)  
      • makes sure that the inverter units have received the start signals (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 [A61] trips if it detects a failure (short circuit between signals, open circuits, redundancy fault when the emergency stop button is pushed) in the safety circuit. The fault reaction function shifts the drive immediately into safe state by activating the Safe torque off (STO) function, switching on the drive emergency stop command, and keeping it on until the detected fault has been repaired. The indication lamp of the reset button is on until the fault has been repaired.

The emergency stop reset circuit must be open when the user releases the emergency stop button. The emergency stop safety relay [A61] detects if the reset circuit is closed and the relay does not close.

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

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

The inverter unit parameter settings in ACS880 primary control program are:
- parameter 21.04 *Emergency stop mode* is set to value *Coast stop (Off2)*
- parameter 21.05 *Emergency stop source* is set to value *DI4* (delivery-specific, refer to the circuit diagrams)
- parameter 31.22 *STO indication run/stop* to value *Warning/Warning* (recommended).

The supply unit parameter settings in the ACS880 supply control programs are:
- parameter 121.04 *Emergency stop mode* is set to value *Warning*
- parameter 121.05 *Emergency stop source* is set to value *DIIL*.

For more information, see the firmware manuals.

Hardware settings

Appropriate hardware settings have been preset at the factory for the safety function.

The settings in the emergency stop safety relay [A61] are:
- cross fault detection is set to value *On*,
- manual reset to value *On*.

**Note:** If the cross fault detection is not *On*, it decreases the fault diagnostics of the wiring.

For more information, see the circuit diagrams delivered with the drive.
Wiring

If option +G331 has been selected 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 (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. This function must be used in a redundant manner, that is, the emergency stop button must be connected to both terminals with a separate contact.

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. Follow the rules below:

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 inverter unit as it detects a redundancy fault.

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

4. Ensure that the sum resistance for one channel (loop resistance) does not exceed 70 Ohm.

5. Follow 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. Follow the rules below:

1. Sum resistance of the external reset circuit may not exceed 70 Ohm.

2. Follow the general control cable installation instructions given in the drive hardware manual.
Start-up and acceptance test

You need the Drive composer PC tool or a control panel to perform the start-up and acceptance test.

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

### Action

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WARNING!</strong> Obey the <em>Safety instructions</em>, page 7. If you ignore them, injury or death, or damage to the equipment can occur.</td>
</tr>
</tbody>
</table>

### Checks and settings with no voltage connected

If any connections of emergency stop circuit have been done 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.

**Drives with R8i inverter modules:** Check that the STO OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules. The STO circuit is disabled in spare part modules.

Check that the hardware settings relevant to the safety function are set as defined in section *Hardware settings* on page 14.

### Settings with voltage connected

Check that the parameters relevant to the safety function are set as defined in section *Parameter settings* on page 14.

### Acceptance test

Ensure that the motors can be run and stopped freely during the test.

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

Start the inverter units and ensure that the motors are running. If possible, use a motor speed close to the maximum speed of the application.

Push the emergency stop button [S61].

Ensure that the inverter units stop the motors by coasting and display the related warning. See section *Emergency stop indications* on page 18.

Ensure that the emergency stop indication lamp [P62] switches on.

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

Ensure that you cannot start the inverter units and motors from any control location: Ensure 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.

Push the emergency stop reset button [S62]. Ensure that the emergency stop indication lamp [P62] switches off.
<table>
<thead>
<tr>
<th>Action</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch off the inverter unit start signals.</td>
<td>✓</td>
</tr>
<tr>
<td>If a fault message is generated, reset the inverter units.</td>
<td></td>
</tr>
<tr>
<td>See section Parameter settings on page 14.</td>
<td></td>
</tr>
<tr>
<td>Restart the inverter units and motors and check that they operate</td>
<td></td>
</tr>
<tr>
<td>normally.</td>
<td></td>
</tr>
<tr>
<td>Repeat the test from each operating location (every emergency stop</td>
<td></td>
</tr>
<tr>
<td>button and reset button).</td>
<td></td>
</tr>
<tr>
<td>Fill in and sign the acceptance test report which verifies that the</td>
<td></td>
</tr>
<tr>
<td>safety function is safe and accepted to operation.</td>
<td></td>
</tr>
</tbody>
</table>
Use of the safety function

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

Resetting
1. Turn the emergency stop button [S61] until it releases.
3. Reset the inverter units if necessary.
4. Make sure that the inverter units have received the external start signals (depends on the configuration, see the firmware manual).
5. You can now restart the inverter units.

Note: You have to reset the emergency stop circuit with the reset button [S62] also after you have powered up the drive.

Emergency stop indications

When the emergency stop is on:
• the inverter unit control program has the warning Safe torque off active and warning Emergency stop (off2),
• the emergency stop reset button [S62] on cabinet door is illuminated (indication lamp [P62]).

Fault tracing

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

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

To reset the emergency stop safety relay [A61] after fault situations, switch off the external power supply of the safety relay.

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 and relay K1 energized.</td>
</tr>
<tr>
<td>K2</td>
<td>Power supply is connected and relay K2 energized.</td>
</tr>
</tbody>
</table>

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

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

In addition to proof testing, it is a good practice to check the operation of the function when other maintenance routines of the machinery are carried out.

If you change any wiring or component after the start up, or restore parameters to their 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. Follow the rules given in section Start-up and acceptance test on page 16.
  • Document the tests and store the report into the logbook of the machine.

Proof test interval

After the operation of the safety function is validated at start-up, the safety function must be maintained by periodic proof testing. In high demand mode of operation, the maximum proof test interval is 20 years. In low demand mode of operation, the maximum proof test interval is 2 or 5 years (high or low demand as defined in IEC 61508, EN/IEC 62061 and EN ISO 13849-1). Regardless of the mode of operation, it is a good practice to check the operation of the safety function at least once a year. Do the test as described in section Start-up and acceptance test on page 16.

The person responsible for the design of the complete safety function should also note the Recommendation of Use CNB/M/11.050 published by the European co-ordination of Notified Bodies 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 inverter unit 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 adequate 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 an inverter unit, make sure that the safety of the machine is maintained until the decommissioning is complete.

Safety data

Safety data values

Each multidrives delivery is unique. If included in the customer order, ABB calculates the safety data for the safety function, and delivers the data separately to the customer.

Safety component types

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

Safety block diagram

Each multidrives delivery is unique. If included in the customer order, ABB defines the safety block diagram for each multidrives delivery, and delivers the diagram separately to the customer.

Relevant failure modes

Internal failures of safety relays, the emergency stop button and STO. 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: less than 250 ms
General rules, notes and definitions

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

**Validation procedure**
You must do the acceptance test using the checklist given in section *Start-up and acceptance test* on page 16:

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

The acceptance test must include at least the following steps:

- 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.

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

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

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

**Competence**
The acceptance test of the safety function must be carried out by a competent person with adequate 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.
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- **Ambient conditions**
  For the environmental limits for the safety functions and the drive, refer to the hardware manual.

- **Reporting problems and failures related to safety functions**
  Contact your local ABB representative.

### Related standards and directives

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN ISO 13849-1:2015</td>
<td>Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design</td>
</tr>
<tr>
<td>IEC 61511-1:2016</td>
<td>Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements</td>
</tr>
<tr>
<td>IEC 61326-3-1:2008</td>
<td>Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications</td>
</tr>
<tr>
<td>2006/42/EC</td>
<td>European Machinery Directive</td>
</tr>
<tr>
<td>Other</td>
<td>Machine-specific C-type standards</td>
</tr>
</tbody>
</table>

- **Compliance with the European Machinery Directive**
  The drive is an electronic product which is covered by the European Low Voltage Directive. However, the drive internal safety function of this manual (option +Q963) 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.

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