Options for ABB drives

User’s manual
Prevention of unexpected start-up (option +Q957) for ACS880 multidrives
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<td>Mechanical installation instructions for ACS880 multidrive cabinets</td>
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<td>ACS880-307 (+A003) diode supply units hardware manual</td>
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<td>ACS880-307 (+A018) diode supply units hardware manual</td>
<td>3AXD50000011408</td>
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<td>ACS880 diode supply control program firmware manual</td>
<td>3AUA0000103295</td>
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<td>ACS880 regenerative rectifier control program firmware manual</td>
<td>3AXD50000020827</td>
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<td>ACS880 primary control program firmware manual</td>
<td>3AUA0000085967</td>
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<td>ACS880 primary control program quick start-up guide</td>
<td>3AUA0000098062</td>
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<th>PC tool manuals</th>
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<tbody>
<tr>
<td>Start-up and maintenance PC tool Drive composer user’s manual</td>
<td>3AUA0000094606</td>
</tr>
<tr>
<td>Functional safety design tool user’s manual</td>
<td>3AXD10000102417</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Option manuals and guides</th>
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<tr>
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<td>3AUA0000085685</td>
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<td>Functional safety; Technical guide No. 10</td>
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<td>1SFC001008B0201</td>
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<td>ABB Safety information and solutions</td>
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</tr>
<tr>
<td>Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.</td>
<td></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

Prevention of unexpected start-up (option +Q957) 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: Prevention of unexpected start-up (option +Q957).

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. You must not work on the electrical parts of the drive or the motor before you have also disconnected the drive system from the electric supply and ensured by measuring that there is no dangerous voltage present.

WARNING! After making additions to the drive safety circuit or modifying it, or changing circuit boards inside the drive, always test the functioning of the safety circuit according to the acceptance test procedure. Any changes in the electrical installations of the drive may affect the safety performance or operation of the drive 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! (With permanent magnet or synchronous reluctance [SynRM] motors only) In case of a multiple IGBT power semiconductor failure, the inverter 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.

WARNING! Read and obey all safety instructions given for the drive in ACS880 multidrive cabinets and modules safety instructions (3AUA0000102301 [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 circuit 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 circuit 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 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. 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 ISO 13849-1</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>POUS</td>
<td>Prevention of unexpected start-up</td>
<td>EN 1037</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

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the appropriate functional safety standard for the implementation: EN ISO 13849-1, EN/IEC 62061, IEC 61511 or other.</td>
<td></td>
</tr>
<tr>
<td>If you select EN/IEC 62061 or IEC 61511, make a safety plan. See EN/IEC 62061 or IEC 61511.</td>
<td></td>
</tr>
<tr>
<td>Assess safety: analyze and evaluate risks (estimate SIL/PL) and define risk reduction strategies. Define the safety requirements.</td>
<td></td>
</tr>
<tr>
<td>Design the safety system. The part of the design made by ABB is described in chapter Option description and instructions on page 11.</td>
<td></td>
</tr>
<tr>
<td>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]).</td>
<td></td>
</tr>
<tr>
<td>Connect the wiring. See section Wiring on page 15.</td>
<td></td>
</tr>
<tr>
<td>Set the parameters. See section Parameter settings on page 14.</td>
<td></td>
</tr>
<tr>
<td>Validate that the implemented system meets the safety requirements:</td>
<td>• Do the acceptance test. See section Start-up and acceptance test on page 16.</td>
</tr>
<tr>
<td>Write the necessary documentation.</td>
<td></td>
</tr>
</tbody>
</table>
Introduction to the manual
Contents this chapter

This chapter describes the +Q957 Prevention of unexpected start-up option and instructs how to wire, start up, test, validate, use and maintain it.

Overview

The Prevention of unexpected start-up (POUS) function disables the control voltage of the power semiconductors of the drive (inverter) output stage. This prevents the drive from generating the torque required to rotate the motor. The POUS function activates the Safe torque off (STO) function of the drive. By using this function, short-time operations (like cleaning) and/or maintenance work on the non-electrical parts of the machinery can be performed without switching off and disconnecting the drive.

The user activates the Prevention of unexpected start-up function using a switch mounted on a control desk. When the switch is open (off), the POUS function is active and the POUS indicator lamp is on.

The customer is responsible for installing and connecting the operating switch and the indicator lamp on site. They are not included in the delivery. See the machine-specific C-type standards whether the indication lamp is required.

For a detailed description of the Safe torque off function, see the appropriate hardware manual.
Option description and instructions

**Note:** Drives with the Emergency stop, stop category 1 function (option +Q952 or +Q964):
If the user activates the POUS function during the emergency stop deceleration ramp, it overrides the emergency stop function. This activates the STO function of the drive immediately and the motor coasts to a stop. For more information on the emergency stop function, see the appropriate user’s manual.

The design principles of the option +Q957 comply with EN 1037.


For a complete list of related standards and European directives, see section *Related standards and directives* on page 23.
**Operation principle**

Initial status: The drive is in operation and the motor is **not** running.

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The user activates Prevention of unexpected start-up by switching off the POUS switch [Sxx].</td>
</tr>
<tr>
<td>2.</td>
<td>The POUS safety relay [A65] de-energizes the XSTO inputs IN1 and IN2 of the inverter units control boards [A41].&lt;br&gt;The inverter units indicate the status. See section <strong>POUS indications</strong> on page 18.</td>
</tr>
<tr>
<td>3.</td>
<td>The POUS indication lamp [Pxx] switches on.</td>
</tr>
<tr>
<td>4.</td>
<td>The motors coast to zero speed (if running) and cannot start while STO is on.</td>
</tr>
<tr>
<td>5.</td>
<td>Normal operation resumes after the user:&lt;br&gt;• switches on the POUS switch [Sxx]&lt;br&gt;• resets the inverter units (if the STO indication parameter 31.22 has been set so that a fault is generated)&lt;br&gt;• makes sure that the inverter units have received the start signals (depends on the configuration, see the firmware manual).</td>
</tr>
</tbody>
</table>
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 POUS safety relay [A65] trips if it detects a failure (short circuit between signals, open circuits, redundancy fault when the POUS switch is pressed) in the safety circuit. The fault reaction function shifts the drive immediately into the safe state by activating the STO function. The STO function is active until the fault has been repaired. The POUS indication lamp is on until the fault has been repaired.

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

For more information, see the firmware manuals.

Hardware settings

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

The settings in the POUS safety relay [A65] are:
- cross fault detection is set to value On,
- reset is set to value Automatic.

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

The operating switch and the indication lamp for the POUS function are not factory-installed. The user must install and wire them to the drive on site.

There are double contacts in the POUS switch [Sxx] and double wiring (two-channel connection) between the button and the POUS safety relay [A65]. The safety relay detects cross faults and faults across one contact from the POUS switch. This function must be used in a redundant manner, that is, the POUS switch must be connected to both terminals with a separate contact.

Wire the POUS switch to the appropriate terminals inside the drive cabinet. For the POUS indication lamp [Pxx], we recommend an LED indication lamp. See the circuit diagrams delivered with the drive. Follow the rules below:

1. Use only double-contact switches. We recommend approved and lockable switches.
2. Connect the switch with two conductors (two-channel connection). **Note:** Keep the channels separate. Otherwise the cross-fault detection of the POUS safety relay trips.
3. Use a shielded, twisted pair cable. We recommend a double-shielded cable and gold-plated contacts in the POUS switch.
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 inverter unit 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.

<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

After the wiring to the POUS switch and indication lamp has been done, 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 the parameters relevant to the safety function 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)

Close the disconnector and switch on the power. The POUS function should be activated only when the motors are stopped.

Switch off the POUS switch.

Ensure that the inverter units stop the motors by coasting and indicate POUS as defined in section *POUS indications* on page 18.
Note that there may be several POUS groups in a multidrive system. Make sure that only the desired inverter units indicate POUS.

Ensure that the POUS indication lamp [Pxx] switches on.

Ensure that you cannot start the inverter units and motors from any control location: Switch the external start signal off and on (in the external control mode) and press the start key of the panel (in the local control mode).

Deactivate the POUS function by switching on the POUS switch. Ensure that the inverter units do not restart directly after deactivation.

Ensure that the POUS indication lamp [Pxx] switches off.
<table>
<thead>
<tr>
<th>Action</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drives with R8i inverter modules:</strong> Ensure that “STO hardware failure” (5090) is not generated.</td>
<td>✔</td>
</tr>
<tr>
<td>Switch off the inverter start signals.</td>
<td></td>
</tr>
<tr>
<td>If a fault message is generated, reset the inverter units. <strong>See section POUS indications on page 18.</strong></td>
<td></td>
</tr>
<tr>
<td>Restart the inverter units and motors and check that they operate normally.</td>
<td></td>
</tr>
<tr>
<td>Repeat the acceptance test for each POUS group.</td>
<td></td>
</tr>
<tr>
<td>Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted to operation.</td>
<td></td>
</tr>
</tbody>
</table>
Use of the safety function

- **Activating**
  1. Switch off the POUS switch.

- **Resetting**
  You do not need to press any reset button to restore to normal operation after inactivating the POUS function. The reset input of the POUS safety relay [A65] is set to autoreset mode at the factory. However, you must reset the inverter units if they have tripped on fault at the activation of the POUS function. The reaction of the inverter units depends on the parameter settings. See section *Parameter settings* on page 14.

POUS indications

When the POUS is activated:
- the inverter unit control program has the warning *Safe torque off* active,
- the POUS indication lamp [Pxx] is on.

**Note:** The POUS indication is not SIL/PL rated.

Fault tracing

This table describes the status LEDs of the POUS safety relay [A65].

<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>

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. Obey 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 a POUS group 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 each POUS circuit of the multidrives delivery, and delivers the data separately to the customer.

Safety component types

Safety component types as defined in IEC 61508-2:

- POUS 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 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

Total delay for the POUS function: less than 100 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 test.

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.

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 +Q957) 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.

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3AUA0000119894 Rev D (EN) 2018-02-02