OPTIONS FOR ABB DRIVES

Emergency stop, stop category 0 (option +Q951) for ACS880 multidrives

User's manual

Emergency stop, stop category 0 (option +Q951) for ACS880 multidrives

User's manual

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1

Safety instructions

Contents of this chapter

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

Use of warnings and notes

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

The manual uses these warning symbols:

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

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

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

Instructions for functional safety circuits

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

Only a qualified electrician who has appropriate knowledge on functional, machine, and process safety is allowed to install, start up and maintain the safety circuit. All user-made changes are on the user's responsibility.

WARNING! Always test the operation of the safety circuit according to its acceptance test procedure at the start-up and after any changes to the safety circuit.

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

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

Electrical safety precautions

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

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

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

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

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - If the drive is equipped with a DC/DC converter unit (optional): Open the DC switch/disconnector ([Q11], option +F286) of the DC/DC converter. Open the disconnecting device of the energy storage connected to the DC/DC converter unit (outside the drive cabinet).
   - If you have a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Make sure that re-connection is not possible. Lock out and tag out.
   - Disconnect any dangerous external voltages from the control circuits.
   - After you disconnect power from the drive, always wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
3. Protect any other energized parts in the work location against contact.
4. Take special precautions when close to bare conductors.
5. Measure that the installation is de-energized.
   - Use a multimeter with an impedance greater than 1 Mohm.
   - Make sure that the voltage between the drive input power terminals (L1, L2, L3) and the grounding (PE) busbar is close to 0 V.
   - If you have a permanent magnet motor connected to the drive, make sure that the voltage between the drive output terminals (T1/U, T2/V, T3/W) and the grounding (PE) busbar is close to 0 V.
6. Ask the person in control of the electrical installation work for a permit to work.

2

Introduction to the manual

Contents of this chapter

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

Applicability

The manual applies to ACS880 air-cooled and liquid-cooled multidrives which have the option: Emergency stop, stop category 0 with main contactor/breaker, with safety relays (option +Q951).

Target audience

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

Exclusion of liability

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

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

Quick reference guide for taking a safety function into use

Task	☑
Connect the user-defined wiring (if any). See the wiring instructions in this manual and the circuit diagrams delivered with the drive.	☐
Check and/or set the safety function related parameters (as listed in this manual).	☐
Do the acceptance test to ensure that the implemented system meets the safety requirements. Instructions for the acceptance test can be found in this manual.	☐
Document the acceptance test procedure. Guidelines for the acceptance test report can be found in this manual.	☐

Related manuals

Manual	Code
Drive hardware	
Mechanical installation instructions for ACS880 multidrive cabinets	3AUA0000101764
Electrical planning instructions for ACS880 multidrive cabinets and modules	3AUA0000102324
Supply units	
ACS880-207 IGBT supply units hardware manual	3AUA0000130644
ACS880-307 (+A003) diode supply units hardware manual	3AUA0000102453
ACS880-307 (+A018) diode supply units hardware manual	3AXD50000011408
ACS880-907 regenerative rectifier units hardware manual	3AXD50000020546
Inverter units	
ACS880-107 inverter units hardware manual	3AUA0000102519
Drive firmware	
ACS880 primary control program firmware manual	3AUA0000085967
ACS880 primary control program quick start-up guide	3AUA0000098062
ACS880 diode supply control program firmware manual	3AUA0000103295
ACS880 IGBT supply control program firmware manual	3AUA0000131562
ACS880 regenerative rectifier control program firmware manual	3AXD50000020827
PC tools	
Drive composer start-up and maintenance PC tool user's manual	3AUA0000094606
Functional safety design tool user’s manual	3AXD10000102417
Safety	
Functional safety; Technical guide No. 10 Safety and functional safety; A general guide	3AUA0000048753
Safety and functional safety; A general guide	1SFC001008B0201
Safety instructions for ACS880 multidrive cabinets and modules	3AUA0000102301
ABB Safety information and solutions	www.abb.com/safety
Options	
ACX-AP-x assistant control panels user’s manual	3AUA0000085685
Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.	
Other documents	
Circuit diagrams	Delivered with the drive

Manual	Code
Part lists	Delivered with the drive
Safety data report (if the safety circuit is application-engineered)	

You can find manuals and other product documents in PDF format on the Internet. See Document Library. For manuals not available in the Document library, contact your local ABB representative.

For additional ABB safety information and solutions visit http://www.abb.com/safety.

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)
DI	Digital input
DIIL	Digital input interlock
E-stop	Emergency stop
HFT	Hardware fault tolerance (IEC 61508)
IGBT	Insulated gate bipolar transistor
PFH	Average frequency of dangerous failures per hour (IEC 61508)
PL	Performance level. Levels a...e correspond to SIL (EN ISO 13849-1)
SIL	Safety integrity level (1...3) (IEC 61508)

3

Option description

Contents of this chapter

This chapter describes the +Q951 emergency stop option and its settings.

Overview

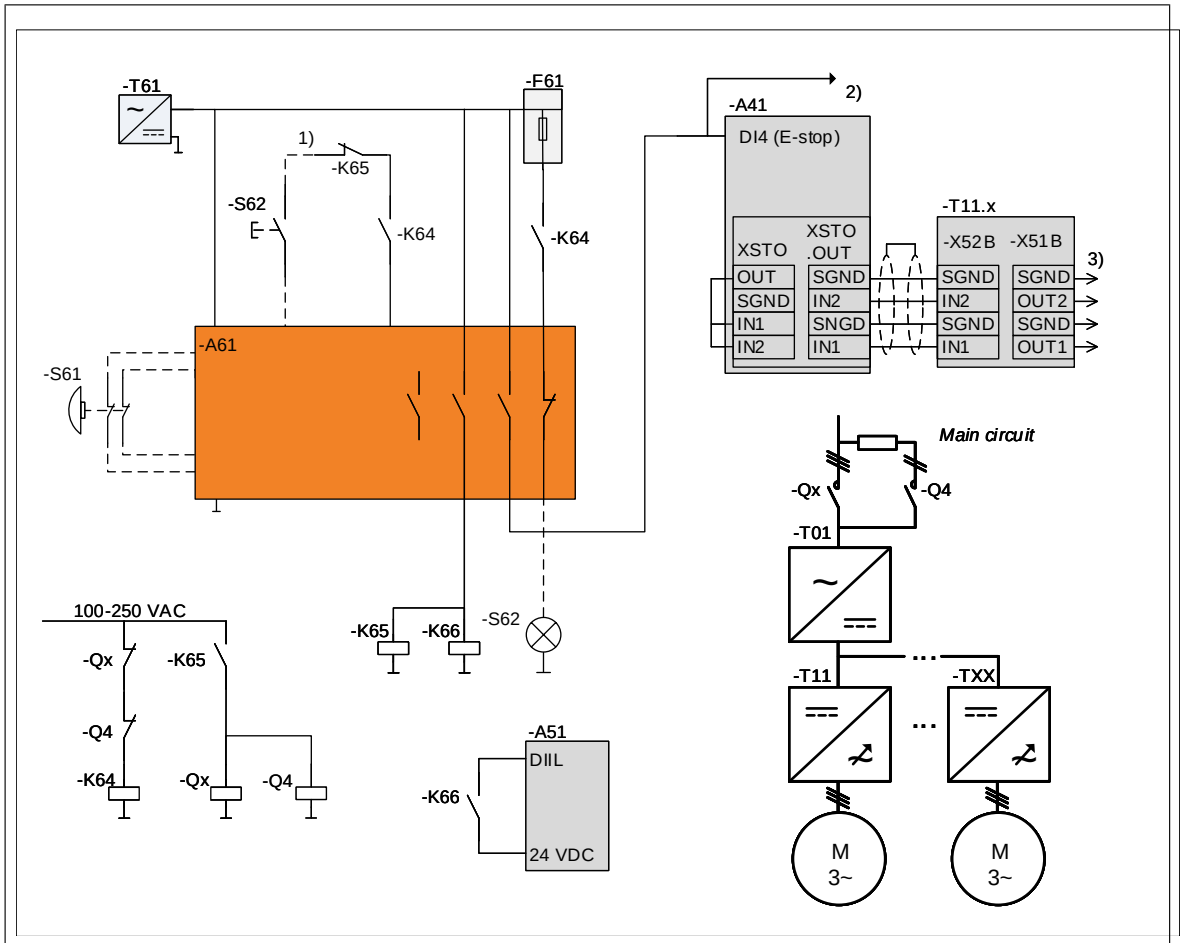
Option +Q951 corresponds to an uncontrolled stop in accordance with stop category 0 (EN/IEC 60204-1). After the emergency stop command has been given, the drive trips the main contactor/breaker which cuts off the input power of the drive. The motor(s) coasts to a stop.

The design principles of the option +Q951 comply with EN ISO 13850.

For a list of related standards and European directives, see section *Related standards and directives (page 30)*.

Operation principle

The figure shows a simplified operation principle. Implementation of main contactor/breaker and charging circuit can vary depending on the product. For a more detailed description, see the circuit diagrams delivered with the drive.



-----	The dashed line in the figure indicates a user-defined installation.
A41	Inverter control unit
A51	Supply control unit
A61	Emergency stop safety relay with delay contacts
S61	Emergency stop button (user-defined)
S62	Emergency stop reset button with indicator light (user-defined)
K64	Safety relay
K65	Safety relay
K66	Safety relay
Qx	Main contactor/breaker (Q2 or Q1)
Q4	Charging contactor
T01	Supply unit
T11…Txx	Inverter unit(s)
T11.x	Inverter module(s) under inverter unit T11
T61	24 V power supply
F61	Circuit protection switch
1)	Reset circuit

2)	To other inverter control units
3)	To parallel inverter modules (if any)

Initial status: The drive is in operation and the motor is running.

1. The user activates emergency stop by pushing the emergency stop button [S61].
2. The emergency stop safety relay [A61] switches off the DI input of the inverter control unit [A41].
   The auxiliary relay [K66] switches off the DIIL input of the supply control unit [A51].
   The auxiliary safety relay [K65] de-energizes the main contactor/breaker [Qx].
   The main contactor/breaker [Qx] switches off the power supply to the supply unit and inverter units.
3. The emergency stop reset button indicator light [S62] switches on.
4. The motors coast to a stop and remain stopped as long as 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 circuit with the emergency stop reset button [S62]
   - closes the main contactor/breaker [Qx] with the operating switch
   - 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 trips the system if it detects a failure (short circuit between signals, open circuits, redundancy fault when the emergency stop button is pressed) in the safety circuit consisting of, for example, emergency stop button and the contacts wired to it.

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

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

Parameter settings

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

The inverter unit parameter settings in ACS880 primary control program:

- parameter **10.24 RO1 source** is set to value *P.10.1.3-*
- 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** is set to value *Warning/Warning* (recommended).

The supply unit parameter settings in the ACS880 supply control programs:

- parameter **121.04 Emergency stop mode** is set to value *Stop and 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 is set 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.

4

Electrical installation

Contents of this chapter

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

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 (redundant two-channel connection) between the button and the emergency stop safety relay [A61]. The safety relay detects cross faults and faults across one contact from the emergency stop button.

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

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

   Note: Keep the channels separate. If you use only one channel, or if the first and second channels are connected together (for example, in a chain), the cross-fault detection of the emergency stop safety relay trips and activates the emergency stop command of the inverter unit as it detects a redundancy fault.

3. Use shielded, twisted pair cables. We recommend a double-shielded cable and gold-plated contacts in the emergency stop button.
4. Ensure that the sum resistance for one channel (loop resistance) does not exceed 70 ohm.
5. Obey the general control cable installation instructions given in the drive hardware manual.

You can also install additional reset buttons and indication lamps for the emergency stop circuit on site. We recommend gold-plated contacts in the reset button. Wire the buttons to the appropriate terminal block inside the drive cabinet. See the circuit diagrams delivered with the drive. Obey the rules below:

1. Sum resistance of the external reset circuit may not exceed 70 ohm.
2. Obey the general control cable installation instructions given in the drive hardware manual.

Customer-installed main breaker in liquid-cooled ACS880 multidrives

Liquid-cooled ACS880 multidrives can be delivered without a factory-installed main breaker. In these cases, customer must install and connect the main breaker to the safety circuit as described in the circuit diagrams.

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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

1. Push the emergency stop button [S61]. The emergency stop is activated and the button locks in the “ON” (open) position.
   When the emergency stop is on, the following indications are shown:
   - the inverter unit control program has the warning *Emergency stop* active,
   - the emergency stop reset button indicator light [S62] on cabinet door is lit.

Resetting the safety function

1. Turn the emergency stop button [S61] until it releases.
2. Push the emergency stop reset button [S62] on the cabinet door. The emergency stop reset button indicator light [S62] goes out, the emergency stop is deactivated.
3. Reset the inverter units if necessary.
4. If necessary, close the main contactor with the operating switch (see the hardware and firmware manuals).
   The main contactor/breaker closes and the drive is powered up.
5. Make sure that the inverter units have received the start signal (depends on the configuration, see the firmware manual).
6. 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.

6

Start-up and acceptance test

Contents of this chapter

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

Validation of the safety functions

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

Competence

The acceptance test of the safety function must be carried out by a competent person with expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.

Validation procedure

You must do the acceptance test using the checklist given in section Start-up and acceptance test:

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

The acceptance test must include at least the following steps:

- you must have an acceptance test plan
- you must test all commissioned functions for proper operation, from each operation location
- you must document all acceptance tests

- you must sign and store the acceptance test report for further reference.

Acceptance test reports

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

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

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

Start-up and acceptance test

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

Action	☑
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.	☐
WARNING! Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.	☐
Checks and settings with no voltage connected	
Stop the drive and do the steps in section *Electrical safety precautions (page 8)* before you start the work.	☐
If you have done any connections for the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the appropriate circuit diagrams.	☐
Check that the hardware settings relevant to the safety function are set as defined in section Hardware settings.	☐
Settings with voltage connected	
Close the cabinet doors and power up the drive. See the hardware manual.	☐
Check the parameters that are relevant to the safety function. If necessary, set the parameters as defined in section Parameter settings. Note: ACS880 primary control program controls the inverter unit by default. There are dedicated control units for the supply and inverter units.	☐
Acceptance test	

Action	☑
We recommend that you monitor these signals with the Drive composer PC tool: • 01.01 Motor speed used (rpm) • 01.02 Motor speed estimated (rpm) • 01.07 Motor current (A) • 01.10 Motor torque (%) • 23.01 Speed ref ramp input (rpm) • 23.02 Speed ref ramp output (rpm) • 90.01 Motor speed for control (rpm) • When using an encoder, also: 90.10 Encoder 1 speed (rpm)	☐
Make sure that it is safe to start, run and stop the motor(s) during the test.	☐
Start the 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 Activating the safety function.	☐
Make sure that the emergency stop reset button indicator light [S62] switches on.	☐
Make sure that the main contactor/breaker opens as described in section Operation principle.	☐
Make sure that you cannot close the main contactor/breaker with the operating switch or by any other means.	☐
Make sure that you cannot start the inverter units and motors from any control location: make sure that the motors do 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]. • Make sure that the emergency stop reset button indicator light [S62] switches off.	☐
Switch off the start signals of the inverter units. If a fault message is generated, reset the inverter units.	☐
Power up the inverter units (see the hardware manual).	☐
Restart the inverter units and motors and check that they operate normally.	☐
Repeat the test from each operating location (for every emergency stop button and reset button).	☐
Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted for operation.	☐

7

Fault tracing

Contents of this chapter

This chapter provides general diagnostics and troubleshooting tips.

Fault tracing

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

LED	LED is lit and steady
Netz	Power supply is connected.
K1	Relay K1 is energized.
K2	Relay K2 is energized.

To reset the emergency stop safety relay [A61] after fault situations, switch off the external power supply of the safety relay. If the emergency stop safety relay cannot be reset, check the reset circuit connections.

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

Reporting problems and failures related to safety functions

Contact ABB.

8

Maintenance

Contents of this chapter

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

Safety circuit maintenance

After the operation of the safety function is tested at start-up, the safety function must be maintained by:

- periodic proof testing
- replacing main contactor or breaker before the end of its specified lifetime

See the contactor/breaker data sheet or manual.

It is also a good practice to check the operation of the safety function when other maintenance routines are carried out on the machinery. Include this check in the routine maintenance program of the machinery that the drive runs.

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

- Use only ABB-approved spare parts.
- Register the change to the change log for the safety circuit.
- Test the safety function again after the change. Do the start-up and acceptance test of the safety function.
- Document the tests and store the report into the logbook of the machine.

Proof test interval

After the operation of the safety function is validated, 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 1 year

(high or low demand as defined in IEC 61508, EN/IEC 62061 and EN ISO 13849-1). Regardless of the mode of operation, it is a good practice to check the operation of the safety function at least once a year by doing the start-up and acceptance test of the safety function.

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

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

This is a recommendation and depends on the required (not achieved) SIL/PL. For example, safety relays, contactor relays, emergency stop buttons, switches, etc. are typically safety devices which contain electromechanical outputs.

Competence

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

Residual risk

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

Intentional misuse

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

Decommissioning

When you decommission an emergency stop circuit or an inverter unit, make sure that the safety of the machine is maintained until the decommissioning is complete.

9

Technical data

Contents of this chapter

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

Safety data

Safety data values

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
- safety relay(s): type A
- main contactor(s): type A
- main breaker: type A.

Safety block diagrams

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

Relevant failure modes

Relevant failure modes are:

- the main contactor/breaker does not open when requested. (All contactor/breaker failures are considered dangerous.)

- internal failures of safety relays and the emergency stop button. These failures are included in the PFH value of the function.

Fault exclusions

Fault exclusions (not considered in the calculations):

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

Operation delays

Emergency stop total delay: less than 500 ms.

Ambient conditions

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

Related standards and directives

Standard	Name
EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems – Part 2: Validation
EN ISO 13850:2015	Safety of machinery. Emergency stop. Principles for design.
EN 60204-1:2006 + AC:2010 IEC 60204-1:2016	Safety of machinery – Electrical equipment of machines – Part 1: General requirements
IEC 61326-3-1:2017	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61511-1:2016	Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements
EN 61800-5-2:2007 IEC 61800-5-2:2016	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional
EN 62061:2005 + AC:2010 + A1:2013 + A2:2015 IEC 62061:2015 Ed. 1.2	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

Standard	Name
2006/42/EC	European Machinery Directive
Other	Machine-specific C-type standards

Compliance with the European Machinery Directive

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

Further information

Product and service inquiries

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

Product training

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

Providing feedback on ABB manuals

Your comments on our manuals are welcome. Navigate to new.abb.com/drives/manuals-feedback-form.

Document library on the Internet

You can find manuals and other product documents in PDF format on the Internet at www.abb.com/drives/documents.

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