OPTIONS FOR ABB DRIVES

Emergency stop, configurable stop category 0 or 1 (option +Q978) for ACS880-07/07LC/17/17LC/37/37LC drives

User's manual

Emergency stop, configurable stop category 0 or 1 (option +Q978) for ACS880-07/07LC/17/17LC/37/37LC drives

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 contain the complete safety instructions of the drive. It only includes the instructions related to the scope of this manual.

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

WARNING!
The safety function described in this manual does not isolate the main circuit or auxiliary circuit from the power supply. Do not do work on the drive, motor cable or motor before you have isolated the drive system from all power supplies and measured that there are no dangerous voltages. Before you start the work, do the steps in section *Electrical safety precautions (page 10)*.

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 electrical professional, do not do installation or maintenance work.

Electrical safety precautions

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

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

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

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

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Make sure that re-connection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - If you have a permanent magnet motor connected to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Disconnect all dangerous external voltages from the control circuits.
   - After you disconnect power from the drive, always wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
3. Protect any other energized parts in the work location against contact.
4. Take special precautions when close to bare conductors.

5. Measure that the installation is de-energized.
   - Before and after measuring the installation, verify the operation of the voltage tester on a known voltage source.
   - Make sure that the voltage between the drive input power terminals (L1, L2, L3) and the grounding (PE) busbar is zero.
   - Make sure that the voltage between the drive output terminals (T1/U, T2/V, T3/W) and the grounding (PE) busbar is zero.
6. Install temporary grounding as required by the local regulations.
7. Ask the person in control of the electrical installation work for a permit to work.

2

Introduction to the manual

Contents of this chapter

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

Applicability

The manual is applicable to ACS880-07/07LC/17/17LC/37/37LC drives which have the option +Q978: Emergency stop, configurable stop category 0 or 1 with opening the main contactor/breaker and STO, with FSO.

Required versions with the FSO-12 module:

- ACS880 primary control program: 1.80 or later
- FSO-12 safety functions module: revision C or later
- Drive composer pro: 1.6 or later.

Required versions with the FSO-21 module:

- ACS880 primary control program: 2.2 or later
- FSO-21 safety functions module: revision D or later
- FSE-31 pulse encoder interface module: revision D or later (if used)
- Drive composer pro: 1.8 or later.

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 make sure that the implemented system meets the safety requirements. You can find the instructions for the acceptance test in this manual.	☐
Document the acceptance test procedure. You can find the guidelines for the acceptance test report in this manual.	☐

Related manuals

Manual	**Code**
Drive hardware	
ACS880-07 drives (560 to 2800 kW) hardware manual	3AUA0000143261
ACS880-07 drives (45 to 710 kW, 50 to 700 hp) hardware manual	3AUA0000105718
ACS880-07LC drives hardware manual	3AXD50000569786
ACS880-17 drives (160 to 3200 kW) hardware manual	3AXD50000020436
ACS880-17 drives (45 to 400 kW) hardware manual	3AXD50000035158
ACS880-17LC drives hardware manual	3AXD50000250295
ACS880-37 drives (160 to 3200 kW) hardware manual	3AXD50000020437
ACS880-37 drives (45 to 400 kW) hardware manual	3AXD50000035159
ACS880-37LC drives hardware manual	3AXD50000251407
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
PC tools	
Drive composer start-up and maintenance PC tool user's manual	3AUA0000094606
Functional safety design tool user’s manual	TT201312111015
Safety	
Functional safety; Technical guide No. 10	3AUA0000048753
Safety and functional safety; A general guide	1SFC001008B0201
ABB Safety information and solutions	www.abb.com/safety

Manual	Code
Options	
ACX-AP-x assistant control panels user's manual	3AUA0000085685
FSO-12 safety functions module user's manual	3AXD50000015612
FSO-21 safety functions module user's manual	3AXD50000015614
FSE-31 pulse encoder interface module user's manual	3AXD50000016597
Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.	
Other documents	
Circuit diagrams	Delivered with the drive
Part lists	Delivered with the drive
Safety data report (if the safety circuit is order-based engineered)	

See www.abb.com/drives/documents for all manuals on the Internet.

ACS880-07 (45 to 710 kW) manuals

ACS880-07 (560 to 2800 kW) manuals

ACS880-17 (45 to 400 kW) manuals

ACS880-17 (160 to 3200 kW) manuals

ACS880-17LC manuals

ACS880-37 (45 to 400 kW) manuals

ACS880-37 (160 to 3200 kW) manuals

ACS880-37LC manuals

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)
DIIL	Digital input interlock
E-stop	Emergency stop
Frame, frame size	Physical size of the drive or power module
FSE-31	Optional pulse encoder interface module for safety encoder
FSO-12, FSO-21	Optional functional safety modules
HFT	Hardware fault tolerance (IEC 61508)
IGBT	Insulated gate bipolar transistor
Inverter unit	Inverter module(s) under control of one control unit, and related components. One inverter unit typically controls one motor.
modoff	No modulation
NC	Normally closed
PL	Performance level. Levels a...e correspond to SIL (EN ISO 13849-1)
POUS	Prevention of unexpected start-up
SAR	Safe acceleration range
SBC	Safe brake control
SC	Systematic capability (IEC 61508)
SIL	Safety integrity level (1...3) (IEC 61508)
SILCL	Maximum SIL (level 1...3) that can be claimed for a safety function or subsystem (IEC/EN 62061)
SLS	Safely-limited speed
SS1	Safe stop 1 (IEC/EN 61800-5-2)
SSE	Safe stop emergency
STO	Safe torque off (IEC/EN 61800-5-2)
Stop category	There are three categories of stop functions defined by IEC/EN 60204-1: • 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).
Supply unit	Supply module(s) under control of one control unit, and related components.
T_1	Proof test interval. Defines the probabilistic failure rate (PFH or PFD_{avg}) for the safety function or subsystem. Performing a proof test at a maximum interval of T_1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. Note that any T_1 values given cannot be regarded as a guarantee or warranty.
TP	Test pulse

3

Option description

Contents of this chapter

This chapter describes the operation and settings of the option +Q978: Emergency stop, configurable stop category 0 or 1 with opening the main contactor/breaker and STO, with FSO.

Overview

The option +Q978 uses the FSO-12 safety functions module (option +Q973) or the FSO-21 safety functions module (option +Q972) for the emergency stop safety function. In this emergency stop option, the Safe torque off (STO) circuit of the drive and the main contactor/breaker are opened.

ABB installs the FSO module, the main contactor (option +F250) or the main breaker (option +F255), and the emergency stop circuit to the drive. ABB sets default parameter values for the option at the factory. The user adjusts the operation of the emergency stop function with the safety parameters at the start-up, for example, sets the stop category (0 or 1). ABB sets stop category 0 at the factory.

If option +L521 is selected, ABB installs the FSO-21 safety functions module and FSE-31 pulse encoder interface module to the drive. With this option, you can use a safety encoder in the application.

Note: The FSE-31 module requires the FSO-21 module. The FSO-12 module is not compatible with the FSE-31 module or safety encoders.

The option +Q978 supports the following emergency stop functions:

- Emergency stop, stop category 0
  This is an uncontrolled stop (IEC/EN 60204-1). When the user pushes the emergency stop button, the Safe torque off (STO) function of the FSO module is activated. This activates the STO function of the drive and opens the main contactor/breaker. The motor coasts to a stop.
- Emergency stop, stop category 1
  This is a controlled stop (IEC/EN 60204-1). When the user pushes the emergency stop button, the Safe stop 1 function (SS1) of the FSO module is activated. After the drive has decelerated the motor speed to a user-defined zero speed limit, the FSO module activates the STO function of the drive and opens the main contactor/breaker.
  The SS1 function can operate in time monitoring or in ramp monitoring mode. In time monitoring mode, the FSO module monitors that a user-defined deceleration time limit is not exceeded. In ramp monitoring mode, the FSO module monitors that the motor decelerates along a user-defined stop ramp.

Note: The safety function request to the FSO module must be active for a minimum of 20 ms.

Note: The main contactor/breaker is controlled with the Safe brake control (SBC) function. For more information on the SBC function, see the FSO module user's manual.

To be able to start the drive, the user must release the emergency stop button and then push the emergency stop reset button for 0.3 … 3 s. This resets the emergency stop circuit, closes the main contactor/breaker and deactivates the drive STO function.

The drive main circuit is de-energized while the emergency stop is active and the main contactor/breaker is open, but the auxiliary circuit stays energized. Note that activating the emergency stop function does not isolate the drive or motor from dangerous voltages.

Note: Drives with the Prevention of unexpected start-up (POUS) option (+Q950): If the user activates the POUS function during the emergency stop deceleration ramp, it overrides the emergency stop function. This activates the drive Safe torque off (STO) function, opens the main contactor/breaker and the motor coasts to a stop. For more information on the POUS safety function, see *Prevention of unexpected start-up (option +Q950) for ACS880-07/07LC/17/17LC/37/37LC drives user's manual* (3AUA0000145922 [English]).

For a detailed description of the drive Safe torque off function, see the hardware manual of your drive. For more information on the safety functions of the FSO module, see *FSO-12 safety functions module user's manual* (3AXD50000015612 [English]) or *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]). For more information on the FSE-31 module, see *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

The design principles of the option +Q978 comply with EN ISO 13850.

The STO and SS1 functions comply with IEC/EN 61800-5-2. For a complete list of related standards and European directives, see section *Related standards and directives (page 71)*.

Summary of wirings and settings

The wirings and settings of the emergency stop function are:

- The drive is equipped with the FSO safety functions module (option +Q973 or +Q972). ABB installs the module at the factory.
- One emergency stop button is installed on the cabinet door and wired to the FSO module. ABB wires the button at the factory. The user can add buttons to the emergency stop circuit.

- One emergency stop reset button is installed on the cabinet door and wired to the FSO module. The reset button also includes an emergency stop indication lamp. ABB wires the button and the indication lamp at the factory. The user can add reset buttons to the reset circuit.
- The digital output of the FSO module to which the emergency stop indication lamp is connected, is selected as the output for the Stop completed signal. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.
- The main contactor/breaker is installed inside the cabinet (option +F250 or +F255). The auxiliary safety relay(s) that control the main contactor/breaker is installed inside the cabinet and wired to the FSO module. ABB installs and wires the main contactor/breaker and the auxiliary safety relay(s) at the factory.
- The digital output of the FSO module to which the auxiliary safety relay(s) is connected, is selected as the output for the Safe brake control (SBC) output signal. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.

Emergency stop, stop category 0:

- The digital inputs of the FSO module to which the emergency stop button is connected, are selected as the inputs for the STO request. This is an FSO module parameter that ABB sets at the factory by default and the user must check at the start-up.

Emergency stop, stop category 1:

The user must set these FSO module parameters at start-up:

- The digital inputs of the FSO module to which the emergency stop button is connected, are selected as the inputs for the SS1 request.
- The SS1 function is set to use either the time monitoring or ramp monitoring mode.
- The stop ramp that is used to decelerate the motor(s) and the monitoring limits (stop ramp time or ramp monitoring limits) are set according to the application requirements.

Additional wirings and settings when a safety pulse encoder is used:

- The drive is equipped with the FSE-31 pulse encoder interface module (option +L521). ABB installs the module at the factory.
- The motor must be equipped with a safety pulse encoder. The user installs and wires the safety pulse encoder to the FSE-31 module. The user must make sure that the required safety integrity (SIL/PL) can be achieved with the used safety encoder.

Note: The option +Q978 uses the Safe brake control (SBC) function of the FSO module to control the main contactor/breaker. If you use this option, you cannot use the FSO module to control a mechanical brake.

Note: In the option +Q978, the drive STO function is used together with the SBC function of the FSO module, which controls the main contactor/breaker. Thus, every time the drive STO is opened also the main contactor/breaker is opened. For example, if the Safely-limited speed (SLS) function (option +Q965) is included in the drive, the main contactor/breaker is opened after trip limit hits. For more information, see *Safely-limited speed with the encoder interface (option +Q965) for ACS880-07/07LC/17/17LC/37/37LC drives user's manual* (3AXD50000019727 [English]).

Operation principle

The operation and configuration of the emergency stop function is slightly different with and without a safety encoder. Only the FSO-21 module supports the safety encoder interface, and you can also use it without a safety encoder.

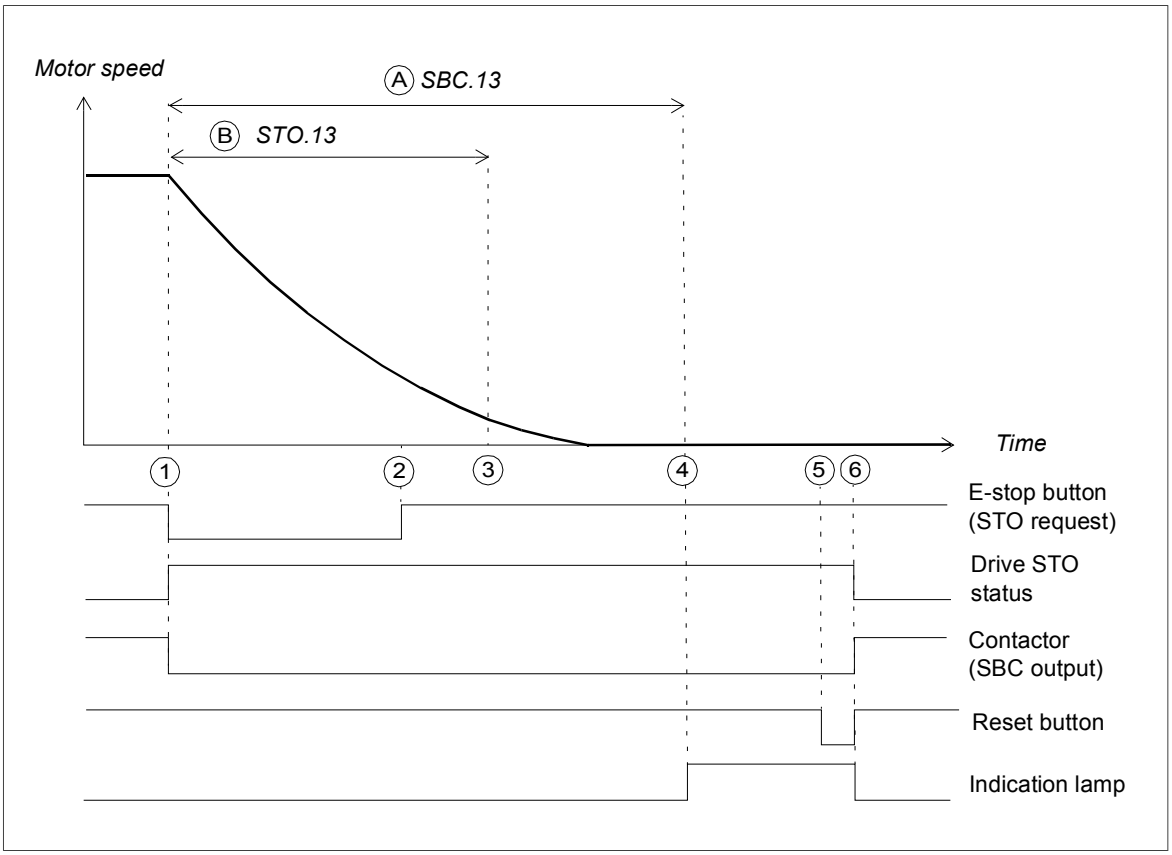
Note: The Emergency stop, stop category 1 function uses the SS1 function of the FSO module. The SS1 function uses SAR1 parameters to define the stop ramp. In some situations (for example, in internal fault situations or due to another safety function) the FSO module can activate the Safe stop emergency (SSE) function. The SSE function uses SAR0 parameters to define the stop ramp.

Note: If the FSO module activates the SSE function while the SS1 function is active, the SSE function overrides the SS1 function. Therefore, SAR0 parameters are used instead of SAR1 parameters to define the stop ramp. You must take this into account when you use the SS1 function to implement an emergency stop (stop category 1).

Time schemes with a speed estimate (no safety encoder)

Emergency stop, stop category 0

This time scheme diagram illustrates the operation of the Emergency stop, stop category 0 safety function. This option uses the Safe torque off (STO) function of the FSO module.



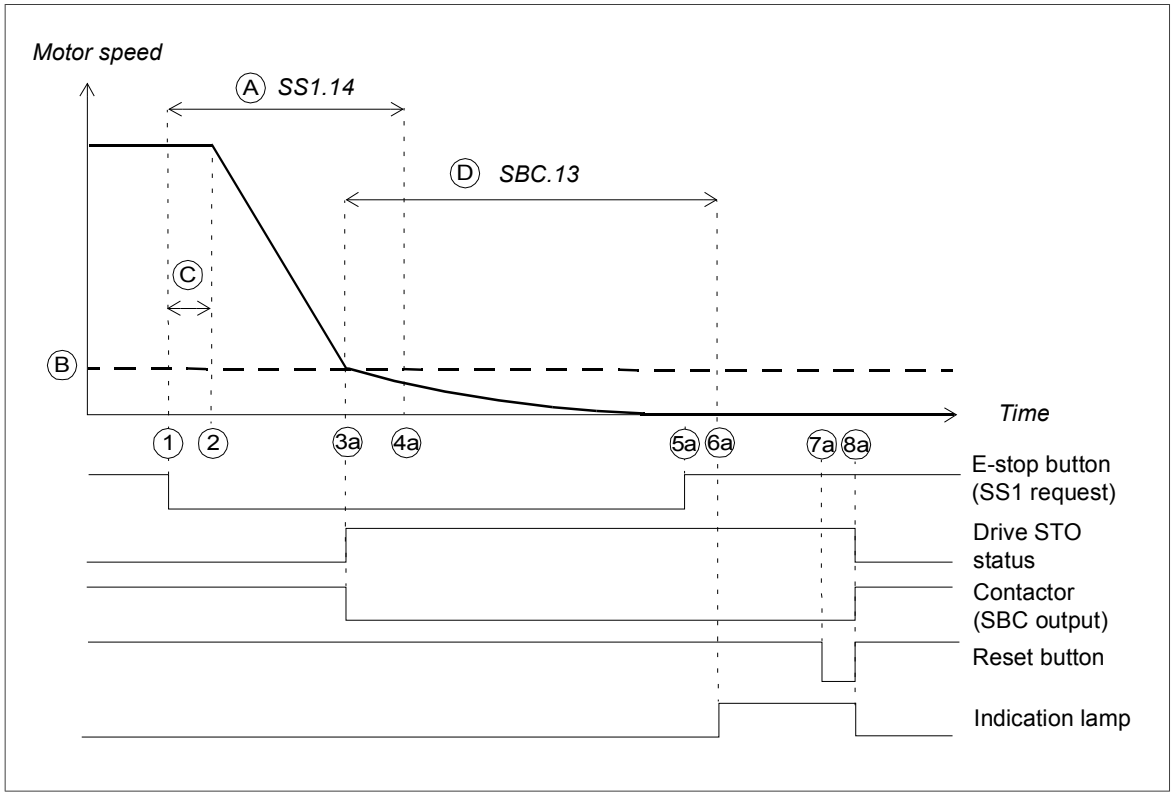
A	SBC time to zero speed: Time from the activation of the STO function to the moment when the STO completed indication becomes active and the indication lamp comes on. The user must set this time longer than the time the motor coasts from the maximum speed to zero speed (parameter *SBC.13 SBC time to zero speed*).
B	Restart delay: Delay from pushing the emergency stop button (and activation of the STO function) to the moment when the user can push the reset button at the earliest (and acknowledge the STO function). With this parameter, it is possible to allow a restart of the drive while the motor is still running (fly-start) (parameter *STO.13 Restart delay after STO*).

1. The user pushes the emergency stop button. The FSO module activates the FSO and drive STO functions and opens the main contactor/breaker. The FSO module starts timers for delays A and B.
2. The user releases the emergency stop button.
3. Time B elapsed. The user can push the reset button, that is, the acknowledgement of the STO function is possible.
4. Time A has elapsed. The emergency stop indication lamp comes on.
5. The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Emergency stop, stop category 1 with time monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with time monitoring. This option uses the Safe stop 1 (SS1) function of the FSO module.

Case A: The motor speed reaches the zero speed limit within the user-defined time



A	Security delay: When time A has elapsed from the start of the counter (step 1), the FSO module activates the drive STO and SBC functions (case B). Activation of the SBC function opens the main contactor/breaker). In case A, the FSO module has already activated the STO and SBC functions. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
B	Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).
C	Safety function response time.
D	SBC time to zero speed: When time D has elapsed from the start of the counter (step 3b, activation of the STO and SBC functions), the user can push the reset button, that is, the acknowledgment of the STO function is possible. The user must set this time longer than the time the motor coasts from the maximum speed to zero speed (parameter *SBC.13 SBC time to zero speed*).

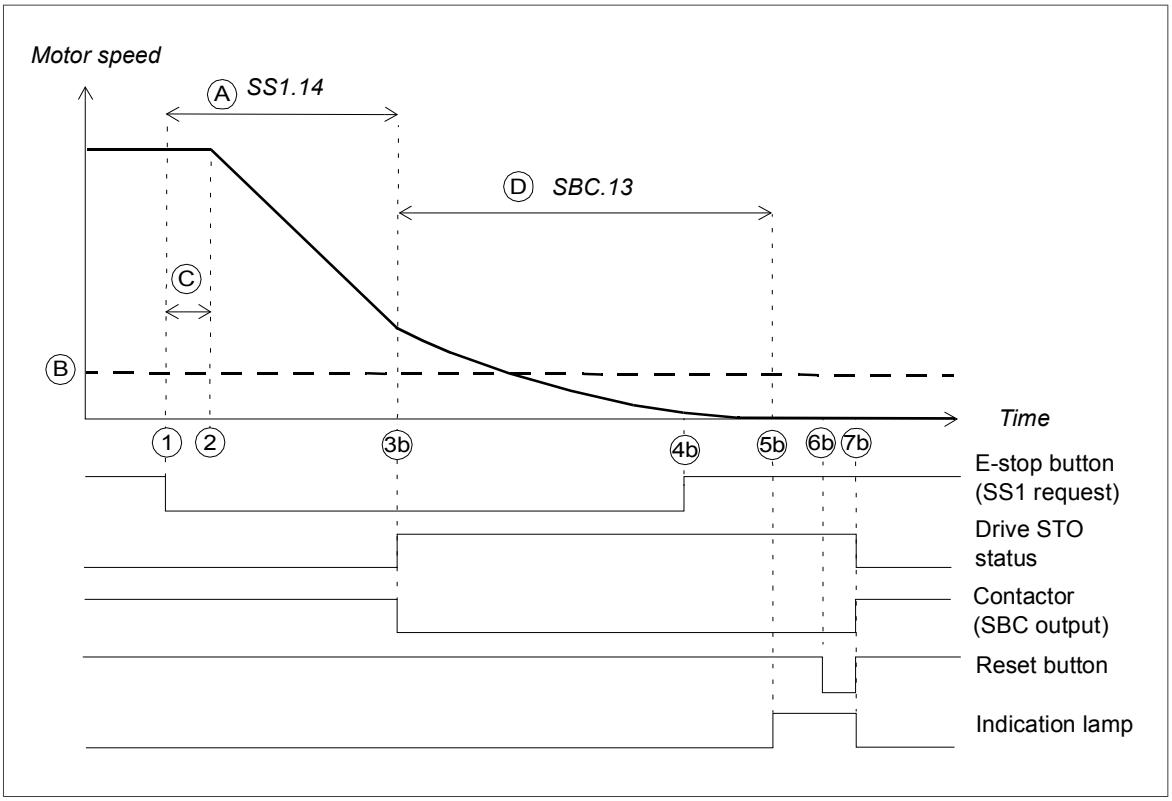
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. a) The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO and SBC functions (this opens the main contactor/breaker).

   Note: You can set an additional delay for the STO and SBC activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).

4. a) Time A has elapsed. The STO function is already active. In this case, this time has no effect.
5. a) The user releases the emergency stop button.
6. a) Time D has elapsed. The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgment of the STO function is possible.
7. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
8. a) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not reach the zero speed limit within the user-defined time

Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.



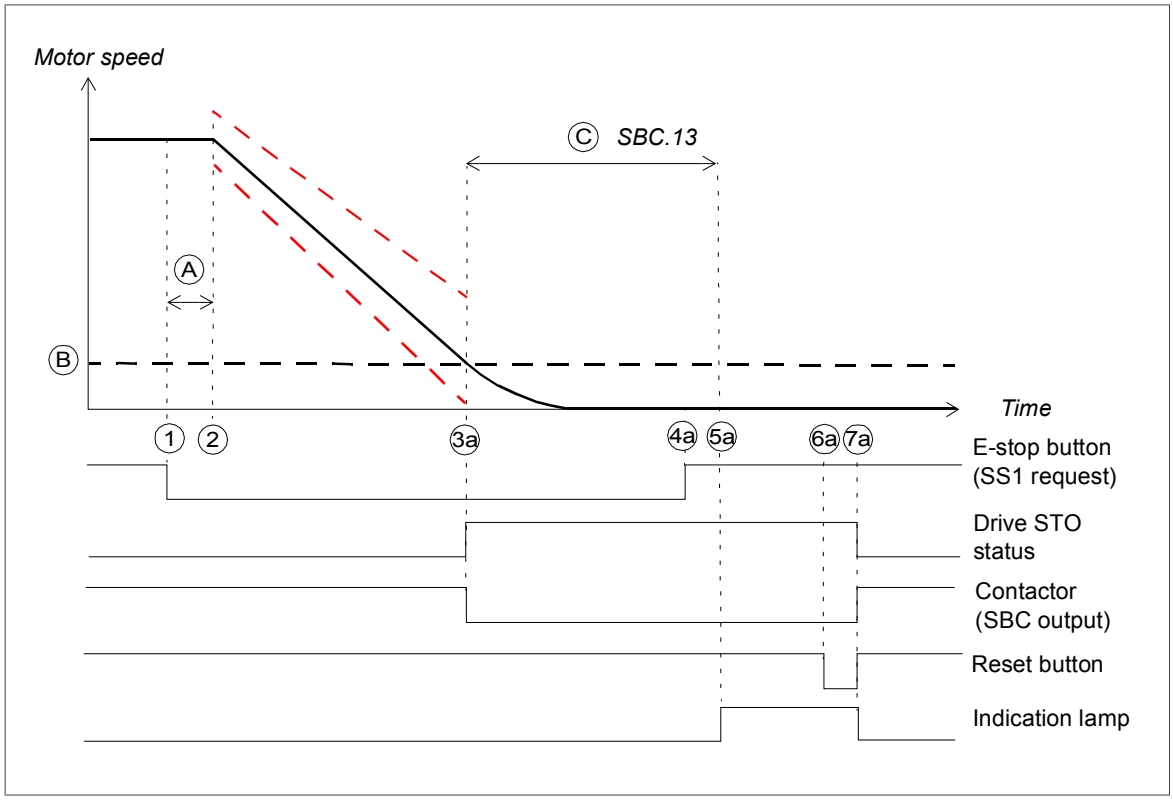
A	Security delay: When time A has elapsed from the start of the counter (step 1), the FSO module activates the drive STO and SBC functions (case B). Activation of the SBC function opens the main contactor/breaker). In case A, the FSO module has already activated the STO and SBC functions. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
B	Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).
C	Safety function response time.
D	SBC time to zero speed: When time D has elapsed from the start of the counter (step 3b, activation of the STO and SBC functions), the user can push the reset button, that is, the acknowledgment of the STO function is possible. The user must set this time longer than the time the motor coasts from the maximum speed to zero speed (parameter *SBC.13 SBC time to zero speed*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. b) The FSO module activates the drive STO and SBC functions (case B), opens the main contactor/breaker and starts a counter for time D. The motor coasts to a stop.
4. b) The user releases the emergency stop button.
5. b) Time D has elapsed. The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgement of the STO function is possible.
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Emergency stop, stop category 1 with ramp monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with ramp monitoring. This option uses the Safe stop 1 (SS1) function of the FSO module.

Case A: The motor speed reaches the zero speed limit within the user-defined stop ramp monitoring window



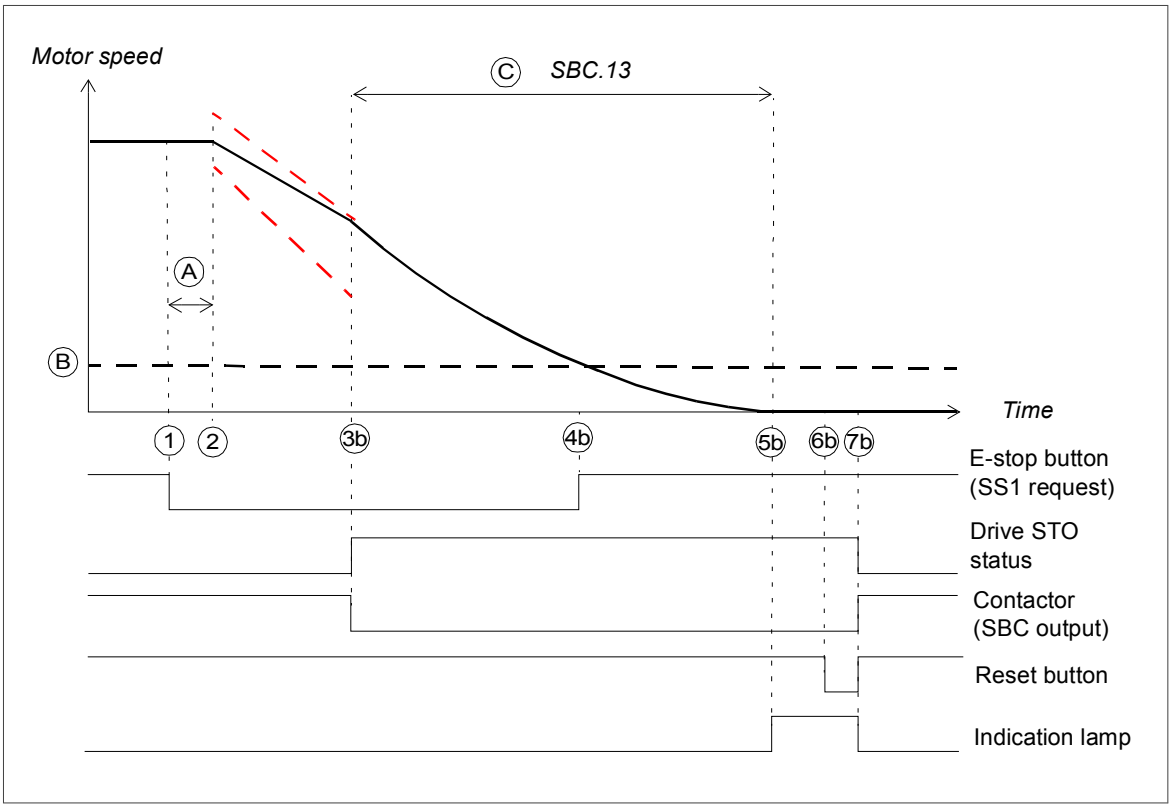
A	Safety function response time.
B	Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).

C — SBC time to zero speed: When time C has elapsed from the start of the counter (step 3b, activation of the STO and SBC functions), the user can push the reset button. This is a user-defined value (parameter *SBC.13 SBC time to zero speed*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).
3. a) The motor speed reaches the zero speed limit. The FSO module activates the drive STO and SBC functions (this opens the main contactor/breaker) and stops the ramp monitoring.

   Note: You can set an additional delay for the STO and SBC activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).
4. a) The user releases the emergency stop button.
5. a) Time C has elapsed. The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgment of the STO function is possible.
6. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. a) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not follow the user-defined stop ramp monitoring window



A — Safety function response time.

B — Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.51 Zero speed without encoder*).

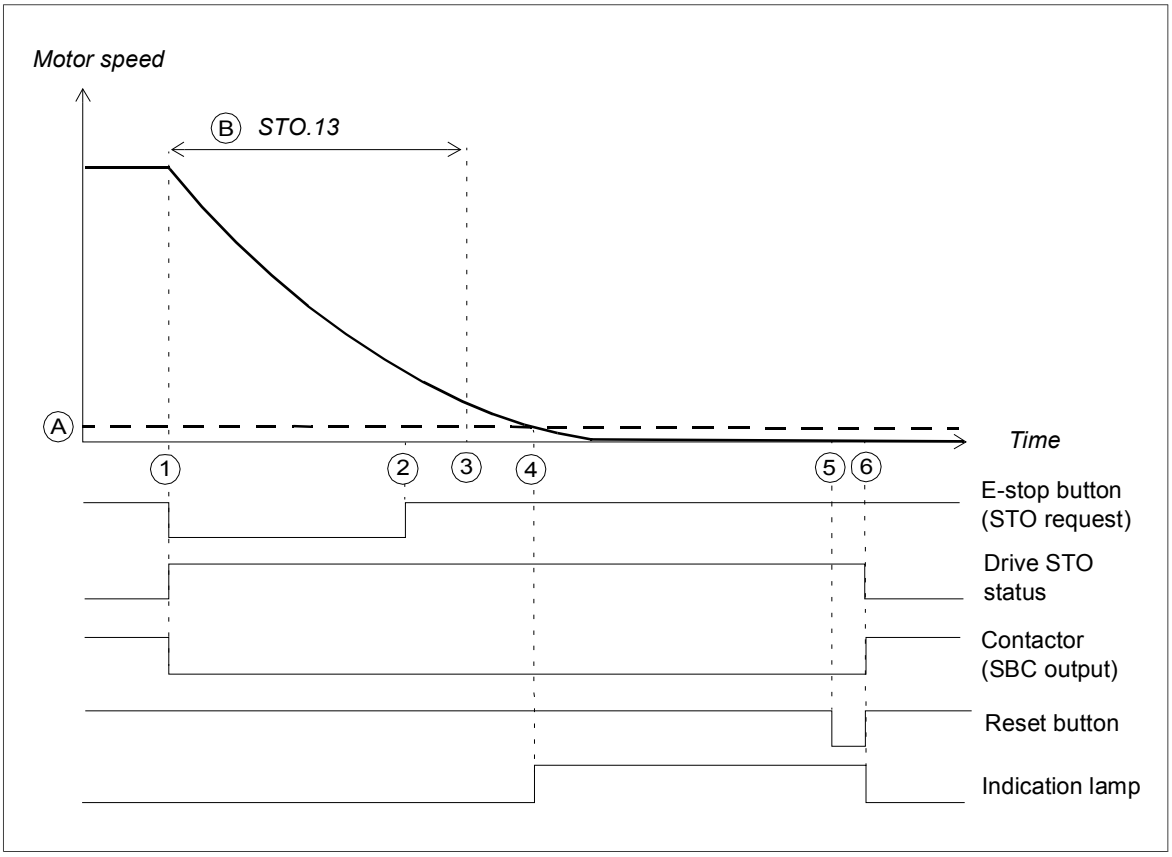
C	SBC time to zero speed: When time C has elapsed from the start of the counter (step 3b, activation of the STO and SBC functions), the user can push the reset button. This is a user-defined value (parameter *SBC.13 SBC time to zero speed*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).
3. b) The FSO module activates the drive STO and SBC functions, opens the main contactor/breaker and stops the ramp monitoring. The FSO module starts a counter for the SBC time to zero speed (C). The motor coasts to a stop.
4. b) The user releases the emergency stop button.
5. b) Time C has elapsed. The emergency stop indication lamp comes on. The user can push the reset button (that is, acknowledgement of the STO function is possible).
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Time schemes with a safety encoder

Emergency stop, stop category 0

This time scheme diagram illustrates the operation of the Emergency stop, stop category 0 safety function when a safety encoder is used. This option uses the Safe torque off (STO) function of the FSO-21 module.



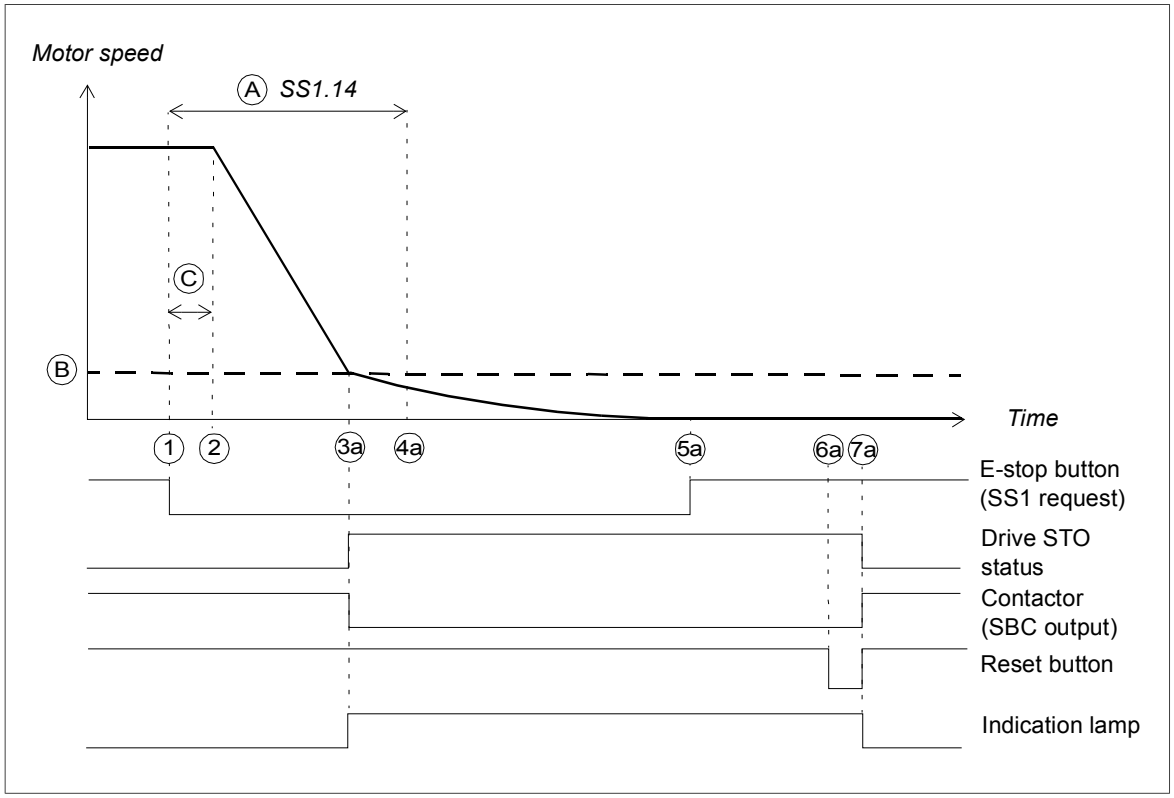
A	Zero speed with encoder: Speed limit at which the motor has stopped, the safety function is completed and the emergency stop indication lamp comes on (parameter FSOGEN.52 Zero speed with encoder).
B	Restart delay: Delay from pushing the emergency stop button (and activation of the STO function) to the moment when the user can push the reset button at the earliest (and acknowledge the STO function). With this parameter, it is possible to allow a restart of the drive while the motor is still running (fly-start) (parameter *STO.13 Restart delay after STO*).

1. The user pushes the emergency stop button. The FSO module activates the FSO and drive STO functions and opens the main contactor/breaker. The FSO module starts a timer for delays A and B.
2. The user releases the emergency stop button.
3. Time B has elapsed. The user can push the reset button, that is, the acknowledgement of the STO function is possible.
4. The motor speed goes below the zero speed limit (A). The emergency stop indication lamp comes on.
5. The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Emergency stop, stop category 1 with time monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with time monitoring when a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module.

Case A: The motor speed reaches the zero speed limit within the user-defined time



A	Security delay: When time A has elapsed from the start of the timer (step 1), the FSO module activates drive STO and SBC functions (case B). Activation of the SBC function opens the main contactor/breaker). In case A, the FSO module has already activated the STO and SBC functions. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
B	Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.52 Zero speed with encoder*).
C	Safety function response time.

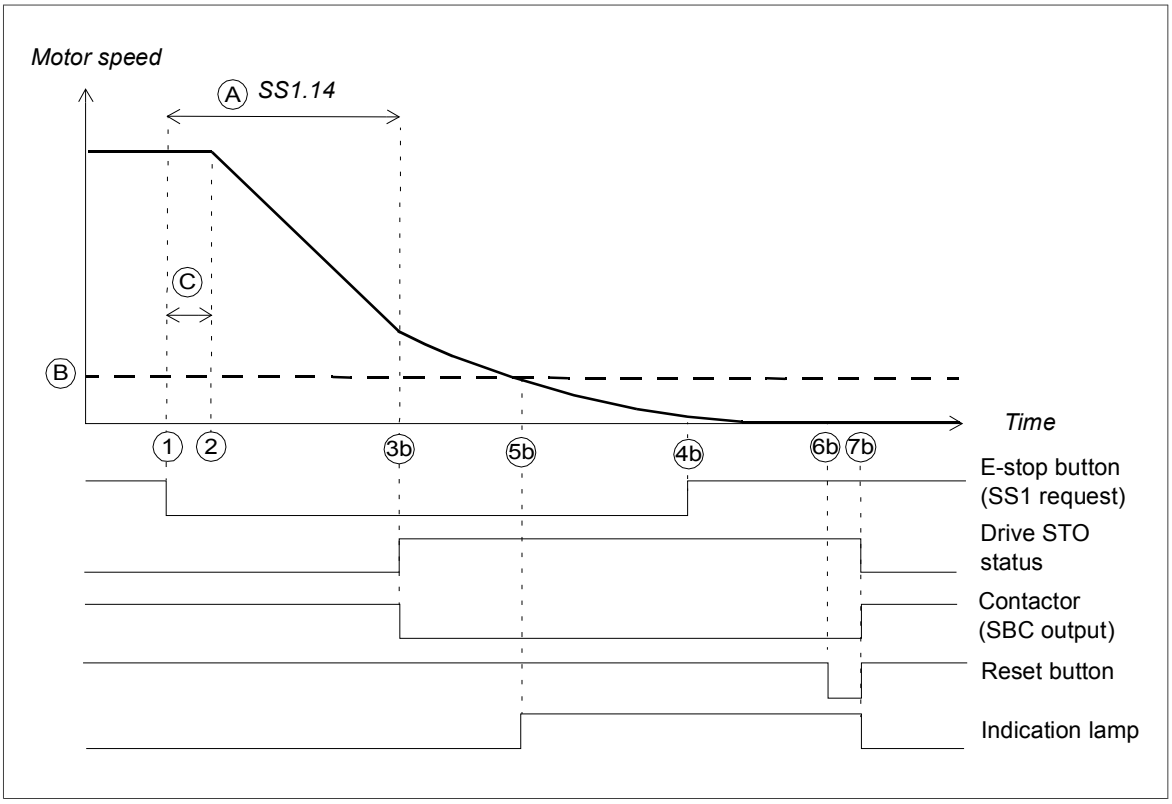
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. a) The motor speed goes below the zero speed limit (B). The FSO module activates the drive STO and SBC functions (this opens the main contactor/breaker). The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgment of the STO function is possible.

   Note: You can set an additional delay for the STO and SBC activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).
4. a) Time A has elapsed. The STO function is already active. In this case, this time has no effect.
5. a) The user releases the emergency stop button.

6. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. a) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not reach the zero speed limit within the user-defined time

Time A has elapsed from the emergency stop command (step 1) but the motor speed still exceeds the zero speed limit.



A	Security delay: When time A has elapsed from the start of the timer (step 1), the FSO module activates drive STO and SBC functions (case B). Activation of the SBC function opens the main contactor/breaker). In case A, the FSO module has already activated the STO and SBC functions. This is a user-defined value (parameter *SS1.14 SS1-t delay for STO*).
B	Zero speed limit: Speed limit for activating the drive STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.52 Zero speed with encoder*).
C	Safety function response time.

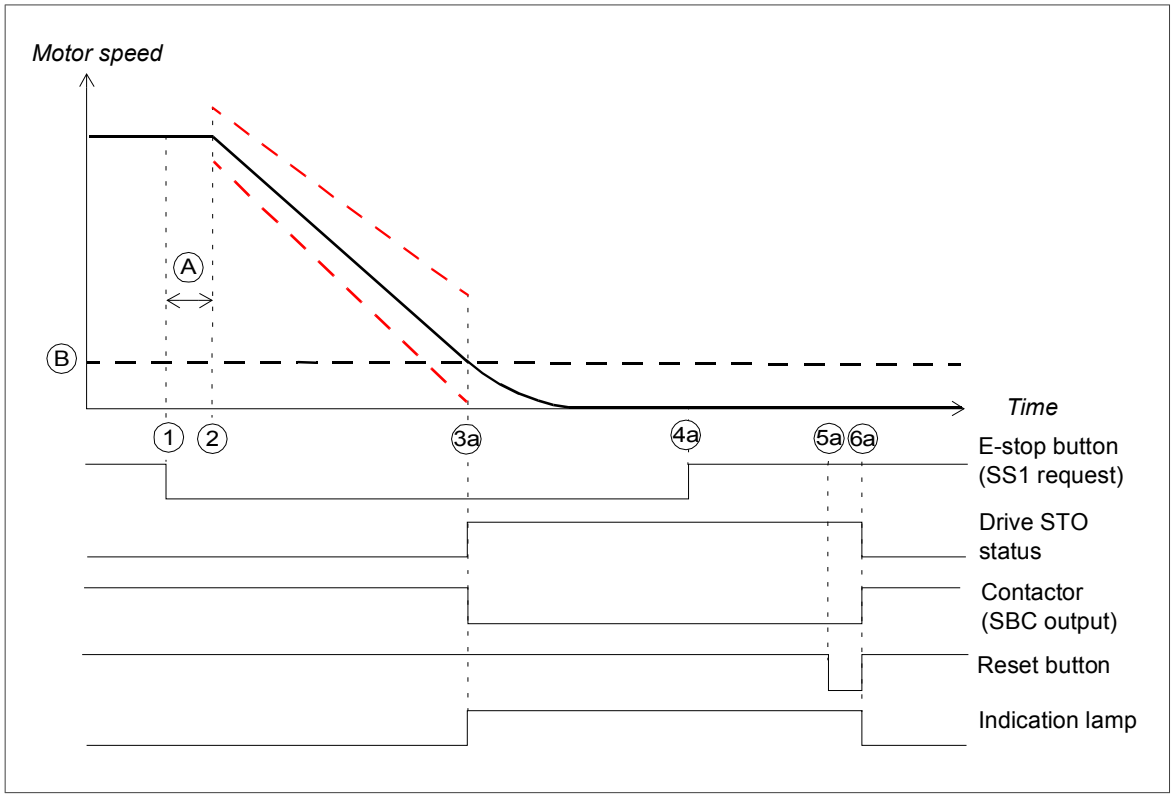
1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module). The FSO module starts a timer for delay A.
2. The drive starts to decelerate the motor along the user-defined stop ramp (SAR1 parameter *200.112 SAR1 ramp time to zero*).
3. b) The FSO module activates the drive STO and SBC functions, and opens the main contactor/breaker. The motor coasts to a stop.
4. b) The motor speed reaches the zero speed limit (B). The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgement of the STO function is possible.
5. b) The user releases the emergency stop button.

6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Emergency stop, stop category 1 with ramp monitoring

This time scheme diagram illustrates the operation of the Emergency stop, stop category 1 safety function with ramp monitoring when a safety encoder is used. This option uses the Safe stop 1 (SS1) function of the FSO-21 module.

Case A: The motor speed reaches the zero speed limit within the user-defined stop ramp monitoring window



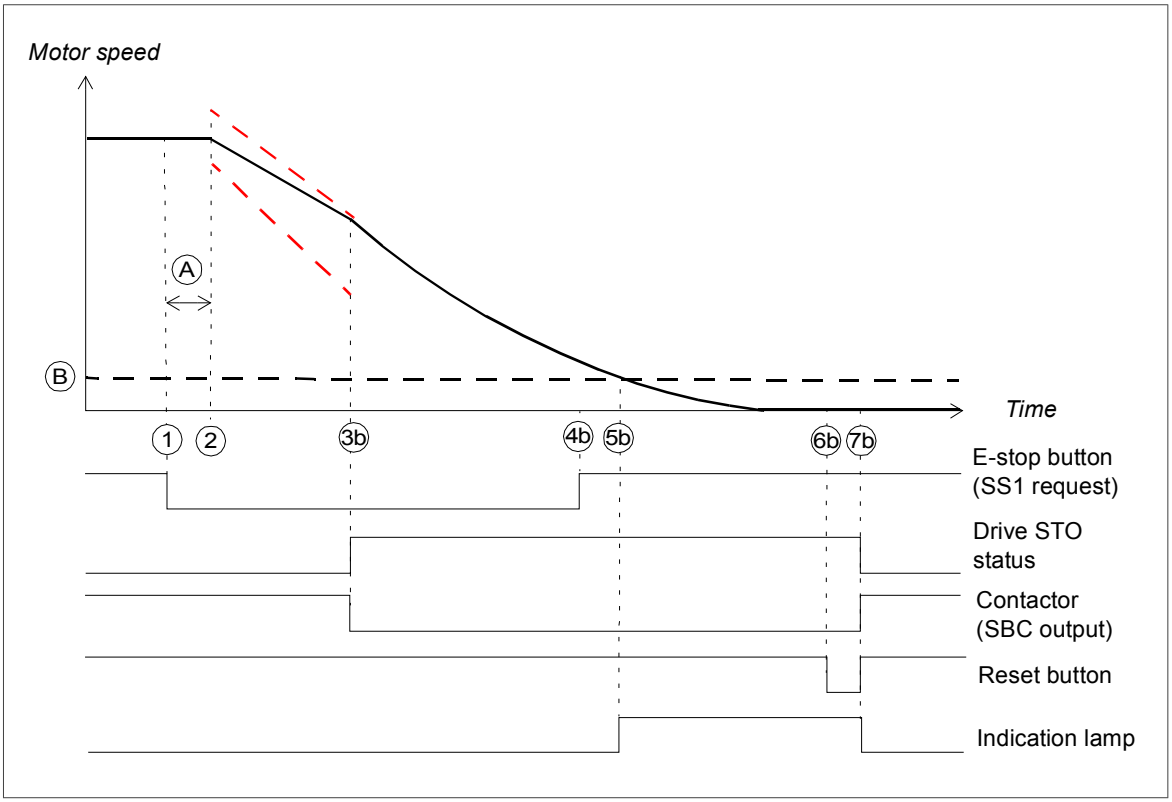
A	Safety function response time.
B	Zero speed limit: Speed limit for activating the STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.52 Zero speed with encoder*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).

3. a) The motor speed reaches the zero speed limit (B). The FSO module activates the drive STO and SBC functions (this opens the main contactor/breaker) and stops the ramp monitoring. The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgment of the STO function is possible.

   Note: You can set an additional delay for the STO and SBC activation (parameter *SS1.15 SS1-r ramp zero speed delay for STO*).
4. a) The user releases the emergency stop button.
5. a) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
6. a) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The drive is ready for a restart.

Case B: The motor speed does not follow the user-defined stop ramp monitoring window



A	Safety function response time.
B	Zero speed limit: Speed limit for activating the STO and SBC functions. Activation of the SBC function opens the main contactor/breaker. This is a user-defined value (parameter *FSOGEN.52 Zero speed with encoder*).

1. The user pushes the emergency stop button (this activates the SS1 function of the FSO module).
2. The drive starts to decelerate the motor along the user-defined stop ramp. The FSO module starts the ramp monitoring (SAR1 parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*).
3. b) The FSO module activates the drive STO and SBC functions, opens the main contactor/breaker and stops the ramp monitoring. The motor coasts to a stop.
4. b) The user releases the emergency stop button.

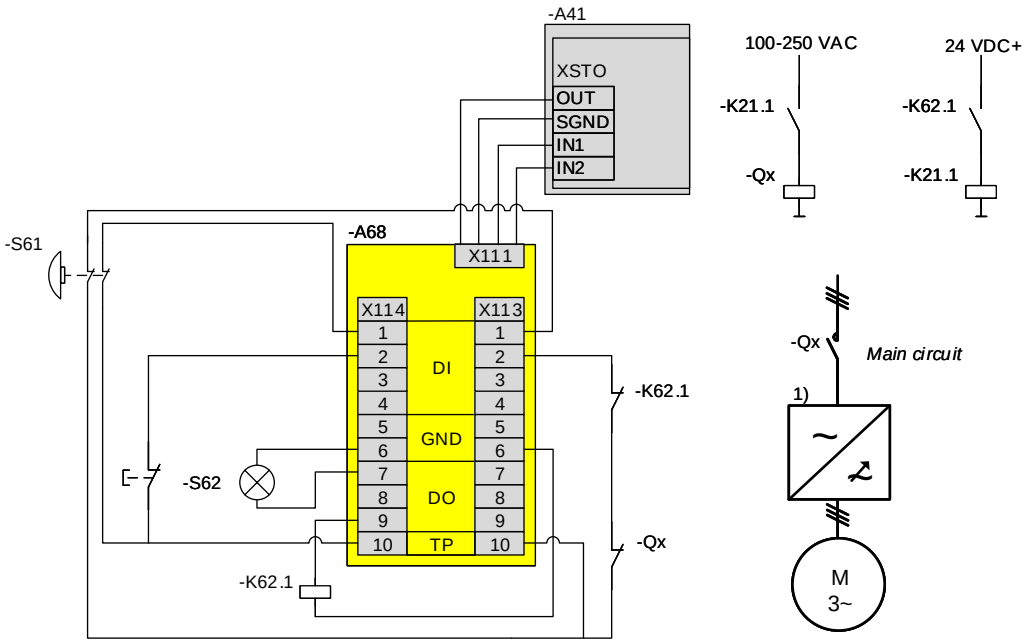
5. b) The motor speed reaches the zero speed limit (B). The emergency stop indication lamp comes on. The user can push the reset button, that is, the acknowledgement of the STO function is possible.
6. b) The user pushes the reset button (this resets the emergency stop circuit and acknowledges the STO function).
7. b) The FSO module deactivates the STO function in the drive and closes the main contactor/breaker. The emergency stop indication lamp goes off. The user must reset the drive before it is ready for a restart (this is because the FSO module generates a fault to the drive after a limit hit [parameter *FSOGEN.62 STO indication safety limit*]).

Operation principle diagrams

These diagrams are example circuit diagrams without the safety encoder interface.

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.

ACS880-07 drives, frames R6 to R11 and ACS880-17/-37 drives, frame R8

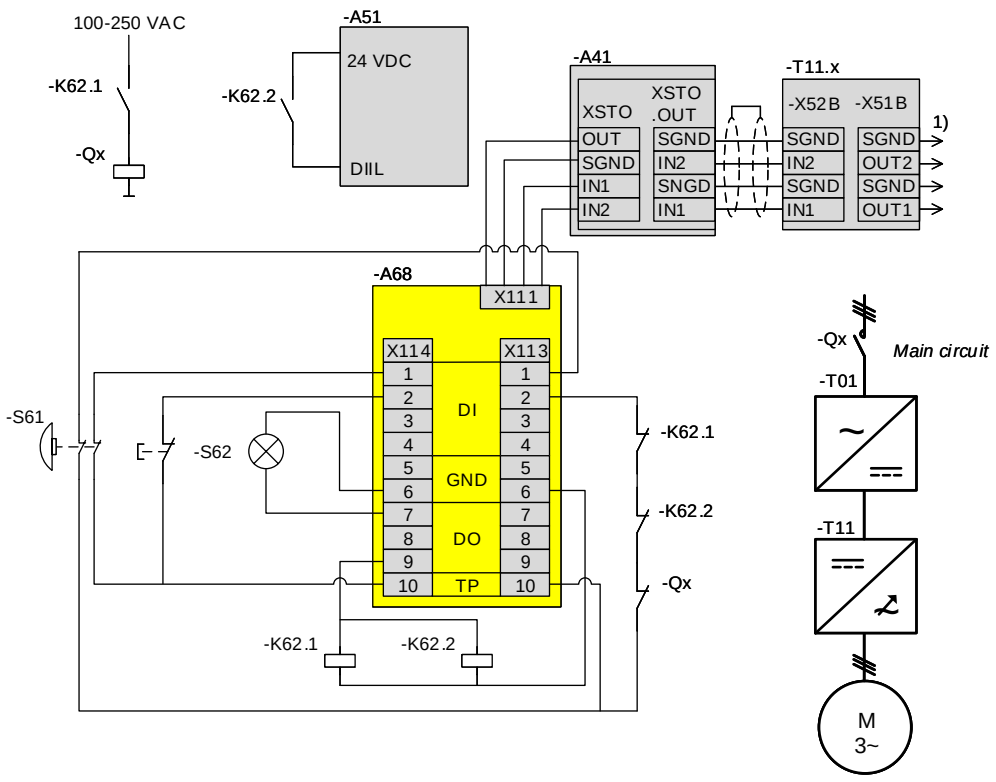


1)	Drive module
A41	Inverter control unit
A68	Safety functions module FSO-12/-21
S61	Emergency stop button
S62	Emergency stop reset button with indicator light
K21.1	Safety relay
K62.1	Safety relay
Qx	Main contactor/breaker (Q2 or Q1)
X111	STO connections to inverter control unit

X113, X114	Terminal block in the FSO module
TP	Test pulse(s) for digital input

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]. This activates the safety function in the FSO module.
2	Emergency stop, stop category 0: The FSO module [A68] activates the drive STO function and opens the main contactor/breaker [Qx]. The motor coasts to a stop. Emergency stop, stop category 1: The drive decelerates the motor to zero speed. The FSO module [A68] then activates the drive STO function and opens the main contactor/breaker [Qx].
3	The emergency stop reset button indicator light [S62] comes on.
4	Normal operation resumes after the user: • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62], which resets the emergency stop circuit and closes the main contactor/breaker [Qx] • switches the external start signal of the drive off and on (only in external control mode) • resets the drive if a fault was generated (see FSO parameter *FSOGEN.61 STO indication ext request*, and drive parameter *31.22 STO indication run/stop*).

ACS880-07/07LC drives, frames n×DXT + n×R8i

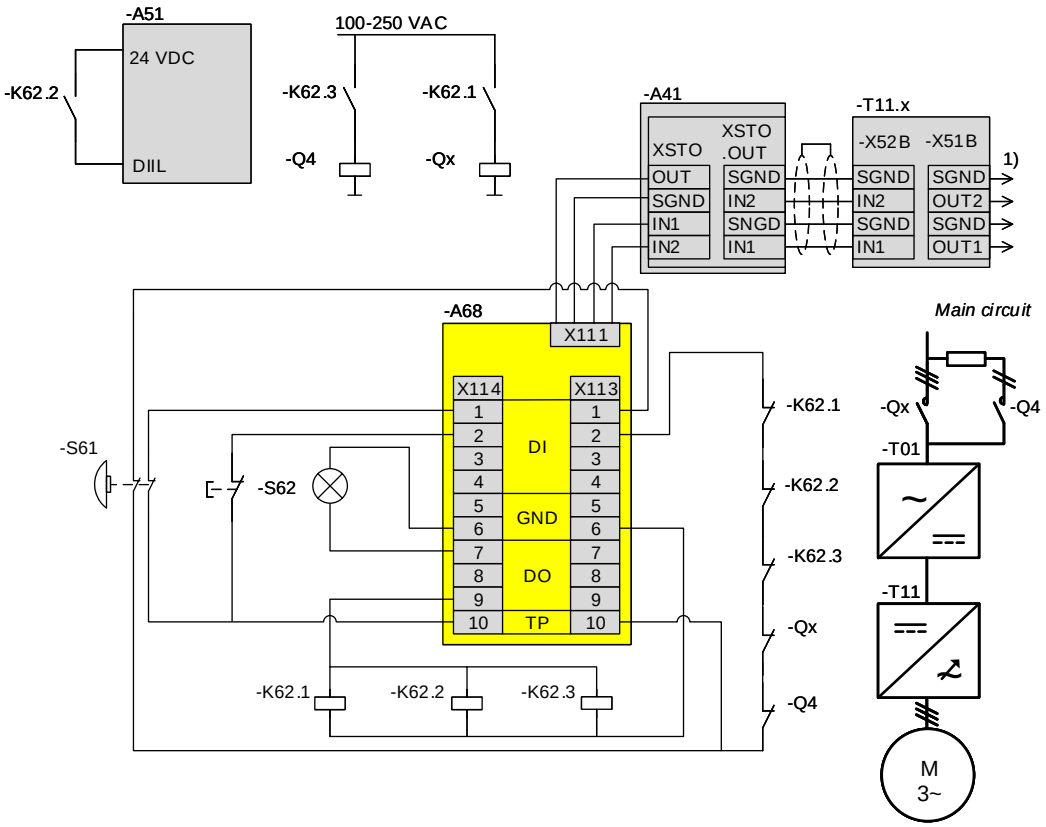


1)	To parallel inverter modules (if any)
A41	Inverter control unit

A51	Supply control unit
A68	Safety functions module FSO-12/-21
S61	Emergency stop button
S62	Emergency stop reset button with indicator light
K62.1	Safety relay
K62.2	Safety relay
Qx	Main contactor or breaker
X111	STO connections to inverter control unit
X113, X114	Terminal block in the FSO module
T01	Supply unit
T11	Inverter unit
T11.1-T11.x	Inverter module(s) under inverter unit T11
TP	Test pulse(s) for digital input

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]. This activates the safety function in the FSO module.
2	Emergency stop, stop category 0: The FSO module [A68] activates the drive STO function and opens the main contactor/breaker [Qx]. The motor coasts to a stop. Emergency stop, stop category 1: The drive decelerates the motor to zero speed. The FSO module [A68] then activates the drive STO function and opens the main contactor/breaker [Qx].
3	The emergency stop reset button indicator light [S62] comes on.
4	The DIIL input of the supply control [A51] is de-energized. This gives the emergency stop command to the supply unit.
5	Normal operation resumes after the user: • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62], which resets the emergency stop circuit and closes the main contactor/breaker [Qx] • switches the external start signal of the drive off and on (only in external control mode) • resets the inverter unit if a fault was generated (see FSO parameter *FSOGEN.61 STO indication ext request*, and drive parameter *31.22 STO indication run/stop*).

ACS880-17/17LC/37/37LC drives, frames n×R8i + n×R8i



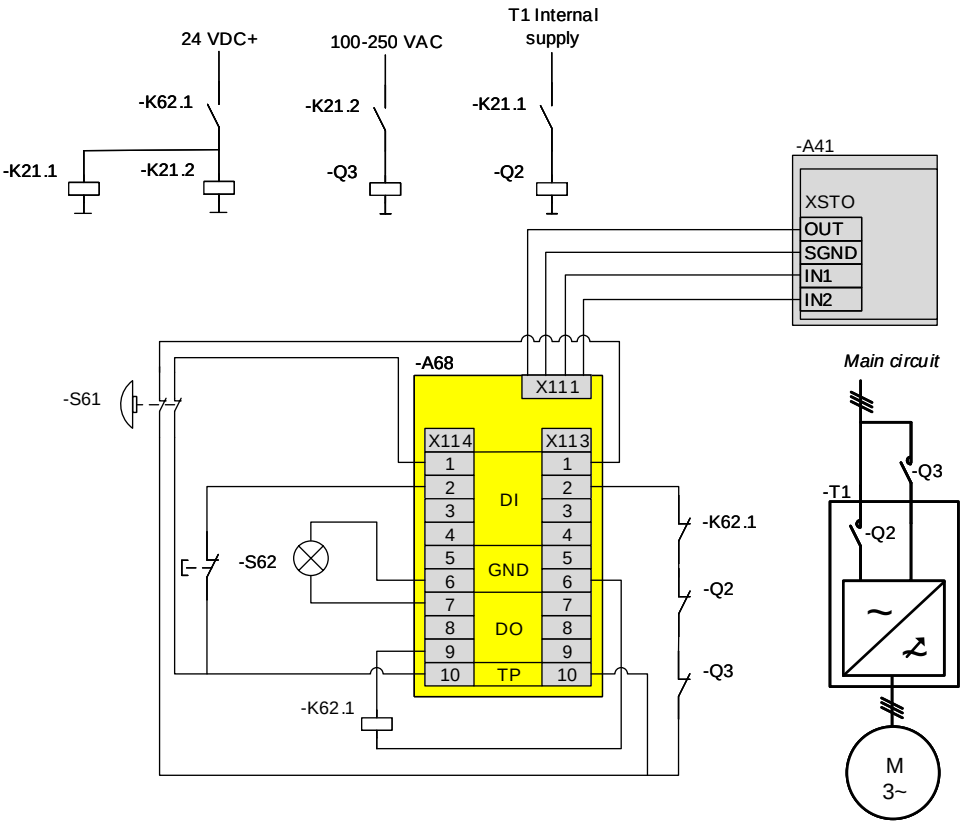
1)	To parallel inverter modules (if any)
A41	Inverter control unit
A51	Supply control unit
A68	Safety functions module FSO-12/-21
S61	Emergency stop button
S62	Emergency stop reset button with indicator light
K62.1	Safety relay
K62.2	Safety relay
K62.3	Safety relay
Qx [1)]	Main contactor/breaker (Q2 or Q1)
Q4	Charging contactor
X113, X114	Terminal block in the FSO module
X111	STO connections to inverter control unit
T01	Supply unit

T11	Inverter unit
T11.1-T11.x	Inverter module(s) under inverter unit T11
TP	Test pulse(s) for digital input

1) Component can also be installed by the customer.

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]. This activates the safety function in the FSO module.
2	Emergency stop, stop category 0: The FSO module [A68] activates the drive STO function and opens the main contactor/breaker [Qx]. If the emergency stop is activated during charging, the charging contactor [Q4] is also opened. The motor coasts to a stop. Emergency stop, stop category 1: The drive decelerates the motor to zero speed. The FSO module [A68] then activates the drive STO function and opens the main contactor/breaker [Qx]. If the emergency stop is activated during charging, the charging contactor [Q4] is also opened.
3	The emergency stop reset button indicator light [S62] comes on.
4	The DIIL input of the supply control [A51] is de-energized. This gives the emergency stop command to the supply unit.
5	Normal operation resumes after the user: • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62], which resets the emergency stop circuit and closes the main contactor/breaker [Qx] • switches the external start signal of the drive off and on (only in external control mode) • resets the drive/inverter unit if a fault was generated (see FSO parameter *FSOGEN.61 STO indication ext request*, and drive parameter *31.22 STO indication run/stop*).

ACS880-17/37 drives, frame R11



1)	Main contactor control
A41	Inverter control unit
A68	Safety functions module FSO-12/-21
S61	Emergency stop button
S62	Emergency stop reset button with indicator light
K62.1	Safety relay
K21.1	Safety relay
K21.2	Safety relay
Q2	Main contactor
Q3	Charging contactor
X111	STO connections to inverter control unit
X113, X114	Terminal block in the FSO module
T1	Drive module R11
TP	Test pulse(s) for digital input

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]. This activates the safety function in the FSO module.
2	Emergency stop, stop category 0: The FSO module [A68] activates the drive STO function, opens the main contactor [Q2], and opens the charging supply contactor [Q3]. Emergency stop, stop category 1: The drive decelerates the motor to zero speed. The FSO module [A68] then activates the drive STO function, opens the main contactor [Q2], and opens the charging supply contactor [Q3].
3	The emergency stop reset button indicator light [S62] comes on.
4	Normal operation resumes after the user: • releases the emergency stop button [S61] to normal (up) position • pushes the emergency stop reset button [S62], which resets the emergency stop circuit and closes the main contactor [Q2] • switches the external start signal of the drive off and on (only in external control mode) • resets the drive/inverter unit if a fault was generated (see FSO parameter *FSOGEN.61 STO indication ext request*, and drive parameter *31.22 STO indication run/stop*).

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.

Examples of different failures:

- a short or open circuit or redundancy failure of the emergency stop button wiring chain
- a missing main contactor/breaker feedback signal
- an internal failure in the FSO or FSE-31 modules, the safety encoder or the drive STO.

This section describes the fault reaction functions in the FSO and FSE-31 modules, the safety encoder and the drive STO.

FSO module

The fault reaction function of the FSO module trips the drive if it detects a failure. The FSO module activates the STO or Safe stop emergency (SSE) function. This activates the drive STO function and opens the main contactor/breaker. The drive STO function is active until the fault is repaired.

The FSO module goes into Fail-safe mode. The STATUS/FAULT LED of the FSO module is red until the fault is repaired. To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module. See section *Resetting the FSO module (page 38)*.

For more information, see the drive firmware manual and the FSO module user’s manual.

Resetting the FSO module

To reset the FSO module:

- switch the power off and on, or
- press the Boot FSO button on the Safety view of Drive composer pro, or
- use the drive parameter *96.09 FSO reboot*.

FSE-31 module

When a safety function is active, the fault reaction function of the FSO module trips the drive if it detects a failure in the FSE-31 module. The FSO module activates the STO function. This activates the drive STO function and opens the main contactor/breaker. The drive STO function is active until the fault is repaired.

When there are no active safety functions, the fault reaction function depends on the value of FSO parameter *S_ENCGEN.11 FSE diagnostic failure reaction*.

The FSO module goes into Fail-safe mode. The STATUS/FAULT LED of the FSO module is red and the STATUS LED of the FSE-31 module is off until the fault is repaired. Also the drive indicates some of the FSE-31 module faults. To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module. See section *Resetting the FSO module (page 38)*.

For more information, see the drive firmware manual, *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]) and *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

Safety encoder

Internal faults of the safety encoder and the FSE-31 module will cause the FSO module to go into Fail-safe mode.

The STATUS/FAULT LED of the FSO module is red and the ENC STATUS LED of the FSE-31 module is off until the fault is repaired. Also the drive indicates a safety encoder fault.

To exit the Fail-safe mode, remove the cause of the fault and reset the FSO module. See section *Resetting the FSO module (page 38)*.

The safety encoder goes into Safe state. To exit Safe state, remove the cause of the fault and reboot the safety encoder (for example, by switching the power off and on).

For more information, see the drive firmware manual, *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]) and *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

STO function in the drive

The STO function in the drive has internal fault diagnostics and a fault reaction function, which causes a fault trip if it detects a redundancy fault of STO control signals or an internal failure. See the hardware and firmware manuals of 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

One emergency stop button and one reset button are installed on the cabinet door and wired to the FSO module at the factory. There are double contacts in the emergency stop button and double wiring (redundant two-channel connection) between the button and the FSO module.

There is an extension terminal block [X68] for the connections to the FSO module inside the drive cabinet. The FSO module connectors [X113] and [X114] have been wired to [X68]. The tables below show the connections between the extension terminal block and the FSO module.

FSO X113	1	2	3	4	5	6	7	8	9	10
X68	3	4	5	6	7	8, 9	10	11	12	13, 14, 15, 16

FSO X114	1	2	3	4	5	6	7	8	9	10
X68	17	18	19	20	21	22, 23	24	25	26	27, 28, 29, 30

If necessary, install additional emergency stop buttons on site. See the tables above and 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, or if the channels are connected together, the cross fault detection of the FSO module detects a redundancy fault and activates the fault reaction function.

   Note: If you change the input and the parameter settings in the FSO module into a one-channel implementation, it has an effect on the safety integrity of the safety function. In this case, the safety data that ABB has calculated for the function is not valid.
3. Use shielded, twisted pair cables. ABB recommends double-shielded cable and gold-plated contacts in the emergency stop button.
4. The maximum permitted cable length between the drive and the emergency stop button is 250 m (820 ft).
5. Obey the general control cable installation instructions given in the drive hardware manual and in the FSO module user's manual.

If necessary, install additional reset buttons and indication lamps for the emergency stop circuit on site. ABB recommends gold-plated NC contacts in the reset button. The maximum permitted cable length between the drive and the reset button (for the whole loop) is 250 m (820 ft). See the circuit diagrams of the delivery. Obey the general control cable installation instructions given in the hardware manual and in the FSO module user's manual.

When a safety pulse encoder is used, ABB installs the FSO-21 and FSE-31 modules and the wirings between the FSO module and the drive at the factory.

The user must wire the safety pulse encoder to the FSE-31 module on site. Obey the instructions of the encoder manufacturer as well as the following rules:

- Use a double-shielded, twisted pair cable.
- The maximum permitted cable length between the safety pulse encoder and the FSE-31 module is 300 m (980 ft).

For more information, see *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

Customer-installed main breaker in ACS880-07LC/17LC/37LC drives

ACS880-07LC/17LC/37LC drives can be delivered without a factory-installed main breaker. In these cases, the customer must install and connect the main breaker to the safety circuit as described in the circuit diagrams.

5

Parameter settings

Contents of this chapter

This chapter contains the parameters that you must set in the FSO module and the drive.

Competence

The person who configures the safety functions in the FSO module must be a competent person as required by IEC 61508-1 clause 6. In this context, the person must have expertise and knowledge of functional safety, the safety functions and the configuration of the FSO module. ABB has training courses on the FSO module available.

FSO module parameter settings

The default parameter values shown below are example values for the safety functions described in this manual. Actual parameter values of the delivery can be different. Always make sure that the parameter settings agree with the application requirements.

You need the Drive composer pro PC tool to set the FSO module parameters, and a password to be able to download the configuration to the FSO module from Drive composer pro. For the default password of the FSO module, see the FSO module user's manual. For more information on the Drive composer pro PC tool, see *Start-up and maintenance PC tool Drive composer user's manual* (3AUA0000094606 [English]).

Note: When the motor is running, you cannot change the password, adjust parameter values, or upload or download the FSO configuration file.

When using SS1, SLS or SMS safety functions: The FSO module activates the STO function if the motor speed hits a ramp monitoring limit during the deceleration ramp. The FSO module activates the SSE function if the motor speed hits a trip limit during SLS or SMS monitoring. Thus, you must also configure the STO and SSE functions.

Follow the configuration steps described in the FSO module user's manual, chapter *Configuration*.

There are parameters that you must always set and parameters that are related to certain safety functions only. These tables list all the parameters that you must check and set for the option +Q978. The example values apply only to the option +Q978.

General parameters

These parameters are common to all safety functions.

Index	Name	Example value	Description
FSOGEN.11	Stop completed output	DO X114:7	Sets the digital output that indicates the completion of any stop function. Active when the FSO module has completed the STO, SSE or SS1 function. For the option +Q978, ABB has configured the emergency stop indication lamp to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
FSOGEN.21	Motor nominal speed	1500 rpm	Sets the nominal motor speed. Adjust the default value to meet the ratings of the motor in use.
FSOGEN.22	Motor nominal frequency	50 Hz	Sets the nominal motor frequency. Adjust the default value to meet the ratings of the motor in use.
FSOGEN.41	Power-up acknowledgement	Automatic	Sets the power-up acknowledgement method of the FSO module. *Automatic*: You do not need to push a reset button after switching on the FSO module. The FSO module generates the acknowledgement signal automatically after the power-up. *Manual*: The FSO module reads the external acknowledgement signal through the digital input defined by parameter *FSOGEN.42*. Make sure that the value is *Automatic*.
FSOGEN.42	Acknowledgement button input	DI X114:2	Sets the digital input for the acknowledgment signal when parameter *FSOGEN.41 Power-up acknowledgement* or *STO.02 STO acknowledgement* has value *Manual*. For the option +Q978, ABB has configured the emergency stop reset button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
FSOGEN.51	Zero speed without encoder	90 rpm	Sets the general zero speed limit for safety functions when no safety encoder is in use. Emergency stop, stop category 0: This value has no effect in the operation. Emergency stop, stop category 1: The FSO module activates the drive STO function and opens the main contactor/breaker when the drive has decelerated the motor speed below this value. Adjust the default value when necessary.

Index	Name	Example value	Description
FSOGEN.52	Zero speed with encoder	10 rpm	Sets the general zero speed limit for safety functions when a safety encoder is in use. Emergency stop, stop category 0: The indication lamp comes on when the motor speed goes below this value. Adjust the default value when necessary. Emergency stop, stop category 1: The FSO module activates drive STO function and opens the main contactor/breaker when the drive has decelerated the motor speed below this value. Adjust the default value when necessary. **Note:** This parameter is used only with FSO-21 and when a safety encoder is used in the application.
FSOGEN.61	STO indication ext request	Warning	Sets the type of the indication that the FSO module generates and sends to the drive after external requests that end to a successful activation of the drive STO function (STO, SSE or SS1). In the safety functions described in this manual, you can use this indication as the Emergency stop indication message. Adjust the default value when necessary.
FSOGEN.62	STO indication safety limit	Fault	Sets the type of the indication that the FSO module generates and sends to the drive/inverter unit for limit hits during ramp and time monitoring of safety ramps SAR0 and SAR1. Emergency stop, stop category 0: This value has no effect in the operation. Emergency stop, stop category 1: When the motor speed does not follow the stop ramp or the time limit is exceeded, the FSO module activates the STO function and generates this user-defined indication. Check the default setting and adjust if necessary. If you select *Fault*, you must reset the drive before you can restart it.

Parameters for the STO function

These parameters are related to the STO function of the FSO module. The Emergency stop, stop category 0 option uses this function. The FSO module can activate the STO function in internal fault situations.

Index	Name	Example value	Description
STO.02	STO acknowledgement	Manual	Sets the acknowledgement method used in the STO, SSE and SS1 functions. *Manual*: The FSO module reads the external acknowledgment signal through the digital input defined by parameter *FSOGEN.42*. In the safety functions described in this manual, the user acknowledges the safety function manually with the emergency stop reset button. Make sure that the value is *Manual*. **WARNING!** If the value is *Automatic*, the FSO module resets the STO function automatically after the user has released the emergency stop button and the drive can restart automatically (if automatic start mode is used). This can cause danger.
STO.11	STO input A	Stop cat. 0: DI X113:1 & X114:1 Stop cat. 1: None	Sets the digital input that is connected to the primary input of the STO function. Emergency stop, stop category 0: For the option +Q978, ABB has connected the emergency stop button to this digital input at the factory. Make sure that the setting corresponds to the circuit diagrams of the delivery. Emergency stop, stop category 1: Make sure that this parameter has value None. (An external signal cannot start the STO function.) **Note:** The default value after factory reset is *DI X113:1&X114:1*. Always check this parameter after factory reset.
STO.13	Restart delay after STO	2000 ms	Sets the time after which the restart of the drive is allowed after the FSO module has activated the drive STO function and opened the main contactor/breaker. With this parameter, you can allow a restart of the drive before the motor has stopped (fly-start). This parameter is valid only if the STO function is requested from STO input A (*STO.11*). Emergency stop, stop category 0: Adjust the value when necessary. If you do not want to use the fly-start feature, set this parameter to the same value as parameter *SBC.13*. Emergency stop, stop category 1: This value has no effect.

Index	Name	Example value	Description
SBC usage			
SBC.11	STO SBC usage	Delayed brake	Sets how the mechanical brake is used together with the STO function. Mechanical brake usage is always coupled with the STO function. In this manual, it is assumed that you do not use a mechanical brake. Instead, the SBC function is used to control the auxiliary safety relay(s) which is connected to the main contactor/breaker. Make sure that the value is *Delayed brake*.
SBC.12	STO SBC delay	0	Sets the time after which the FSO module activates the SBC function after it has activated the STO function. In this manual, the SBC function is used to control the main contactor/breaker. It is assumed that you do not use a mechanical brake. When the value is zero, the main contactor/breaker and drive STO circuit are opened at the same time. Make sure that the value is *0*. **Note:** The default value after factory reset is *3,600,000 ms*. Always check this parameter after factory reset.
SBC.13	SBC time to zero speed	1000 ms	Sets the time after which the motor has stopped and the acknowledgment (and restart of the drive) is allowed after coast stop in the STO, SSE and SS1 functions. Set the value of this parameter to the estimated time in which the motor coasts to a stop from the maximum speed. Emergency stop, stop category 0: This parameter sets the time after which the STO function is completed and the indication lamp comes on. Adjust the value when necessary. Emergency stop, stop category 1: This parameter is used only when the motor speed does not follow the ramp settings or the time monitoring limit is exceeded and the FSO module activates the STO and SBC functions. Adjust the default value when necessary. **Note:** The default value after factory reset is *3,600,000 ms*. Always check this parameter after factory reset. When a safety encoder is used: This parameter is relevant only if an encoder or FSE-31 module failure occurs. The FSO module goes into the Fail-safe mode and activates the STO and SBC functions (this also opens the main contactor/breaker). For more information, see the FSO-21 module user's manual.

Index	Name	Example value	Description
SBC.21	SBC output	DO X113:9 & X114:9	Sets the digital output that is connected to the SBC output. In safety functions described in this manual, the SBC function is used to control the auxiliary safety relay(s) that is connected to the main contactor/breaker of the drive by default. This value must be the same as the value of parameter *SAFEIO.21*. Make sure that the setting corresponds to the circuit diagrams of the delivery.
SBC.22	SBC feedback action	STO	Sets the action that the FSO module takes when there is a problem with the SBC feedback. *STO*: The FSO module goes into the Fail-safe mode and activates the drive STO function.

Parameters for the SSE function

These parameters are related to the Safe stop emergency (SSE) function of the FSO module. The FSO module can activate the SSE function in internal fault situations.

Index	Name	Example value	Description
SSE.13	SSE function	Immediate STO or Emergency ramp	Sets the type of the SSE function. *Immediate STO*: The FSO module activates the drive STO function immediately after the SSE request. *Emergency ramp*: The FSO module first ramps down the motor speed and when the speed has reached the zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*), it activates the STO function. SAR0 parameters define the deceleration ramp (for more information, see the FSO module user's manual). For the option +Q978, ABB sets this parameter to value *Immediate STO* at the factory. Adjust the default value when necessary. **Note:** The default value after factory reset is *Emergency ramp*. Always check this parameter after factory reset.
SBC usage			
SBC.15	SSE/SS1 SBC speed	0 rpm	Sets the absolute speed below which the FSO module activates the brake (SBC) while ramping. *0 rpm*: The feature is not in use. In the safety functions described in this manual, this feature is not used. The SBC activation is connected to the STO function with parameter *SBC.11*. Make sure that the value is *0 rpm*.

I/O parameters

For indication lamps, set the logic state of the corresponding digital output to *Active high*. For digital inputs and outputs, set the diagnostic pulse setting to *On*.

Safety relay 1 settings are used to control the main contactor/breaker.

Index	Name	Example value	Description
SAFEIO.21	Safety relay 1 output	DO X113:9 & X114:9	Sets the digital output connected to safety relay 1. For the option +Q978, ABB has connected the auxiliary safety relay(s) which controls the main contactor/breaker to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery. To connect the safety relay to a certain output signal of the FSO module, you must set the same digital outputs in the output parameter for that signal (see parameter *SBC.21*). **Note:** This digital output must always be redundant. Otherwise the feedback signal of the safety relay cannot be used (see parameter *SAFEIO.22*). In the safety functions described in this manual, there is only one physical connection from the FSO I/O to the auxiliary safety relay (DO X114:9), but in this parameter setting, the output must be redundant. Do not use digital output DO X113:9 for any other purpose.
SAFEIO.22	Safety relay 1 feedback	DI X113:2	Sets the digital feedback input of safety relay 1. For the option +Q978, ABB has configured the auxiliary safety relay(s) and the main contactor/breaker to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.23	Safety relay 1 feedback type	Mechanically linked NC contacts	Sets the type of the feedback signal for safety relay 1. *Mechanically linked NC contacts*: Feedback of the safety relay is NC (normally closed, that is, inverted state compared with the relay). Make sure that the value is *Mechanically linked NC contacts*.
SAFEIO.33	DI X113:1 diag pulse on/off	On [1)]	Sets the diagnostic pulse of digital input X113:1 on or off. *On*: The input monitors that it receives test pulses. For the option +Q978, ABB has configured the emergency stop button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.

Index	Name	Example value	Description
SAFEIO.37	DI X114:1 diag pulse on/off	On[1)]	Sets the diagnostic pulse of digital input X114:1 on or off. *On*: The input monitors that it receives test pulses. For the option +Q978, ABB has configured the emergency stop button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.38	DI X114:2 diag pulse on/off	On	Sets the diagnostic pulse of digital input X114:2 on or off. *On*: The input monitors that it receives test pulses. For the option +Q978, ABB has configured the emergency stop reset button to this digital input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.55	DO X113:9 diag pulse on/off	On	Sets the diagnostic pulse of digital output X113:9 on or off. *On*: The output monitors that it receives test pulses. For the option +Q978, ABB has configured the auxiliary safety relay(s) to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.58	DO X114:9 diag pulse on/off	On	Sets the diagnostic pulse of digital output X114:9 on or off. *On*: The output monitors that it receives test pulses. For the option +Q978, ABB has configured the auxiliary safety relay(s) to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.
SAFEIO.74	DO X114:7 logic state	Active high	Sets the logic state of digital output X114:7. *Active high*: The digital output is on when the indicated signal is active. For the option +Q978, ABB has configured the emergency stop indication lamp to this digital output at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery.

1) The safety data given in this manual is based on the assumption that this diagnostic measure for the emergency stop button wiring is active (On). If pulsing is disabled, other measures should be considered to ensure sufficient diagnostic coverage of the emergency stop button wiring.

Parameters for Emergency stop, stop category 0

The Emergency stop, stop category 0 safety function uses the STO function of the FSO module, see section *Parameters for the STO function (page 46)*. There are no additional parameters related to this function.

Parameters for Emergency stop, stop category 1

The Emergency stop, stop category 1 safety function uses the SS1 function of the FSO module. Set these parameters only for this function.

Index	Name	Example value	Description
SS1.01	SS1 activity and version	Version 1	Activates or deactivates the SS1 function and shows the version of the SS1 function. *Version 1*: Activates version 1 of the SS1 function.
SS1.11	SS1 input A	DI X113:1 & X114:1	Sets the digital input that is connected to the primary input of the SS1 function. For the option +Q978, ABB has connected the emergency stop button to this input at the factory. Make sure that this value corresponds to the actual wiring. See the circuit diagrams of the delivery. Make also sure that you do not use the same input for other functions at the same time (such as the STO function).
SS1.13	SS1 type	SS1-r or SS1-t	Sets the method used for the SS1 monitoring. Adjust the default value when necessary. Time monitoring (SS1-t): The FSO module monitors that a user-defined deceleration time limit is not exceeded. (See parameter *SS1.14*.) Ramp monitoring (SS1-r): The FSO module monitors that the motor decelerates along a user-defined stop ramp. (See SAR1 ramp parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*.)
SS1.14	SS1-t delay for STO	20000 ms	Sets the SS1-t monitoring time after which the FSO module activates the drive STO and SBC at the latest, if the motor speed has not reached the zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*) yet. For more information, see the operation time scheme diagrams. Time monitoring: This value sets the security delay that the FSO module monitors. Adjust the default value when necessary. Ramp monitoring: This value has no effect in the operation.

Index	Name	Example value	Description
SS1.15	SS1-r ramp zero speed delay for STO	0 ms	Sets an extra delay time for the activation of the drive STO and SBC functions at the zero speed limit in the SS1 function. With this parameter, the FSO module delays the STO activation so that the drive is able to reach the axle zero speed before the FSO module activates the STO function. The delay counter starts when the motor speed reaches the zero speed limit (parameter *FSOGEN.51* or *FSOGEN.52*). After this delay has elapsed, the FSO module activates the drive STO and SBC functions. Activation of the SBC opens the main contactor/breaker. You can use this parameter when the motor rotates a high inertia load. **Note:** The FSO module activates the drive STO immediately if the drive stops modulating before the delay has passed (that is, the motor actual speed reaches 0 rpm). Adjust the default value when necessary.
SAR1 ramp settings			
200.112	SAR1 ramp time to zero	2000 ms	Sets the target time for the stop ramp SAR1 that is used in the SS1 function. Adjust the default value when necessary. Target time = The time in which the drive decelerates the motor from speed *200.202 SAR speed scaling* to zero. **Note:** With value *0 ms*, the drive uses the emergency stop ramp set by drive parameter *23.23* (see section *SS1 ramp parameters (page 56)*). Also in this case, the FSO module only monitors the actual ramp (ramp monitoring or time monitoring).
200.202	SAR speed scaling	1500 rpm	Sets a speed value that the FSO module uses as a reference point in ramp parameter calculations (see SAR1 ramp parameters *200.112*, *SARx.21*, *SARx.22* and *SARx.02*). Adjust the default value when necessary.
SARx.02	SAR initial allowed range	100 ms	Sets the initial allowed range for the SAR0/SAR1 ramp. This parameter delays the start of the ramp monitoring. The slope of the ramp stays the same as defined with parameters *200.202* and *SARx.22*. For more information, see the FSO module user's manual. Time monitoring: This value has no effect in the operation. Ramp monitoring: Adjust the default value according to the application requirements.

Index	Name	Example value	Description
SARx.21	SAR1 min ramp time to zero	1000 ms	Sets the minimum ramp time for the SAR1 ramp monitoring. Time monitoring: This value has no effect in the operation. Ramp monitoring: Sets the minimum stop ramp time for the emergency stop. Adjust the default value according to the application requirements. **Note:** With value *0 ms*, the minimum ramp is not monitored.
SARx.22	SAR1 max ramp time to zero	3000 ms	Sets the maximum ramp time for the SAR1 ramp monitoring. Time monitoring: This value has no effect in the operation. Ramp monitoring: Sets the maximum stop ramp time for the emergency stop. Adjust the default value according to the application requirements.
SBC usage			
SBC.15	SSE/SS1 SBC speed	0 rpm	Sets the absolute speed below which the FSO module activates the brake (SBC) while ramping. *0 rpm*: The feature is not in use. In the safety functions described in this manual, this feature is not used. The SBC activation is connected to the STO function with parameter *SBC.11*. Make sure that the value is *0 rpm*.

Changing the stop category from 0 to 1

Stop category 0 is the default setting. This category uses the STO function of the FSO module. Stop category 1 uses the SS1 function of the FSO module.

To change the stop category to 1, set the parameters listed in section *Parameters for Emergency stop, stop category 1 (page 51)*, and those in this table. See also section *SS1 ramp parameters (page 56)*.

Index	Name	Preset value (stop cat. 0)	Value in stop cat. 1
STO.11	STO input A	DI X113:1 & X114:1	None
FSOGEN.51	Zero speed without encoder	90 rpm	If you do not use a safety encoder, adjust the default value to meet the motor in use.
FSOGEN.52	Zero speed with encoder	10 rpm	If you use a safety encoder, adjust the default value to meet the motor in use.
FSOGEN.62	STO indication safety limit	Fault	Adjust the default value when necessary.

FSE-31 module and safety pulse encoder related parameters

Set these parameters when you use a safety pulse encoder in the safety application.

Index	Name	Example value	Description
200.231	FSE 3X act and par version	Version 1	Activates the FSE-31 encoder interface and shows the version of the encoder parameter groups (91 and 92).
200.232	Number of encoders	Single encoder CH1	Shows the number of safety pulse encoders connected to the FSE-31 module.
S_ENCGEN.01	Safe pulse encoder version	Version 1	Activates the safety pulse encoder and shows the version parameter group S_ENCGEN.
S_ENCGEN.11	FSE diagnostic failure reaction	STO	Sets the action taken when there is a problem with the FSE-31 module. *STO*: The FSO module goes into Fail-safe mode and activates the drive STO function. **Note:** This parameter is relevant only when there are no active safety functions.
S_ENCGEN.14	Enc speed cross comp tolerance	1 rpm	Sets the encoder speed cross comparison tolerance. This defines how much the axle speed of the motor can change within 1 ms. Adjust the default value to meet the motor in use.
S_ENCGEN.41	Gear numerator encoder 1	1	Sets the rotation direction for the safety pulse encoder. With this parameter, you can change the rotation direction of the motor. Adjust the default value if necessary.
91.11	Module 1 type	FSE-31	Sets the type of the safety pulse encoder interface module 1.
91.12	Module 1 location	2	Sets the slot in which the safety pulse encoder interface module 1 is located.
92.01	Encoder 1 type	HTL1	Activates or deactivates the communication with the safety pulse encoder interface module 1 and sets the type for the safety pulse encoder.
92.02	Encoder 1 source	Module 1	Sets the safety pulse encoder interface module that the safety pulse encoder 1 is connected to.
92.10	Pulses/revolution	2048	Sets the number of HTL pulses per revolution for safety pulse encoder 1. Adjust the default value to meet the safety pulse encoder in use. Make sure that the value is according to the encoder nameplate.

Index	Name	Example value	Description
92.17	Accepted pulse freq of encoder 1	300 kHz	Sets the maximum pulse frequency range of encoder 1. Adjust the default value to meet the motor and safety pulse encoder in use. You can use this formula to define the value: r_max × ppr_enc + 10%, where • r_max = the maximum motor speed used in the application (or the motor nominal speed) • ppr_enc = Pulses/revolution of the safety pulse encoder (parameter *92.10*).

Drive parameter settings

The parameter setting in ACS880 primary control program:

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

To prevent the drive from generating a fault each time the FSO module activates the drive STO function, ABB recommends that you do not set parameter *31.22 STO indication run/stop* to value *Fault/Fault*, *Fault/Warning*, or *Fault/Event*.

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

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

The parameters are set at the factory. The supply unit parameter settings in the ACS880 supply control programs:

- parameter *121.04 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.

Additional parameter settings for ACS880-17/37, frames R8 and R11

The parameters are set at the factory.

The inverter unit parameter settings in the ACS880 primary control program:

- parameter *06.40 LSU CW user bit 0 selection* is set to Bit 7 (STO) of *06.18 Start inhibit status word*

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

- parameter *121.05 Emergency stop source* is set to Bit12- (user bit 0, inverted value) of *106.01 Main control word*

Safety pulse encoder parameters

The drive parameter settings in ACS880 primary control program when you use a pulse encoder:

- parameter *90.41 Motor feedback selection* is set to value *Encoder 1*.
- parameter *90.45 Motor feedback fault* is set to value *Warning*.

  Note: If you want that the drive trips on encoder faults, set this parameter to value *Fault*. For more information, see the firmware manual.
- parameter *92.21 Encoder cable fault mode* is set to value *A, B, Z*.

SS1 ramp parameters

You must set these parameters only for the Emergency stop, stop category 1 option. If FSO parameter *200.112 SAR1 ramp time to zero* is set to *0*, drive parameters define the stop ramp that is used in the SS1 function (stop category 1):

- *21.04 Emergency stop mode* is set to value *Eme ramp stop (Off3)*
- *23.23 Emergency stop time* is set to a suitable value.

Also in this case, the FSO module monitors the actual stop ramp (ramp monitoring or time monitoring).

For more information, see the firmware manual.

6

Use of the safety function

Contents of this chapter

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

Activating the safety function

1. Push the emergency stop button [S61]. The emergency stop is activated and the button locks in the “ON” (open) position.
   Depending on the stop category, either AAA1 FSO STO request (stop category 0) or AAA3 FSO SS1 request (stop category 1) is shown.
   When the emergency stop function is completed, the following indications are shown:
   - the emergency stop reset button indicator light [S62] on the cabinet door is on, indicating that it is now possible to reset the emergency stop function.
   - AA90 FSO stop completed is indicated.

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

The indications that the FSO module generates are configurable. For more information, see chapter *Parameter settings (page 43)* in this manual and chapter *Fault tracing* in the FSO module user’s manual.

Note: The indication lamp comes on also when the FSO module has completed a stop function after fault situations. Also, the indication lamp comes on momentarily when the drive is started.

Resetting the safety function

WARNING!
If the drive start signal is on, and the operating switch is set to ON (1), the drive starts automatically after the reset.

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 indication lamp of the emergency stop reset button [S62] goes off and the emergency stop deactivates.
3. Reset faults from the drive, if necessary.

You can now close the main contactor/breaker and start the drive.

Note: If you switch off the power after you have released the emergency stop button [S61], the drive resets the safety function automatically. In this case, you do not have to push the emergency stop reset button [S62].

7

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 person who does the acceptance 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 acceptance test using the checklist given in this manual:

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

The 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 must use the Drive composer PC tool to do the start-up and acceptance test.

Action	☑
WARNING! Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.	☐
Initial status	
Safety encoder interface: When you use a safety pulse encoder in the safety application, validate the safety encoder interface as described in *FSO-21 safety functions module user's manual* (3AXD50000015614 [English]), chapter *Verification and validation*.	☐
Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. See the hardware manual.	☐
Make sure that the STO function has been configured and validated. Internal monitoring of the FSO module can trigger the STO function even if you have not defined an external request signal. The STO function has to be validated before other safety functions. **Note:** If parameter *S_ENCGEN.11* is set to *Est switch not active load*, both STO function with speed estimate and STO function with encoder feedback must be tested - most importantly, the value of parameter *STO.14* must be set according to the application requirements.	☐
Checks and settings with no voltage connected	
Stop the drive and do the steps in section *Electrical safety precautions (page 10)* before you start the work.	☐
If you have done any connections for the emergency stop circuit on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the applicable circuit diagrams.	☐
Inverter units with parallel R8i inverter modules: Make sure that the XSTO.OUT output on the inverter control unit [A41] is chained to the STO inputs of all inverter modules.	☐
Settings with voltage connected	
Close the cabinet doors and power up the drive. See the hardware manual.	☐

Action	☑
Make sure that the parameter settings related to the safety functions are correct. See chapter *Parameter settings (page 43)*.	☐
Create a backup file of the drive (button **Backup/restore** in the Drive composer pro PC tool).	☐
Save the FSO safety file (button **Save safety file** in the Drive composer pro PC tool). **Note:** The FSO safety file is not included in the drive backup process.	☐
Acceptance test	
ABB recommends 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) • 200.01 FSO speed ch1 (rpm) • 200.02 FSO speed ch2 (rpm) • 200.03 FSO DI status • 200.04 FSO DO status • 200.05 FSO control word 1 • 200.06 FSO control word 2 • 200.07 FSO status word 1 • 200.08 FSO status word 2 • 200.09 Drive status word 1 • 200.10 Drive status word 2	☐
Make sure that it is safe to start, run and stop the motor(s) during the test.	☐
Start the drive and make sure that the motor is running. If possible, use a motor speed close to the maximum speed of the application.	☐
Push the emergency stop button [S61].	☐
Stop category 0: Make sure that the drive stops the motor by coasting and that the correct warnings and indications are shown. Stop category 1: Make sure that the drive stops the motor by decelerating and that the correct warnings and indications are shown.	☐
Make sure that the emergency stop reset button indicator light [S62] comes on.	☐
Make sure that the main contactor/breaker opens as described in this manual.	☐
Make sure that the drive generates none of these faults: • STO hardware failure (5090) • Safe torque off 1 loss (FA81) • Safe torque off 2 loss (FA82) If the drive generates one or more of these faults, see the hardware and firmware manuals for fault tracing instructions. If the FSO module generates a fault, see the FSO module user's manual, chapter *Fault tracing*.	☐
Make sure that you cannot close the main contactor/breaker with the operating switch or by other means.	☐
Make sure that you cannot start the drive and motor from any control location. Make sure that the motor does not start when you switch the start signal off and on, or push the start key of the panel when the panel is in local control mode.	☐
Switch off the drive start signal.	☐

Action	☑
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] goes off. • the main contactor/breaker closes. • the drive does not restart automatically at this point.	☐
Power up the drive: • 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.	☐
Restart the drive and make sure that the drive and the motor 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.	☐

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, replace the FSO or FSE-31 module, modify FSO module parameters, 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.
- 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 at start-up, the operation of the safety function must be ensured 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, IEC/EN 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 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. Also, the FSO and FSE-31 modules do not have electromechanical outputs.

Competence

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

Residual risk

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

Intentional misuse

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

Decommissioning

When you decommission an emergency stop circuit or a drive, make sure that the 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 performance with different safety pulse encoders

See *FSE-31 pulse encoder interface module user's manual* (3AXD50000016597 [English]).

Safety data values

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

The safety data calculations are based on the following assumptions on the operation of the main contactor [Q2]:

- It is switched at low load current (normal use, ~0%, AC-1).
- It is used for the emergency stop once a month.
- It is used for the ordinary on and off once a day.

The safety data calculations are based on the following assumptions on the operation of the main breaker [Q1]:

- It is switched at low load current (normal use, ~0%, AC-1).
- It is used for the emergency stop once a month.
- It is used for the ordinary on and off once a week.

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

The safety pulse encoder is not included in the calculations since it is not included in the delivery. Only the FSE module is included in the calculations (if used).

ACS880-07/07LC drives without the FSE-31 module

Stop category and monitoring method	SIL / SIL-CL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
With main contactor(s)											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	8.3E-4	≥90	3	1	65	20	20/1
With main breaker											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	1.8E-3	≥90	3	1	65	20	20/1
With two main breakers											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	3.3E-3	≥90	3	1	65	20	20/1
											3AXD10000097591 H

1) PFH values are according to EN ISO 13849.
2) In low demand mode, DC of electromechanical devices is considered as 0%, and therefore no overall DC value is claimed in low demand mode.
3) See the Recommendation of Use CNB/M/11.050 published by the European co-ordination of notified bodies for lower T_1 requirement.
4) T_1 = 20a is used with high demand mode of operation. T_1 = 1a is used with low demand mode of operation.

ACS880-07/07LC drives with the FSE-31 module

Stop category and monitoring method	SIL / SIL-CL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
With main contactor(s)											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	8.3E-4	≥90	3	1	65	20	20/1
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	8.3E-4	≥90	3	1	65	20	20/1
With main breaker											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	1.8E-3	≥90	3	1	65	20	20/1
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	1.8E-3	≥90	3	1	65	20	20/1
With two main breakers											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	3.3E-3	≥90	3	1	65	20	20/1

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	3.3E-3	≥90	3	1	65	20	20/1
											3AXD10000097591 H

1) PFH values are according to EN ISO 13849.
2) In low demand mode, DC of electromechanical devices is considered as 0%, and therefore no overall DC value is claimed in low demand mode.
3) See the Recommendation of Use CNB/M/11.050 published by the European co-ordination of notified bodies for lower T_1 requirement.
4) T_1 = 20a is used with high demand mode of operation. T_1 = 1a is used with low demand mode of operation.

ACS880-17/17LC/37/37LC drives without the FSE-31 module

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
With main contactor(s)											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	1.2E-3	≥90	3	1	65	20	20/1
With main breaker											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	2.2E-3	≥90	3	1	65	20	20/1
With two main breakers											
Stop cat. 0 Stop cat. 1, time monitoring Stop cat. 1, ramp monitoring	3	3	e	9.2E-8	3.5E-3	≥90	3	1	65	20	20/1
											3AXD10000097591 H

1) PFH values are according to EN ISO 13849.
2) In low demand mode, DC of electromechanical devices is considered as 0%, and therefore no overall DC value is claimed in low demand mode.
3) See the Recommendation of Use CNB/M/11.050 published by the European co-ordination of notified bodies for lower T_1 requirement.
4) T_1 = 20a is used with high demand mode of operation. T_1 = 1a is used with low demand mode of operation.

ACS880-17/17LC/37/37LC drives with the FSE-31 module

Stop category and monitoring method	SIL / SILCL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
With main contactor(s)											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	1.2E-3	≥90	3	1	65	20	20/1
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	1.2E-3	≥90	3	1	65	20	20/1

Stop category and monitoring method	SIL / SIL-CL	SC	PL	PFH [1)] [1/h]	PFD_{avg}	DC [2)] [%]	Cat.	HFT	CCF	Mission time [a]	T_1 [3) 4)] [a]
With main breaker											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	2.2E-3	≥90	3	1	65	20	20/1
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	2.2E-3	≥90	3	1	65	20	20/1
With two main breakers											
Stop cat. 0 Stop cat. 1, time monitoring	3	3	e	9.2E-8	3.5E-3	≥90	3	1	65	20	20/1
Stop cat. 1, ramp monitoring	3	3	e	8.9E-8	3.5E-3	≥90	3	1	65	20	20/1
											3AXD10000097591 H

1) PFH values are according to EN ISO 13849.
2) In low demand mode, DC of electromechanical devices is considered as 0%, and therefore no overall DC value is claimed in low demand mode.
3) See the Recommendation of Use CNB/M/11.050 published by the European co-ordination of notified bodies for lower T_1 requirement.
4) T_1 = 20a is used with high demand mode of operation. T_1 = 1a is used with low demand mode of operation.

ACS880-07LC/17LC/37LC drives without a main breaker

ACS880-07LC/17LC/37LC drives can be delivered without a factory-installed main breaker. In these cases, safety data is delivered separately to the customer.

Note: Customer-installed components are not included in the safety data calculations. These values must be added to the calculations by the customer.

Safety component types

Safety component types as defined in IEC 61508-2:

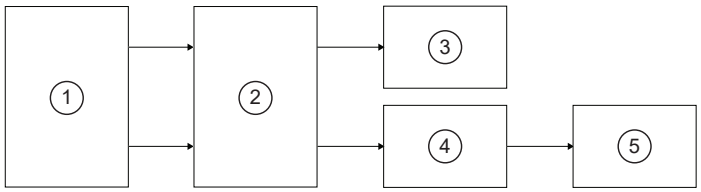
- emergency stop button: type A
- safety relay(s): type A
- main contactor(s): type A
- main breaker: type A.
- FSO module: type B
- FSE module: type B
- drive STO circuit:
  - frame sizes R1...R9 and drives with R1i…R7i inverter modules: type A
  - frame sizes R10 and R11 and drives with R8i inverter modules: type B.

Safety block diagrams

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

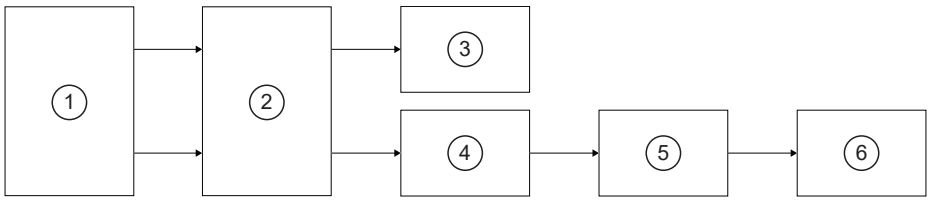
The components that are included in the safety circuit are shown in the safety block diagrams for different drive types.

Diagram 1: ACS880-07 drives, six-pulse variants and ACS880-17/37 drives, frame R8



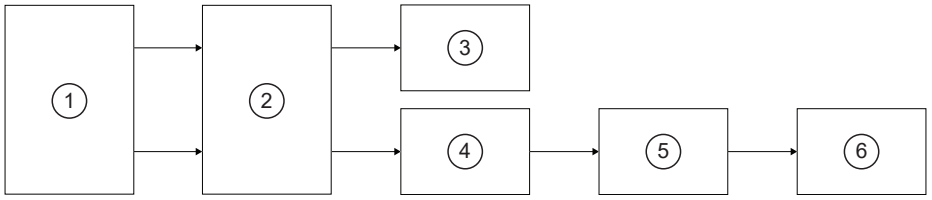
1	Emergency stop button
2	FSO module, and FSE module (if used)
3	Drive STO
4	Auxiliary safety relay
5	Main contactor or main breaker

Diagram 2: ACS880-07 drives, 12-pulse variants with two contactors



1	Emergency stop button
2	FSO module, and FSE module (if used)
3	Drive STO
4	Auxiliary safety relay
5	Contactor
6	Contactor

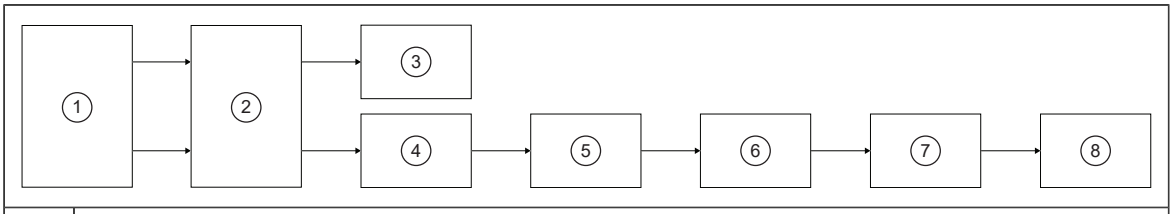
Diagram 3: ACS880-07 drives, 12-pulse variants with a main breaker, and ACS880-07LC drives



1	Emergency stop button
2	FSO module, and FSE module (if used)
3	Drive STO
4	Auxiliary safety relay
5	Main breaker
6	Main breaker

Note: Some ACS880-07LC variants have only one main breaker.

Diagram 4: ACS880-17/17LC/37/37LC drives, frames n×R8i + n×R8i and frame R11



1	Emergency stop button
2	FSO module, and FSE module (if used)
3	Drive STO
4	Auxiliary safety relay
5	Charging contactor
6	Auxiliary safety relay
7	Main contactor or main breaker
8	Main contactor or main breaker

Note: Only some variants have two main contactors or main breakers.

Relevant failure modes

Relevant failure modes are:

- the main contactor/breaker does not open when requested. (All contactor/breaker failures are considered dangerous.)
- the FSO module detects any open circuits, short circuits and redundancy failures of the emergency stop input signal wirings. Similarly, it detects redundancy failures of the emergency stop button when the request is on.
- internal failures of the emergency stop button, the FSO and FSE modules and the STO function in the drive.

These failures are included in the failure rate 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 inside the cabinet
- any short and open circuits in the cabinet terminal blocks of the safety circuits.

Operation delays

Emergency stop total delay and fault reaction response time (includes the response time of the drive STO):

- Stop category 0: less than 500 ms
- Stop category 1: Emergency stop ramp time + possible STO delay settings + less than 500 ms.

Note: If you use a safety pulse encoder, you must add the delays of the encoder when defining the total response time for the safety function and the fault reaction function.

Ambient conditions

For the environmental limits for the safety functions and the drive, refer to the hardware manual of your drive, and to FSO and FSE-31 module user's manuals.

Related standards and directives

Standard	Name
EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems – Part 2: Validation
EN ISO 13850:2015	Safety of machinery. Emergency stop. Principles for design.
EN 60204-1:2018 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
2006/42/EC	European Machinery Directive
Other	Machine-specific C-type standards

Compliance with the European Machinery Directive

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

Further information

Product and service inquiries

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

Product training

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

Providing feedback on ABB manuals

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

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