

Technical description

How to implement an emergency stop, category 1, with an ACS880-01 and the safety functions module



This document presents details how an emergency stop safety function can be designed and implemented using an ACS880-01 industrial drive and a safety functions module together with other ABB safety devices. The safety function is implemented according to EN/IEC 62061, EN ISO 13849-1, EN/IEC 60204-1, EN ISO 13850 and EN/IEC 61800-5-2 machinery standards. Necessary SIL/PL calculations are presented using ABB's Functional safety design tool.

Safer machines with drive-based functional safety

Drive-based safety functions are used in applications that require risk reduction from eg. unexpected and hazardous movement. The aim is to design machines that are safe to use. This safety function example can be implemented with ACS880 series drives only.

ACS880-01 industrial drives, together with the safety functions module, provides an emergency stop safety function. The function brings the

machine to a controlled stop by using the safe torque off (STO) safety function integrated in the ACS880-01 drive. STO eliminates the need to use contactors, meaning the drive is not disconnected from the power during safe stopping. This enables fast restarting of the drive and the machine. The emergency stop safety function is pre-programmed in the safety functions module. Only application specific parameter configuration is necessary to commission the function in addition to the electrical connections.



ACS880-01 R5 drive



INCA 1 emergency stop button



Safety functions module, FSO-12

Effective and reliable emergency stop functionality for drive applications

Emergency stop function details

Requirements according to EN/IEC 60204-1, EN/IEC 61800-5-2 and EN ISO 13850

Emergency stop

- Overrides all other functions and operations in all modes
- Power to the machine actuators that can cause a hazardous situation should be removed
- Reset must not initiate a restart
- The emergency stop function shall not be applied as a substitute for safeguarding measures and other safety functions but should be designed for use as a complementary protective measure

Stop category 0

a controlled stop with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved.

Safety integrity level

SIL 3 (EN/IEC 62061), PL e (EN ISO 13849-1)

Overview of the safety function

Emergency stop, stop category 1, stops the drive with controlled deceleration ramp before disabling the input power to the motor. In this function example, the deceleration ramp is monitored. This safety function can be used, for example, where a synchronized stop of one or more axes is required.

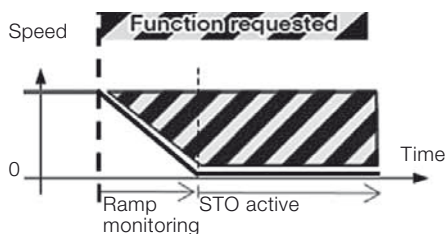


Figure 1: Typical motor speed with stop category 1 stop (with monitored deceleration ramp).

Design of the safety function

The design of the emergency stop, stop category 1, consists of an emergency stop button as an activating switch, safety functions module as a logic unit and a safe torque off (STO) -circuit inside the ACS880-01 drive as an actuator to bring the motor into a non-torque state after the deceleration. There is no need for a separate encoder when the safety functions module is used (only for applications that do not have active loads). See circuit diagram (Figure 2) for connection details.

Operation of the safety function

When the emergency stop button is pressed, the safety functions module detects the button signal and commands the drive to stop the motor by using a deceleration ramp. The safety functions module monitors the deceleration ramp and after the motor has stopped, activates the STO function to bring the motor into a non-torque state.

To continue drive operation after an emergency stop, the emergency stop button is released (pulled up). This deactivates the emergency stop function in safety functions module, causing it to deactivate the STO function. The drive is restarted by a separate start command. The drive is configured to not start automatically.

The safety functions module provides the diagnostics for the emergency stop button wiring. It also enables the use of a separate reset button, if required (reset button is not shown in this example since it is not required by the standard).

Ensuring the required safety performance

The safety function has to fulfil the required safety performance determined by a risk assessment. ABB's Functional safety design tool (FSDT-01) is used to design the desired safety function. This is carried out according to the following steps:

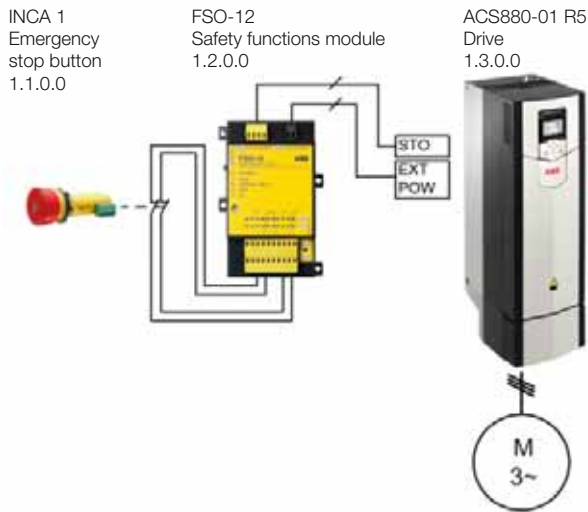


Figure 2: Connection example of the emergency stop function with a ACS880-01 and the safety functions module. The emergency stop reset button is not used in this example.



Figure 3: Safety calculation and design for the emergency stop function according to EN ISO 13849-1 (can also be made according to EN/IEC 62061). The design is made with the Functional safety design tool.

1. **Evaluate the risks** to establish target safety performance (SIL/PL level) for the safety function.

2. **Design** the safety function loop and **verify** the achieved performance level (PL) or safety integrity level (SIL) for the safety function loop (according to EN ISO 13849-1 or EN/IEC 62061, respectively), utilizing the device safety data and the application specific characteristics.

3. **Generate the report** for the machine documentation. The report should contain all the calculation results as well as all assumptions made during the application design.

Figure 3 shows the design of the safe stop 1 safety function with the ACS880-01 drive. The emergency stop function in this document achieves PL e (SIL 3). Calculations are made using the default safety data available for the safety devices. It is also conservatively assumed in this example that the activation frequency of the emergency stop is 1 time per month.

Safety function verification and validation

In addition to the safety calculations for the achieved safety performance (SIL/PL), the safety function needs to be functionally verified as well.

Finally the implemented safety function is validated against the risk assessment to ensure that the implemented safety function actually reduces the targeted risk.

General considerations

Achieving machinery safety requires a systematic approach beyond the physical implementation of a safety function. The overall machinery safety generally covers the following areas:

- **Planning** for and managing functional safety during the lifecycle of the machine
- **Assuring compliance** to local laws and requirements (such as the Machinery directive/CE marking)
- **Assessing machine risks** (analysis and evaluation)
- **Planning the risk reduction** and establishing safety requirements
- **Designing** the safety functions
- **Implementing and verifying** the safety functions
- **Validating** the safety functions
- **Documenting** the implemented functions and results of risk assessment, verification and validation

For more information concerning functional safety and the Functional safety design tool, see www.abb.com/safety and ABB's Technical Guide no. 10.

| Abbreviations | | |
|-------------------|----------------|---|
| Abbr. | Reference | Description |
| DC _{avg} | EN ISO 13849-1 | Diagnostic coverage |
| MTTF _d | EN ISO 13849-1 | Mean time to dangerous failure |
| PFH _d | EN/IEC 62061 | Probability of dangerous failures per hour |
| PL | EN ISO 13849-1 | Performance level: corresponds to SIL, Levels a-e |
| SIL | EN/IEC 62061 | Safety integrity level |

Note: This is an indicative example. Relevant installation, design and safety calculations need to be specifically completed for each system implementation according to machinery safety standards (EN/IEC 62061, EN ISO 13849-1, EN/IEC 60204-1, EN ISO 13850 and EN/IEC 61800-5-2). ABB does not take any responsibility for the accuracy of the data used in this document and reserves right to make changes without further notice. For detailed safety function implementation please contact your local ABB representative.

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Drive-based functional
safety web page

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