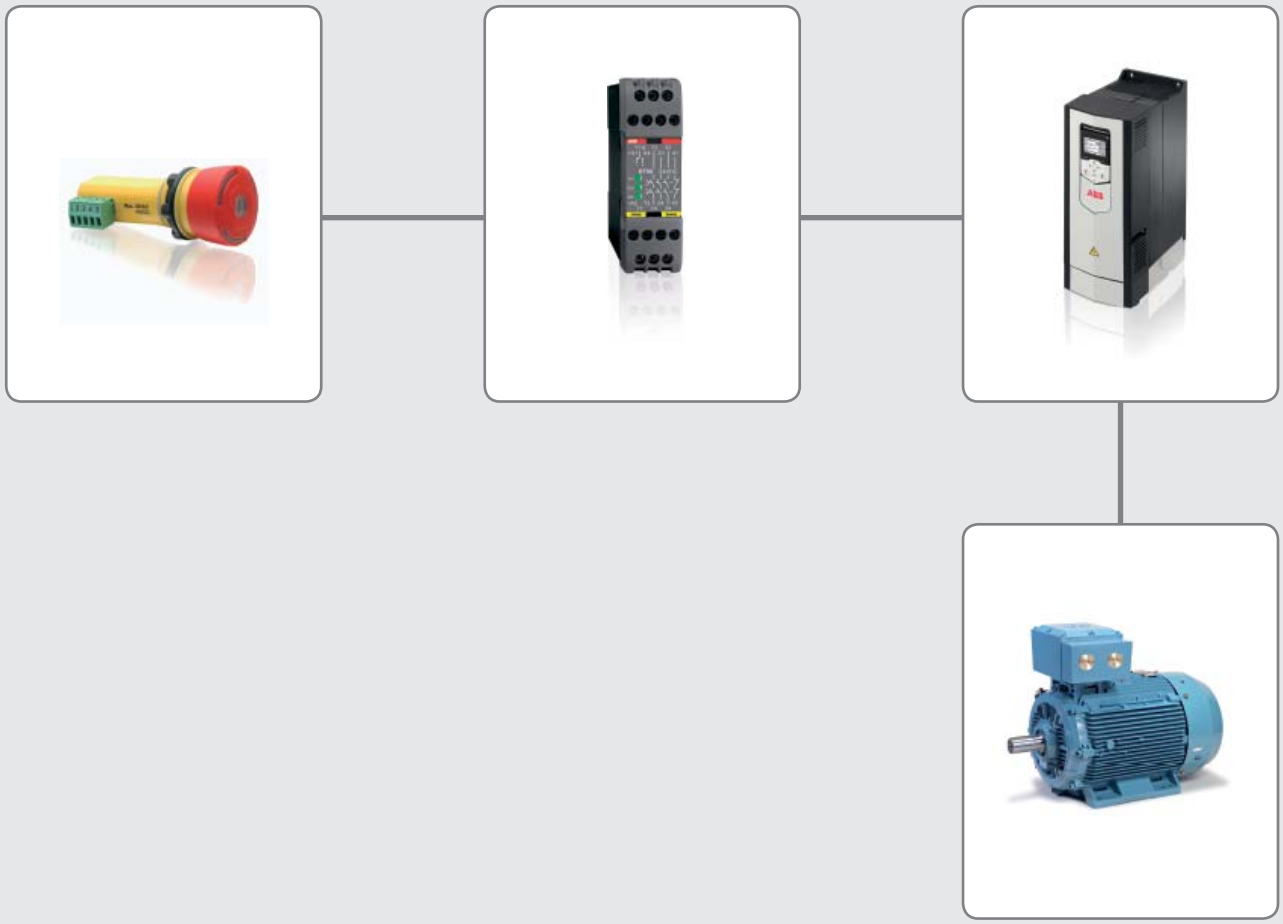
Technical description
How to implement an emergency stop, category 0, with an ACS880-01



This document presents details how an emergency stop, stop category 0, safety function can be designed and implemented using an ACS880 industrial drive together with other ABB safety devices. The safety function is implemented according to EN/IEC 62061, EN ISO 13849-1, EN ISO 13850, EN/IEC 60204-1 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 is presented for specific drive and safety devices, but the function can be implemented with other ABB drives with few modifications.

ACS880-01 industrial drives offer the safe torque off (STO) safety function as a standard integrated feature. STO eliminates the need to use contactors, meaning the drive is not disconnected from the power during safe stopping. This again enables the fast restart of the drive and the machine. STO is also offered as standard in other ABB drive types for easy integration of functional safety.

ACS880-01 R3 drive

INCA 1 emergency stop button

BT50 safety relay

Effective and reliable emergency stop for drive applications

Emergency stop function details	
Requirements according to EN/IEC 60204-1 and EN ISO 13850	**Emergency stop** – Overrides all other functions and operations in all modes at all times – 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** – Immediate removal of power to the machine actuators – Mechanical disconnection between the hazardous elements and their machine actuators and, if necessary, braking
Safety integrity level	SIL 3 (EN/IEC 62061), PL e (EN ISO 13849-1)

Overview of the safety function

Emergency stop, stop category 0 (Figure 1), is used to immediately remove the power to the motor, causing the motor to coast to a stop (the motor stops due to inertia, without being controlled by the drive). The function can be used with applications where it is acceptable to allow movement to coast to stop after the removal of the motor torque and/or the motor stops quickly due to heavy load.

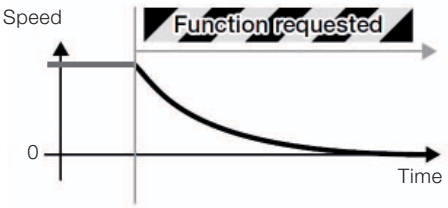


Figure 1: Typical motor speed with stop category 0 stop.

Design of the safety function

The design of the emergency stop, stop category 0, consists of an emergency stop button as an activating switch, a safety relay 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. See the circuit diagram (Figure 2) for connection details.

Operation of the safety function

When the emergency stop button is pressed, the safety relay detects the button signal and opens its contacts to activate the STO safety function. After STO is activated, it disables the drive's power output to the motor, and the motor coasts to a standstill.

To continue drive operation after an emergency stop, the emergency stop button is released (pulled up), which causes the contacts of the relay to close. This deactivates the STO safety function. The drive is restarted by a separate start command: The drive is configured not to start automatically.

The safety relay is used because it provides diagnostics for the emergency stop button wiring. The relay 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:

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

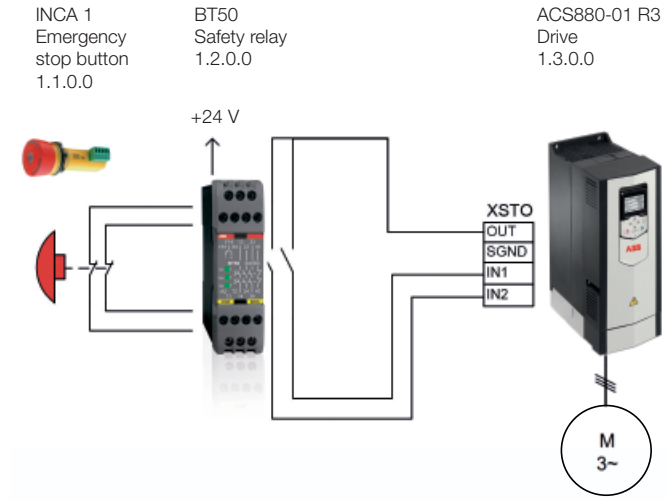
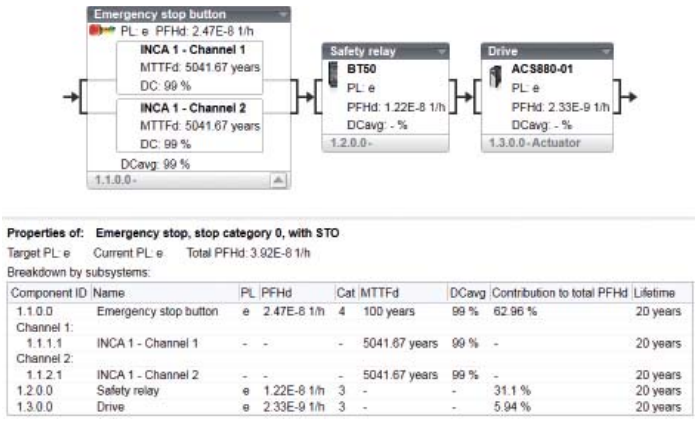


Figure 2: Connection example of the emergency stop function with ACS880-01. Emergency stop reset button is not used in this example.



Properties of: Emergency stop, stop category 0, with STO

Target PL: e Current PL: e Total PFHd: 3.92E-8 1/h

Breakdown by subsystems:

Component ID	Name	PL	PFHd	Cat	MTTFd	DCavg	Contribution to total PFHd	Lifetime
1.1.0.0	Emergency stop button	e	2.47E-8 1/h	4	100 years	99 %	62.96 %	20 years
Channel 1:								
1.1.1.1	INCA 1 - Channel 1	-	-	-	5041.67 years	99 %	-	20 years
Channel 2:								
1.1.2.1	INCA 1 - Channel 2	-	-	-	5041.67 years	99 %	-	20 years
1.2.0.0	Safety relay	e	1.22E-8 1/h	3	-	-	31.1 %	20 years
1.3.0.0	Drive	e	2.33E-9 1/h	3	-	-	5.94 %	20 years

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.

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

3. **Generate a 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 emergency stop function with the ACS880-01 drive. The emergency stop function in this document achieves PL e (SIL 3). Safety calculation is made using the default safety data available for the safety devices. It is 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 has 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 completed specifically for each system implementation according to machinery safety standards (EN/IEC 62061, EN ISO 13849-1, EN ISO 13850, EN/IEC 61800-5-2, and EN/IEC 60204-1) and local laws and regulations. ABB does not take any responsibility for the accuracy of the data used in this document and reserves the right to make changes without further notice. For detailed safety function implementation, please contact your local ABB representative.

Contact us

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Drive-based functional safety web page

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