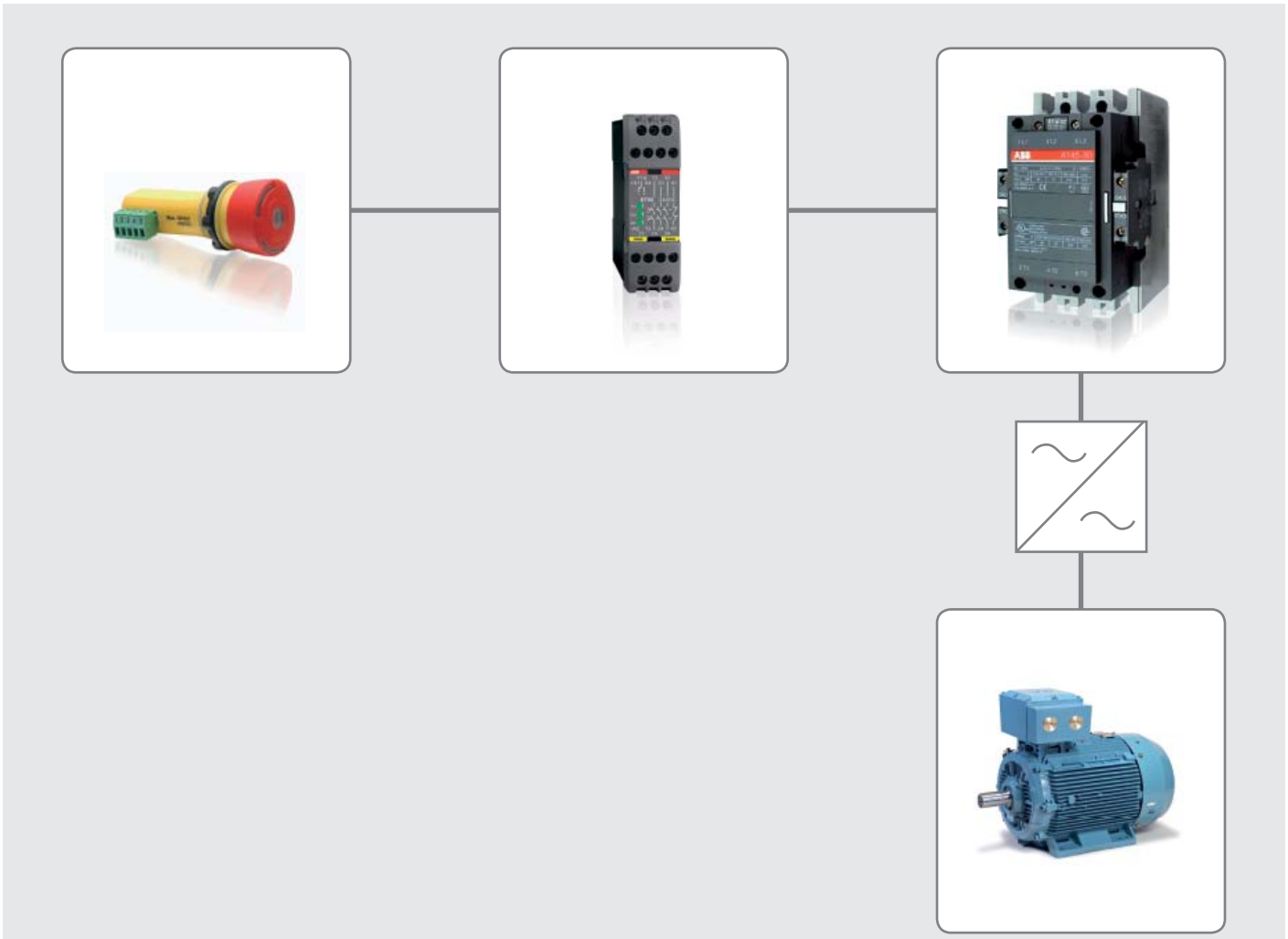
Technical description
How to implement an emergency stop, category 0, using ABB drives with a contactor



This document presents details how an emergency stop, stop category 0, safety function can be designed by using ABB drives together with safety devices and contactors. 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 saety

Safety functions are used in applications requiring risk reduction from unexpected and hazardous situations. The aim is to design machines that are safe to use. This safety function can be applied to any ABB drive.

Contactors offer reliable and fast drive power removal for basic applications. Contactors are used in safety systems when a built-in safe torque off (STO) -circuit is not available in a drive. Contactors are also used if it is required by application, eg. when electrical disconnection is needed.

INCA 1 emergency stop button

BT50 safety relay

KPR1-100L reset button

A145-30-00 contactor

Effective and reliable emergency stop functionality 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 2 (EN/IEC 62061), PL d (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 drive causing the motor to coast to a stop (the motor stops due to inertia, without being controlled by the drive). The safety function can be used when it is acceptable to allow movement to coast stop after the removal of the motor torque and/or the motor stops quickly due to heavy load.

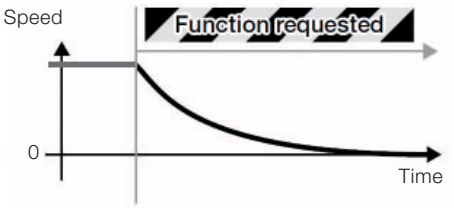


Figure 1: Typical motor speed with stop category 0 stop.

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 contactor as an actuator for bringing the motor into a non-torque state. See 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 causing the main contactor to open.

Opening of the contactor disables the power input to the drive causing the motor to coast to a standstill.

To continue drive operation after an emergency stop, the emergency stop button is released (pulled up). A separate reset button is pressed to close the relay's contacts, also causing the main contactor to close. At this point the drive can be started again.

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.

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 done according to the following steps:

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 (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.

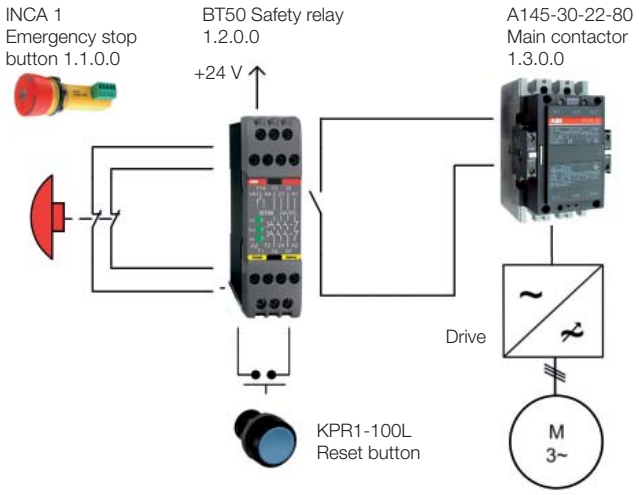
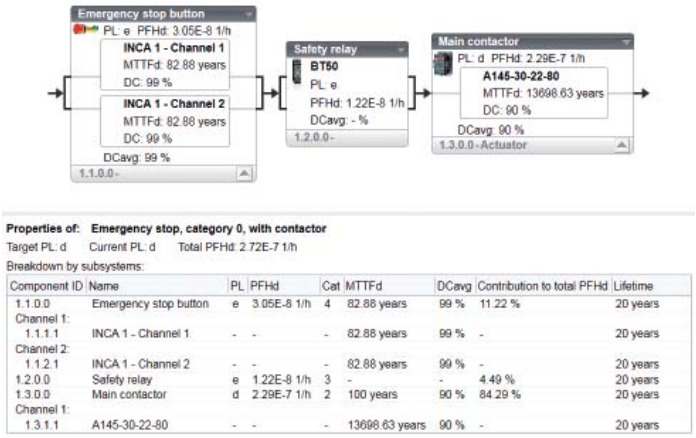


Figure 2: Connection example of the emergency stop function with a contactor.



Properties of: Emergency stop, category 0, with contactor

Target PL: d Current PL: d Total PFHd: 2.72E-7 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	3.05E-8 1/h	4	82.88 years	99 %	11.22 %	20 years
Channel 1:								
1.1.1.1	INCA 1 - Channel 1	-	-	-	82.88 years	99 %	-	20 years
Channel 2:								
1.1.2.1	INCA 1 - Channel 2	-	-	-	82.88 years	99 %	-	20 years
1.2.0.0	Safety relay	e	1.22E-8 1/h	3	-	-	4.49 %	20 years
1.3.0.0	Main contactor	d	2.29E-7 1/h	2	100 years	90 %	84.29 %	20 years
Channel 1:								
1.3.1.1	A145-30-22-80	-	-	-	13698.63 years	90 %	-	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. The reset button is not included in the calculation, as it is not considered as part of the primary safety circuit.

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

Figure 3 shows the design of the emergency stop function with a contactor. The emergency stop function in this document achieves PL d (SIL 2). Safety calculation is made using the default safety data available for the safety devices. In this example it is assumed that the activation frequency of emergency stop is 2 times per day, since the contactor is used by the normal operation of the drive, not only by the emergency stop function.

Safety function verification and validation

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

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 of 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 speficially completed 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 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
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