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 safety
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.
Effective and reliable emergency stop functionality for drive applications

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.

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.
INCA 1 Emergency stop button 1.1.0.0

BT50 Safety relay 1.2.0.0

A145-30-22-80 Main contactor 1.3.0.0

+24 V

KPR1-100L Reset button

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

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

<table>
<thead>
<tr>
<th>Abbr.</th>
<th>Reference</th>
<th>Description</th>
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<tbody>
<tr>
<td>DCavg</td>
<td>EN ISO 13849-1</td>
<td>Diagnostic coverage</td>
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<tr>
<td>MTTFd</td>
<td>EN ISO 13849-1</td>
<td>Mean time to dangerous failure</td>
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<tr>
<td>PFHd</td>
<td>EN/IEC 62061</td>
<td>Probability of dangerous failures per hour</td>
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<tr>
<td>PL</td>
<td>EN ISO 13849-1</td>
<td>Performance level: corresponds to SIL, Levels a-e</td>
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<td>SIL</td>
<td>EN/IEC 62061</td>
<td>Safety integrity level</td>
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**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 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.