APPLICATION NOTE

Novolink modules for AF contactors
Implement emergency stop with SSR10
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1. **Important notice**

**Target group**

This description is intended for use by trained specialists in electrical installation and control and automation engineering, who are familiar with the applicable national standards.

**Safety requirements**

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Symbols used in this application note:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>!</td>
<td>Symbol to indicate important information and conditions</td>
</tr>
<tr>
<td>✗</td>
<td>Symbol that indicated a potentially dangerous situation that can cause personal injury</td>
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</table>

**Important notice**

Diagrams shown here are indicative examples. 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.

2. **Purpose and basic description**

This document presents details on how an emergency stop, stop category 0, safety function can be designed and implemented using the Novolink devices together with AF contactors and an ABB safety relay. The safety function design is done according to EN ISO 13849-1.

Necessary SIL/PL calculations are presented using ABB’s functional safety design tool.

Safety functions are used in applications that require risk reduction from e.g. unexpected and hazardous movement. The aim is to design machines that are safe to use. This safety function example is presented for the new Novolink and safety relay SSR10.

Note: It is expected that the reader is familiar with the used devices. Please read the related documentation if this is not the case before you go on reading.
3. Effective and reliable safe torque off for Novolink applications

3.1. Overview of the safety function

The STO function is the most common and basic safety function integrated. When STO is activated, the motor is no longer supplied with rotation or movement causing energy.

Requirements according to EN IEC 60204-1 and EN ISO 13850:

Safe torque off

- Safe Torque Off (STO) removes power to the electrical motor, preventing a torque of force to be generated.
- Leaving the STO state must not lead to an uncontrolled start of the electrical motor.
- The emergency stop function is a complementary protective measure and shall not be applied as a substitute for safeguarding measures and other functions or safety functions.

Stop category 0

- Stopping by immediate removal of power to the machine actuators.
- Mechanical disconnection between the hazardous elements and their machine actuators

Safe torque off, 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). Additional breaking can be necessary. The function can be used with applications where it is acceptable to allow movement to coast to a 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.
3.2. **Design of the safety function for a single motor**

The design of the safe torque off function, stop category 0, consists of an emergency stop button as an emergency power off switch, a safety relay as a logic unit and two contactors. The presented solution can be used up to PL e, category 4 according to EN ISO 13849-1.

**Operation of the safety function**

When the emergency stop button is pressed, the safety relay detects the signal from the button and opens its contacts to activate the STO safety function. After STO is activated, it de-energizes both contactors KS1 and K1. While contactor K1 is used for the regular operation of the motor, KS1 is only de-energized in case the safe function was activated.

The safety relay switches off the 24 V supply of the Novolink modules. In this case, a fault signal is sent to the PLC that the module is no longer operational.

To continue the motor operation after an emergency stop, the emergency stop button is dis-engaged (pulled up), which causes the contacts of the relay to close. This deactivates the STO safety function. When a new switch-on command is received from the PLC, the contactor K1 is released again.

A reset of the safety function is only possible when both contactors are in the off position. This detects if a contactor has welded and/or is stuck in its activated position. A reset button and a start command prevent unwanted starts. If there is a problem with a contactor and it is detected, a reset cannot be performed. SCV10 which is also in the mains path has no electrical connection to the motor wires and can be ignored in the safety evaluation.

Please note the following points:

- **Note 1:** The number of operations of K1 must be on a level that MTTFd is achieved according to safety requirements in the application.
- **Note 2:** The MTTFd will decrease if the number of annual “on-off” of K1 is high. The contactor must also be oversized according to well-proven safety principles.
- **Note 3:** Some contactors have built-in mirror contacts. In this case CA401 is not needed and the contactor provided mirror contacts can be used.

See the circuit diagram (figure 2) for connection details.
Figure 2: Circuit diagram of a motor feeder with safety function for a single motor.
3.3. Ensuring the required safety performance

In this design, two contactors are used in the actuator part of the safety function. KS1 is a contactor that is only broken when an emergency stop is initiated. K1 is a contactor that performs regular operations but is also used when an emergency stop is initiated.

The safety function must fulfill the required safety performance determined by a risk assessment. ABB’s Functional Safety Design Tool (FSDT-01) is used to account for the desired safety function. This is carried out according to the following steps:

1. Evaluate the risks often according to ISO 12100 and ISO/TR 14121-2 to establish the target safety performance (SIL/PL level) level for the safety function.
2. Design the safety function circuit and verify the achieved performance level according to EN ISO 13849-1, or safety integrity level according to EN IEC 62061.
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: Safety logical diagram and calculation results for a single motor feeder.
3.4. Design of the safety function for a group of motors

The design of the safe torque off function, stop category 0, consists of an emergency stop button as an emergency power off switch, a safety relay as a logic unit and two contactors. The presented solution can be used up to PL d, category 4 according to EN ISO 13849-1. In contrast to the example in the previous section, a group of motors can be stopped with a single safety relay. All motor relays must be in the OFF position before the safety function can be reset after an emergency power off.

Operation of the safety function

When the emergency stop button is pressed, the safety relay detects the signal from the button and opens its contacts to activate the STO safety function. After STO is activated, it de-energizes both contactors KS1 and KS2.

The contactors related to normal motor operation (e.g. K1) can be in any position.

To continue the motor operation after an emergency stop, the emergency stop button must be disengaged (pulled up), the reset button pressed and the condition of KS1 and KS2 being in their off state confirmed first. This deactivates the STO safety function by switching on the two contactors KS1 and KS2. New start commands will have now an effect again.

A reset of the safety function is only possible when all contactors (safety ones and operational ones) are in the off position. This prevents unwanted motor restarts. This is realized by adding auxiliary signals (CA401) into the reset path of the SSR10 relay. Having the work-contactor K1 within the reset signal chain is optional.

See the circuit diagram (figure 3) for connection details.

Please note that the Novolink devices do not play any role in the safety function and must not be considered in the safety design tool.
Figure 3: Circuit diagram for a group of motors with safety function.
3.5. Ensuring the required safety performance

In this example of an emergency stop function, two contactors are used in the actuator part of the safety function to switch off a group of motors.

The safety function must fulfil the required safety performance determined by a risk assessment. ABB’s Functional Safety Design Tool (FSDT-01) is used to account for the desired safety function. This is carried out according to the following steps:

1. Evaluate the risks often according to ISO 12100 and ISO/TR 14121-2 to establish the target safety performance (SIL/PL level) level for the safety function.
2. Design the safety function circuit and verify the achieved performance level according to EN ISO 13849-1, or safety integrity level according to EN IEC 62061.
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 4: Safety logical diagram and calculation results for a group of motors.](image)

3.6. 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 and CE-marking in the European Union)
- 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
4. Additional information

For more information concerning functional safety and the Functional safety design tool, see:
and ABB’s technical guide no. 10.

4.1. Abbreviations

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<tr>
<th>Term</th>
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<tr>
<td>DC_{avg}</td>
<td>EN ISO 13849-1</td>
<td>Diagnostic coverage</td>
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<tr>
<td>MTTF_{d}</td>
<td>EN ISO 13849-1</td>
<td>Mean time to dangerous failure</td>
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<tr>
<td>PFH_{d}</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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4.2. Related documents

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<td>Novolink – smart function and sensor modules for AF contactors</td>
<td>2CDC100017M0201</td>
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<td>Sentry safety relays</td>
<td>2TLC010002M0201</td>
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<td>3</td>
<td>Functional Safety Design Tool, version 1.2.0.1</td>
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5. Revisions

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<th>Date Dept./Init.</th>
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<td>A</td>
<td>-</td>
<td></td>
<td>Initial version</td>
<td>19.03.2021</td>
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