Safe shutdown with the SIRIUS 3RM1 motor starters

SIRIUS Safety

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Table of contents

1 Introduction ........................................................................................................ 3
  1.1 Device versions ................................................................................................... 3
  1.2 Device connectors ............................................................................................ 4
  1.3 Information on the application examples ...................................................... 4

2 Failsafe versions 3RM11 and 3RM13 ............................................................... 5
  2.1 Monitoring the feedback circuit ................................................................. 5
  2.2 Safe shutdown via control supply voltage up to SIL 3 or PL e ............. 6
  2.3 Safe shutdown via control inputs up to SIL 3 or PL e ................................. 9
  2.4 Safe shutdown in conjunction with 3SK1 safety relays to SIL 3 or PL e ......................... 12
  2.5 Safe shutdown of several motor starter groups up to SIL 3 or PL e ......................... 15

3 Standard versions 3RM10 and 3RM12 ........................................................... 18
  3.1 Safe switching up to SIL 1 or PL c ............................................................ 18
  3.2 Safe switching up to SIL 2 or PL d ............................................................ 20
  3.3 Safe switching up to SIL 3 or PL e ........................................................... 24
  3.4 Safe switching of a group of motor starters up to SIL 3 or PL e ........ 26

4 Contact/Support ............................................................................................... 28
1 Introduction

Two versions of the SIRIUS 3RM1 motor starters are available: Standard and Failsafe. While the 3RM1 Failsafe already has certification to SIL 3 or PL e, further measures are required for safe shutdown in the case of the 3RM1 Standard. The different options for both versions are explained below.

1.1 Device versions

The SIRIUS 3RM1 motor starters are available in a Standard and Failsafe version, and in each case as direct-on-line starters or reversing starters:

<table>
<thead>
<tr>
<th>3RM10</th>
<th>3RM11</th>
<th>3RM12</th>
<th>3RM13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Failsafe</td>
<td>Standard</td>
<td>Failsafe</td>
</tr>
<tr>
<td>Direct-on-line starter</td>
<td>Direct-on-line starter</td>
<td>Reversing starter</td>
<td>Reversing starter</td>
</tr>
</tbody>
</table>

The following application examples apply to both direct-on-line starters and reversing starters.

Note

Additional measures, such as a 3RV motor starter protector, are required for protecting the cable, the switching devices, and the motor. Since this protection is not part of the functional safety, it is not included in the overviews and circuit diagrams.
1.2 Device connectors

Up to five SIRIUS 3RM1 motor starters can be connected to each other and combined into a group using the 3ZY1212 device connectors. The individual motor starters are supplied with control supply voltage (24 V DC) via the device connectors. Terminals A1 (+) and A2 (-) need only be supplied with voltage from one motor starter per group, which saves on wiring costs.

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**WARNING**

Hybrid operation of 3RM10/3RM12 Standard motor starters with 3RM11/3RM13 Failsafe motor starters in safety-related applications is not admissible.

Only ever use safety-related motor starters (3RM11 Failsafe and 3RM13 Failsafe) in safety-related applications.

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**WARNING**

When using a 3SK1 safety relay and device connectors, the supply voltage for the 3RM1 motor starters is provided via the device connectors.

In this case, do not connect anything to terminals A1 and A2 of the 3RM1 motor starters, in order to prevent bypassing of the safety function.

You can find more information on the 3ZY1212 device connectors in the manuals for the 3RM1 motor starters or the 3SK1 safety relays.

1.3 Information on the application examples

In the following examples, it is assumed that the evaluation unit and the motor starter are always in the same control cabinet.

If the evaluation unit and the motor starter are not located in one control cabinet, the wiring must be two-channel (pm switching) or protected against cross-circuits (e.g. armored conduit) to achieve a safety level from SIL 2 or PL d.

In addition, the optional 3ZY1212 device connectors are used in every application example with more than one motor starter.

In the graphics and circuit diagrams, this is indicated by having the devices side by side.
2  Failsafe versions 3RM11 and 3RM13

The Failsafe versions of the motor starter can be used with any evaluation units in safety-related applications up to SIL 3 / PL e. Safe shutdown can be carried out here in different ways depending on the application.

2.1 Monitoring the feedback circuit

In the case of 3RM11/3RM13 Failsafe motor starters, the OFF state is defined as the safe state. The 3RM11/3RM13 Failsafe motor starters are self-monitoring in compliance with SILCL 3 or PL e and therefore do not need to be monitored in the feedback circuit of the upstream evaluation unit.

In the event of a fault, the motor starter itself prevents restart.

In a group configuration using device connectors, a fault in an individual motor starter (e.g. overload detected) does not result in shutdown of the entire group. It is also possible to restart the group in the event of the failure of an individual motor starter. The motor starter affected by the fault does not switch on.

If it should prove impossible to restart the group while there is a fault in one motor starter, the fault signaling outputs of the motor starters can be monitored by the evaluation unit as the ON condition. Whether this is necessary or not depends on the respective risk assessment and the application.
2.2 Safe shutdown via control supply voltage up to SIL 3 or PL e

In the case of safe shutdown via the control supply voltage, the control supply voltage is disconnected from a motor starter, at which point safe shutdown of the load is started.

Groups of up to five motor starters can be set up using the optional 3ZY1212 device connectors. In this case, the control supply voltage is disconnected from just one of the motor starters, at which point the remaining motor starters of the group also shut down safely.

The advantage of this solution is that up to five motor starters can be safely shut down with minimum wiring.

The disadvantage is that the devices cannot carry out any diagnostics in the shutdown state, and they have a longer recovery time. The cooling down period following overload cannot run in this state.

Note
When using pp-switching modules, only A1 (+) is shut down. By contrast, pm-switching modules shut down A1 (+) and A2 (-).

If the evaluation unit and the motor starter are not located in one control cabinet, the wiring must be two-channel (pm switching) or protected against cross-circuits (e.g. armored conduit) to achieve a safety level from SIL 2 or PL d.

Note
The test pulses of the dark test of failsafe modules must not exceed 10 ms.
Basic configuration

Fig. 2-1
Circuit diagram

Fig. 2-2
2.3 Safe shutdown via control inputs up to SIL 3 or PL e

The 3RM11 motor starter (direct-on-line starter) has the safe control input IN1. The 3RM13 motor starter (reversing starter) by contrast has two control inputs, IN1 and IN2, for specifying the direction of rotation. Operational switching as well as safe shutdown can be carried out via these inputs.

**Note**

When using the 3RM13 reversing starter, both control inputs (IN1 and IN2) must be switched off for safe shutdown.

**Note**

The test pulses of the dark test of failsafe modules must not exceed 10 ms.

**Basic configuration**

![Diagram](image-url)
The advantage of this circuit is that when the emergency stop command device is actuated, the motor starter remains in readiness and only the load is safely shut down. This enables a shorter recovery time, and the option of diagnostics during standstill is retained. The cooling down period in the case of an overload trip continues to run in this state.

In a group configuration of several motor starters, each motor starter must be safely shut down individually via its control inputs with this type of connection.

**Note**

If the motor starter is switched via a pm-switching safe output, output M1 (and M2 in the case of the 3RM13 reversing starter) must be routed back to the output module.

With pp-switching safe outputs, M1 (and M2) are connected to ground.

If the evaluation unit and the motor starter are not located in one control cabinet, the wiring must be two-channel (pm switching) or protected against cross-circuits (e.g. armored conduit) to achieve a safety level from SIL 2 or PL d.
2 Failsafe versions 3RM11 and 3RM13

Fig. 2-4
2.4 Safe shutdown in conjunction with 3SK1 safety relays to SIL 3 or PL e

The SIRIUS 3SK1 safety relays and the SIRIUS 3RM1 motor starters can be connected up using the 3ZY1212 device connectors without any further wiring. Up to five motor starters can be operated together with one safety relay on one device connector group. The motor starters are supplied with control supply voltage from the safety relay via the device connector.

**WARNING**

When using a 3SK1 safety relay and device connectors, the supply voltage for the 3RM1 motor starters is provided via the device connectors. In this case, do not connect anything to terminals A1 and A2 of the 3RM1 motor starters, in order to prevent bypassing of the safety function.

The emergency stop command device is monitored by the safety relay. When actuated, the safety relay safely switches off the control supply voltage of the motor starters via the device connector. This in turn also shuts down the load safely.

The advantage of this solution is that up to five motor starters can be safely shut down with minimum wiring.

The disadvantage is that the motor starters cannot carry out any diagnostics in the shut down state, and they have a longer recovery time. The cooling down period following overload cannot run in this state.
Basic configuration

Fig. 2-5

Emergency stop

Safety relay

Distributed I/O

Drive 1  Drive 2  Drive 3  Drive 4  Drive 5
Circuit diagram

Fig. 2-6

Safe switching of SIRIUS 3RM1 motor starters
Entry-ID: 67478946, V2.0, 01/2014
2.5 Safe shutdown of several motor starter groups up to SIL 3 or PL e

If more than five motor starters are used, these can be placed on device connectors in groups of five. Safe shutdown of the individual groups takes place in the same way as the examples shown above.

In the example below, two groups of five motor starters each are shut down via a SIRIUS 3SK1 safety relay. This can be done in the same way using a SIRIUS 3RK3 modular safety system or a failsafe controller.

Fig. 2-7

Group 1 is supplied with voltage and shut down by the safety relay via the device connector. Group 2 is supplied with voltage and shut down via an enabling circuit of the safety relay.

Note
Several motor starter groups can be supplied with voltage and shut down via an enabling circuit of the safety relay depending on the switching capacity of the enabling circuit.
Note

If the evaluation unit and the motor starter are not located in one control cabinet, the wiring must be two-channel (pm switching) or protected against cross-circuits (e.g. armored conduit) to achieve a safety level from SIL 2 or PL d.

In this case, two-channel wiring would mean that both A1 and A2 are shut down via the enabling circuits of the safety relay.

WARNING

When using a 3SK1 safety relay and device connectors, the supply voltage for the 3RM1 motor starters is provided via the device connectors.

In this case, do not connect anything to terminals A1 and A2 of the 3RM1 motor starters, in order to prevent bypassing of the safety function.
Figure 2-8

2 Failsafe versions 3RM11 and 3RM13
3 Standard versions 3RM10 and 3RM12

The 3RM1 motor starter has no effect or influence on the safety function of the application. For this reason, the 3RM1 motor starter is not taken into consideration in the safety application, either in the positive or negative sense, and thus does not have to be included in the calculation for normative proof.

The following application examples apply to both the 3RM10 direct starters and the 3RM12 reversing starters.

3.1 Safe switching up to SIL 1 or PL c

If achievement of SIL 1 according to IEC 62061 or PL c according to ISO 13849-1 is required, the series connection of an additional contactor with the 3RM1 motor starter, in conjunction with a safety relay suitable for this (e.g. 3SK1111), is necessary, along with monitoring of the contactor's auxiliary contacts.

**Basic configuration**

![Diagram](image)
Circuit diagram

Figure 3-2

Safe switching of SIRIUS 3RM1 motor starters
Entry-ID: 67478946, V2.0, 01/2014
3.2 Safe switching up to SIL 2 or PL d

Safe switching up to SIL 2 according to IEC 62061 or PL d according to ISO 13849-1 can either be achieved by a combination of a contactor and a circuit breaker with undervoltage release (e.g. 3RV2902) or by the use of two redundant contactors.

Two-channel monitoring of the EMERGENCY STOP is required in either variant.

**Combination of contactor and circuit breaker with undervoltage release**

The use of a combination of a power contactor and a circuit breaker with undervoltage release in a safety function is only possible in conjunction with a safety-related evaluation, for example, with a SIMATIC S7 F fail-safe controller, a 3RK3 modular safety system, or a 3SK1 safety relay. The reason behind this is the control of failures by suitable diagnostic measures and the fault reactions triggered by these.

This is not the preferred method because it results in fewer switching cycles and because an automatic restart is not possible since the circuit breaker has to be manually reset.

Time monitoring of the power contactor is achieved by a set time delay on the safety relay (e.g. 3SK1121-1CB41).

The time delay is required so that a power contactor fault can be detected and a corresponding fault reaction – tripping of the circuit breaker by means of an undervoltage release – can be initiated.

A time delay must be set according to the switching time of the contactor. An appropriate time delay could be around 100 ms.
Note
Once the final time value has been set, measures must be taken to protect against a subsequent unintentional change. Application of a sealable cover (e.g. 3ZY1321-2AA00) is therefore mandatory.

The set time value must be documented verifiably.

Basic configuration
While the enabling circuits of the safety relay are closed, the undervoltage release is supplied with voltage. When the EMERGENCY STOP is actuated, the power contactor switches off immediately. The voltage at the time-delayed outputs 37/38 and 47/48 is retained for the set time. After expiration of this time, the undervoltage release will continue to be supplied with voltage via the power contactor’s auxiliary contact, which is now closed again.

Only in the case of a fault in which the contactor does not switch off and the auxiliary contact thus remains open does the undervoltage release switch off after expiration of the set time according to the switching time of the contactor.
Note

If the contactor fails to act, the reaction time increases by the amount of the set delay time.

Please note that when this occurs the circuit breaker must be manually reset.

To avoid accumulating undetected faults, the circuit breaker must be tested after 6 to 12 months at the latest. This can be done using the test button shown in the circuit diagram.

Note

This test setup must be documented in the description of the safety function and the operating instructions of the machine.

In addition, the tests performed by the user during the use phase must be documented verifiably.

An example of the configuration with two contactors can be found in the next section.
3.3 Safe switching up to SIL 3 or PL e

Safe switching up to SIL 3 according to IEC 62061 and PL e according to ISO 13849-1 requires the use of two redundant contactors and monitoring of the auxiliary contacts of both contactors. Two-channel monitoring of the EMERGENCY STOP is also required here.

Basic configuration

Figure 3-5

E-Stop  Safety relay  Power contactor  Power contactor  Motor starter
Circuit diagram

Figure 3-6
3.4 Safe switching of a group of motor starters up to SIL 3 or PL e

Safe switching of a group of motor starters up to SIL 3 according to IEC 62061 or PL e according to ISO 13849-1 is implemented in the same way as for an individual motor starter. The power contactors must be dimensioned accordingly.

The 3ZY1 device connector enables up to five motor starters to be connected to each other. In this case, the control supply voltage only has to be connected to the first motor starter and is then distributed to the downstream motor starters via the device connectors. In order not to have to expand the circuit diagram unnecessarily, an example configuration with only three motor starters is shown here.

**Basic configuration**
Circuit diagram

Figure 3-8
4 Contact/Support

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