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# Positively driven contact elements of contactor relays and mirror contacts of power contactors

Contactor relay / power contactor / Safety Integrated

<https://support.industry.siemens.com/cs/ww/en/view/109758261>

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# 1 Question

What is the difference between positively driven contact elements of contactor relays and mirror contacts of power contactors? What is the impact for the application?

## 2 Answer

In the IEC 60947-5-1 the term "positively driven contact" is defined in detail in Annex L. Also a corresponding symbol was specified and tests for the verification of "positively driven contactor relay contacts" are described. These characteristics of positively driven operation only referred to the contacts in the contactor relay.

For the contact characteristics of power contactors, the IEC 60947-4-1 standard defines the term "mirror contact" for power contactors. In addition, a symbol for such mirror contacts as well as tests for the verification of the mirror contact characteristics are specified.

Details will be described in the following chapters.

### NOTE

Both contact characteristics, the positively driven contact element in the contactor relay as well as the mirror contact in the power contactor, are absolutely equal.

### 2.1.1 Positively driven contact elements in accordance with IEC 60947-5-1, Annex L

#### Definition:

Positively driven contact elements in accordance with IEC 60947-5-1, Annex L, are a combination of  $n$  NO contacts and  $m$  NC contacts whose construction prevents their simultaneous closing.

For the "positively driven operation" characteristic, only auxiliary switch elements must be employed which are contained in switching devices and whose operating forces are generated internally.

An example are the SIRIUS – contactor relays 3RH.

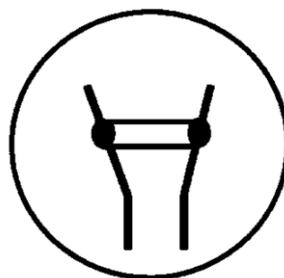


Figure 2-1 Symbol for positively driven contacts

### 2.1.2 Mirror contacts in accordance with IEC 60947-4-1, Annex F

**Definition:**

A mirror contact in accordance with IEC 60947-4-1, Annex F, is an auxiliary NC contact which cannot be closed simultaneously with an NO main contact.



Figure 2-2 Symbol für mirror contacts

### 2.1.3 Approval of contactor relays in accordance with EN 60947-5-1

All SIRIUS 3RH contactor relays (with at least 1 NC) are tested in accordance with IEC 60947-5-1 and have been featuring positively driven contact elements since their introduction (in the basic device itself or in the basic device in connection with auxiliary switches).

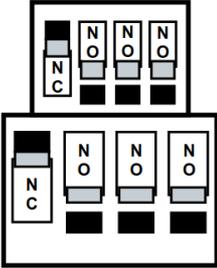
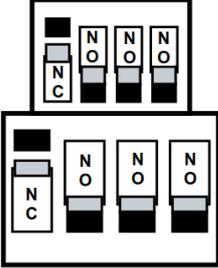
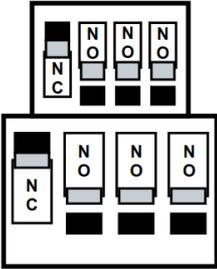
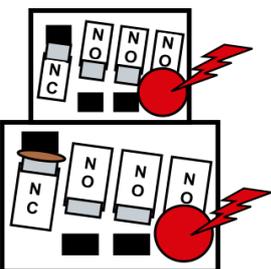
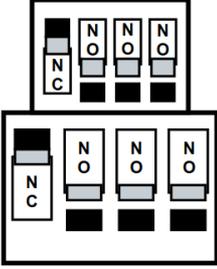
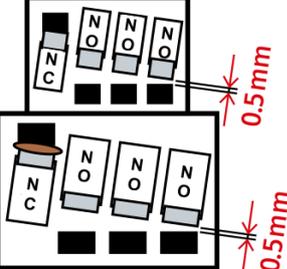


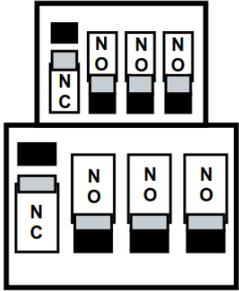
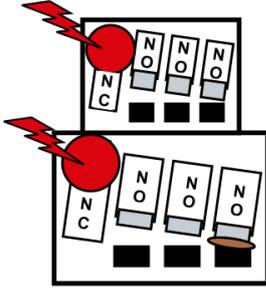
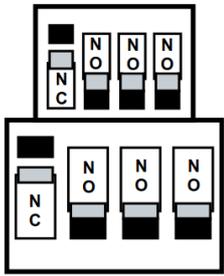
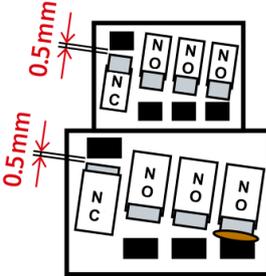
Figure 2-3 SIRIUS contactor relay 3RH

Table 2-1 shows the functional principles of the positively driven contact elements in the contactor relay. These both apply to standard as well as safety applications.

To illustrate the advantages of contactor relays with positively driven contact elements, each of the examined fault cases (e.g. fault on NC, fault on NO) first exemplifies a NON-Siemens contactor relay without positively driven operation and then a Siemens contactor relay with positively driven operation. The effects on the system are described in the "Explanation sequential state" column.

Table 2-1 Illustration of positively driven contactor relays in accordance with EN 60947-5-1

	Initial state	Sequential state	Explanation sequential state
<b>1. Uninterrupted operation</b>	 <p>Contactor relay switched off</p>	 <p>Contactor relay switched on</p>	<p>"Start" Request</p> <ol style="list-style-type: none"> <li>1. Contactor relay switched off. All NC contacts are closed, all NO contacts are open.</li> <li>2. Contactor relay is powered on.</li> <li>3. Contactor relay is switched on. All NC contacts are open, all NO contacts are closed.</li> </ol> <p>Result: No dangerous situation. Everything is normal.</p>
<b>2. Fault at the NC</b>	 <p>Contactor relay switched off</p>	 <p>Contactor relay without positively driven contacts, Fault at the NC</p>	<p>"Start" Request</p> <ol style="list-style-type: none"> <li>1. Contactor relay switched off. All NC contacts are closed, all NO contacts are open.</li> <li>2. Contactor relay is powered on.</li> <li>3. Fault at the NC contact, it can't open. The contactor relay is in an undefined state. All NC contacts are closed but also some NO contacts are closed.</li> </ol> <p>Result: The feedback signal give wrong information. There is a risk that the plant will start with this fault This kind of contactor relay is not approved for the use in safety applications.</p>
<b>3. Fault at the NC</b>	 <p>Contactor relay switched off</p>	 <p><b>SIRIUS contactor relay 3RH</b> with positively driven contacts , Fault at the NC</p>	<p>"Start" Request</p> <ol style="list-style-type: none"> <li>1. Contactor relay switched off. All NC contacts are closed, all NO contacts are open.</li> <li>2. Contactor relay is powered on.</li> <li>3. Fault at the NC contact, it can't open. All NC contacts are closed, all NO contacts are still opened (At least a distance of 0,5mm according IEC 60947-5-1 is ensured).</li> </ol> <p>Result: No dangerous situation. If a NC contact is welded, all NO contacts remain open. The feedback signal can be used to detect this fault.</p>

	Initial state	Sequential state	Explanation sequential state
<b>4. Fault at the NO</b>	 <p>Contactor relay switched on</p>	 <p>Contactor relay without positively driven contacts, Fault at the NO</p>	<p>"Stop" Request</p> <ol style="list-style-type: none"> <li>1. Contactor relay is switched on. All NC contacts are open, all NO contacts are closed.</li> <li>2. Contactor relay is powered off</li> <li>3. Fault at the NO contact, it can't open. The contactor relay is in an undefined state. Some NO contacts are closed but also some NC contacts are closed.</li> </ol> <p>Result: The feedback signal give wrong information. There is a risk that the plant will start with this fault This kind of contactor relay is not approved for the use in safety applications.</p>
<b>5. Fault at the NO</b>	 <p>Contactor relay switched on</p>	 <p><b>SIRIUS contactor relay 3RH</b> with positively driven contacts , Fault at the NO</p>	<p>"Stop" Request</p> <ol style="list-style-type: none"> <li>1. Contactor relay is switched on. All NC contacts are open, all NO contacts are closed.</li> <li>2. Contactor relay is powered off</li> <li>3. Fault at the NO contact, it can't open. Some NO contacts are closed, all NC contacts are still opened (At least a distance of 0,5mm according IEC 60947-5-1 is ensured).</li> </ol> <p>Result: No dangerous situation. If a NO contact is welded, all NC contacts remain open. The feedback signal can be used to detect this fault.</p>

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Legend

Symbol	Meaning	Symbol	Meaning
	Movable contact element (bridge)		Hazardous state
	Stationary contact element	NO	Auxilliary NO (normally open) contact
	Welding	NC	Auxilliary NC (normally closed) contact

**NOTE**

All examined cases are based on the assumption that a feedback loop is realized in the application. With this feedback loop, the states of the contactor's auxiliary NC contacts are evaluated. The consumer can only be switched on with the feedback loop closed.

### 2.1.4 Approval of power contactors in accordance with IEC 60947-4-1

All SIRIUS 3RT motor contactors (with at least 1 NC) are tested in accordance with IEC 60947-4-1 and have been featuring mirror contact characteristics in connection with auxiliary switches since their introduction.



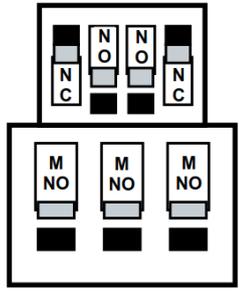
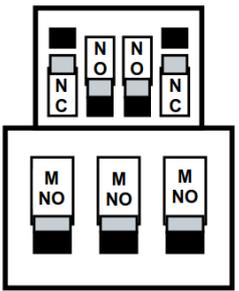
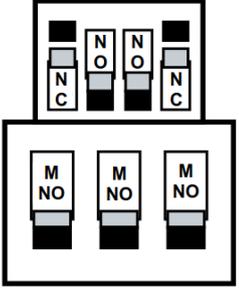
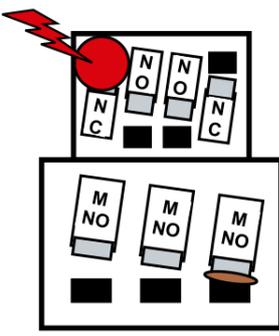
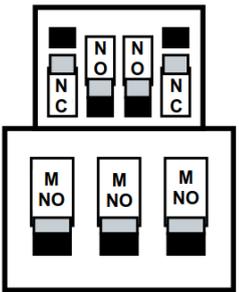
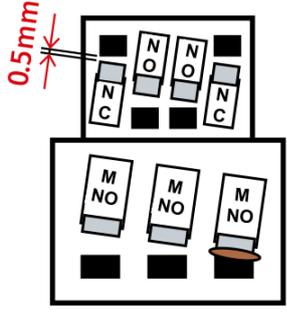
Figure 2-4 SIRIUS contactor 3RT

Table 2-2 shows the functional principles of the mirror contacts in the power contactor. These both apply to standard as well as safety applications. To illustrate the advantages of power contactors with mirror contacts, each of the examined fault cases first exemplifies a NON-Siemens power contactor without mirror contacts and then a Siemens power contactor with mirror contacts. The effects on the system are described in the "Explanation sequential state" column.

#### NOTE

All examined cases are based on the assumption that a feedback loop is realized in the application. With this feedback loop, the states of the contactor's auxiliary NC contacts are evaluated. The consumer can only be switched on with the feedback loop closed.

Table 2-2 Illustration mirror contacts of a contactor according EN 60947-4-1

	Initial state	Sequential state	Explanation of sequential state
1. Uninterrupted operation	 <p>Contactor switched off</p>	 <p>Contactor switched on</p>	<p>"Start" Request</p> <ol style="list-style-type: none"> <li>1. Contactor is switched off. All normally open contacts (M-NO, NO) are open, all normally closed contacts (NC) are closed.</li> <li>2. Contactor is powered on.</li> <li>3. Contactor is switched on. All normally closed contacts (NC) are open, all normally open (M-NO, NO) contacts are closed.</li> </ol> <p>Result: No dangerous situation. Everything is normal.</p>
2. Fault at NO contact	 <p>Contactor switched on</p>	 <p>Contactor without mirror contacts, Fault at M-NO contact</p>	<p>"Stop" Request</p> <ol style="list-style-type: none"> <li>1. Contactor is switched on. All normally closed contacts (NC) are open, all normally open (M-NO, NO) contacts are closed.</li> <li>2. Contactor is powered off.</li> <li>3. Fault at the normally open contact (M-NO), it can't open. The contactor is in an undefined state. Some normally open contacts (M-NO, NO) are closed but also some normally closed contacts (NC) are closed.</li> </ol> <p>Result: The feedback signal give wrong information. There is a risk that the plant will start with this fault. This kind of contactor relay is not approved for the use in safety applications.</p>
3. Fault at NO contact	 <p>Contactor switched on</p>	 <p><b>SIRIUS Contactor 3RT</b> (with 4-pol. auxillary contact relay) with mirror contacts, Fault at the NO contact</p>	<p>"Stop" Request</p> <ol style="list-style-type: none"> <li>1. Contactor is switched on. All normally closed contacts (NC) are open, all normally open (M-NO, NO) contacts are closed.</li> <li>2. Contactor is powered off.</li> <li>3. Fault at the normally open contact (M-NO), it can't open. All normally closed contacts (NC) are still opened (At least a distance of 0,5mm according IEC 60947-4-1 is ensured).</li> </ol> <p>Result: No dangerous situation. If a NO contact is welded, all NC contacts remain open. The feedback signal can be used to detect this fault.</p>

Legend

Symbol	Meaning	Symbol	Meaning
	Movable contact element (bridge)		Hazardous state
	Stationary contact element	NO	Auxiliary NO (normally open) contact
	Welding	NC	Auxiliary NC (normally closed) contact
		M NO	Main NO (normally open) contact

### 2.1.5 Protection against manipulation

One of the essential aspects of safety is the reduction of manipulation to minimize dangerous situations for the operators. The importance of these measures for the protection of persons is also enshrined in the recommendations of the German professional associations and the Swiss Accident Insurance Institute (SUVA). In the case of devices in the main circuit, the manual actuation of the devices is a manipulation.

A means of reducing the incentives for manipulation is the use of an auxiliary switch, which are permanently mounted at the factory and thus no actuation of the contactor by the operator is possible. Another advantage of permanently mounted auxiliary switch is a much higher reliability of the function. When auxiliary switches are mounted by the user, the correct installation and the function of the forced guide must be checked.

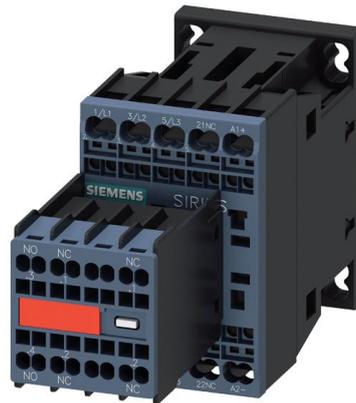


Figure 2-5 SIRIUS contactor 3RT with permanently mounted auxiliary switch

Another way to prevent manual actuation when using a contactor without an auxiliary switch is to use a sealable cover. These covers are available for all sizes S00 to S12 and make an equally large contribution to tamper protection as an permanently mounted auxiliary switch.

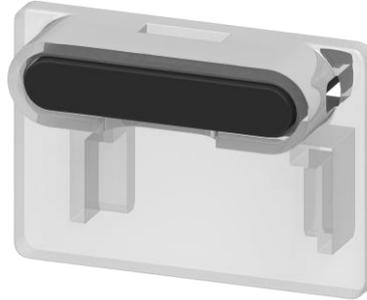


Figure 2-6 SIRIUS sealable cover 3RT2916-4MA10

### 2.1.6 Typical application examples

#### SIRIUS 3RH contactor relays

Contactor relays with positively driven contact elements are generally employed for self-monitoring in machine control circuits.

#### SIRIUS 3RT power contactors

Power contactors with mirror contacts are generally employed in control circuits of machines for reliable monitoring of the contactor state. The ISO 13839-1 as well as the IEC 62061 safety standards define the contactor as a safety-relevant control component which responds to input signals and generates safety-relevant output signals.

At the same time, IEC 60947-4-1 specifies that mirror contacts should not be relied upon as the sole safety mechanism.

As of safety category 2, the ISO 13849-1 standard calls for a feedback signal as auxiliary NC, e.g. on a 3SK safety relay as evaluation device.

This type of construction prevents "switching on a fault".

### 2.1.7 **Applikation examples**

The references below refer to some available Siemens functional examples in which SIRIUS contactors are employed in safety applications in accordance with ISO 13849-1 and IEC 62061:

Application manual SIRIUS Safety Integrated

<https://support.industry.siemens.com/cs/de/en/view/81366718>

Some examples applications are:

<http://support.automation.siemens.com/WW/view/en/73136378>

<http://support.automation.siemens.com/WW/view/en/109479271>

<http://support.automation.siemens.com/WW/view/en/69064698>

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