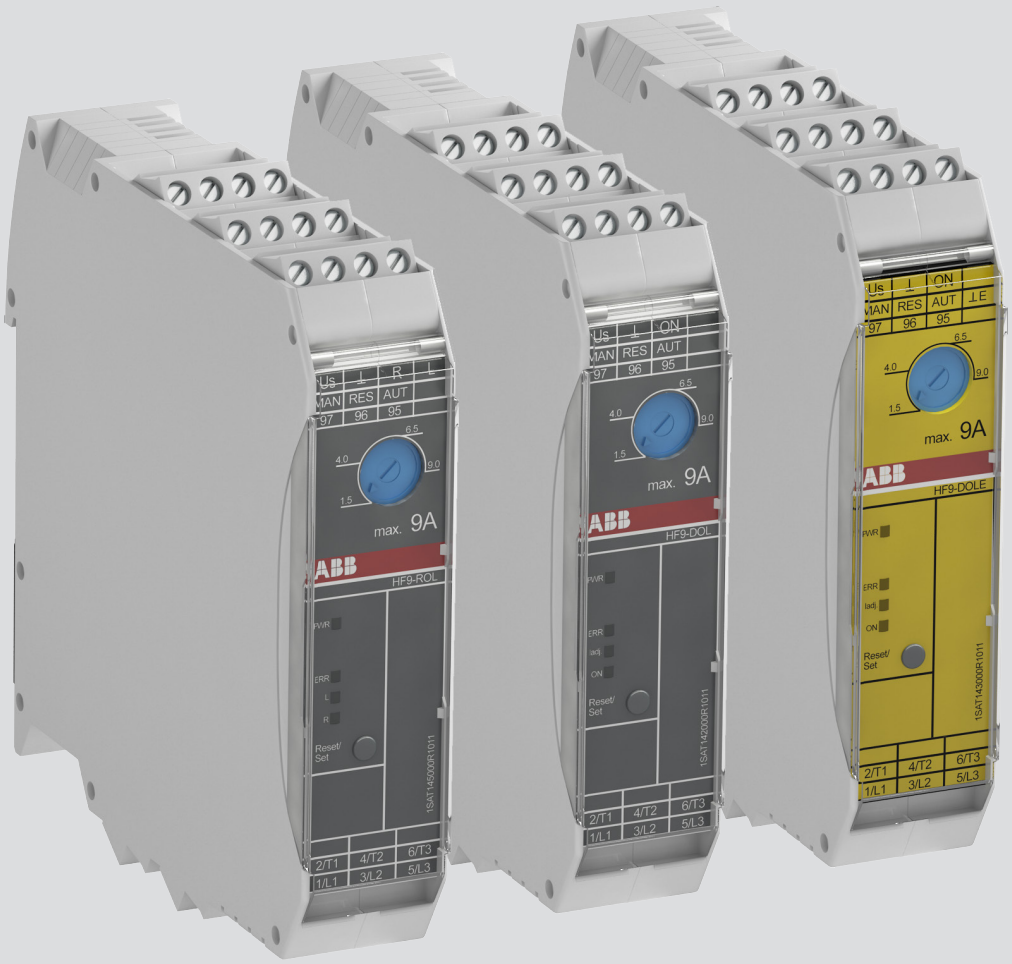
MANUAL

Electronic compact starter

HF range



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Electronic compact starters are becoming more and more popular due to their compactness and flexibility.

Based on hybrid technology, ABB's 22.5 mm-wide HF-Series provides direct on-line and reversing motor starter protects against overload, phase failures and phase asymmetry. A safety range supports the devices use in safety applications.

This manual provides an overview of the product and its applications to assist in the implementation and use of the electronic compact starter.

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1 Product overview

The electronic compact starter HF-range is used for switching functions of three-phase induction motors (AC-53a)- as well as direct on-line and resistive loads (AC-51).

The range is available as direct on-line starters (HFxx-DOL) with overload protection as a standard feature and with a safety design for emergency applications (HFxx-DOLE) with a safety-related shutdown.

Reversing starters (HFxx-ROL) with overload protection and with emergency switch-off function (HFxx-ROLE) are also available. The standard- DOL/ROL series and the DOLE/ROLE safety series come with electronic overload protection already integrated. For applications where only a reversing starter is needed, the HFx-R is available – this starter does not have an integrated electronic overload protection but is the only starter able to control single-phase motors.

For safety applications, a safety relay (e.g. SSR10 or USR10), signal devices and additional devices are required. The manufacturer of a plant or a machine is responsible for ensuring its safe functioning with safety-related components.

Definition
In this manual, 'HF range' and 'Electronic Compact Starter – ECS' refer to all variants of ABB's electronic compact starters. They complement ABB's motor starting solution offer, providing the right product for various applications up to 3 kW/400 V AC.

Conformity
The HF-range complies with the following standards:
- IEC 60947-1
- IEC 60947-4-2

The safety related variants comply with the following standards:
- EN 62061:2005
- EN ISO 13489-1:2010
- IEC 61508-1:2010
- IEC 61508-2:2010
- IEC 61508-3:2010

Approvals
For confirmation of approvals please visit:
https://new.abb.com/low-voltage/products/motor-controllers/electronic-compact-starters

Basic function
In general, the easiest way to start a motor is with a contactor. Combining it with a protective device against short circuit, overload protection and in many cases also an isolation device, this combination is then called a motor starter. For reversing applications where the motor operates in both directions, an additional contactor is needed. This conventional solution – contactors in combination with overload relays - can be replaced by the electronic compact starter.

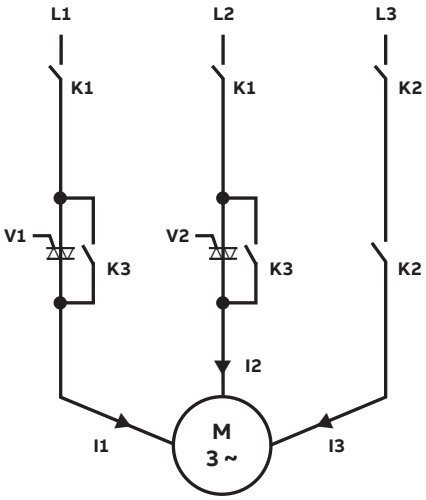
Applications

The electronic compact starter is used mainly in the OEM-segment, whereever space is limited, long lifetime is necessary and frequent switching is need. Applications include:

- Conveyor technology
- Logistics
- Production machines
- Machine tools
- Small elevators
- Pumps and compressors
- Solar tracker
- Snow guns

Hybrid technology

In order to achieve the greatest possible advantage, hybrid technology combines two technologies. Semiconductors switch the motor on and off with bypass relays used while the motor is running. A microcontroller ensures the right interaction between the components, shown in figure 1 below. Before starting the motor, all relays are opened as can be seen in figure 1. When the relays K1 and K2 are energized, the currents I1, I2, I3 are still approx. zero, see figure 2.



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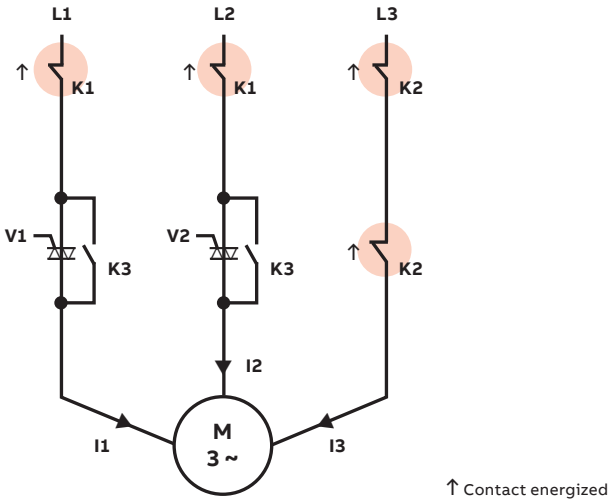
01 Semiconductors with relay bypass



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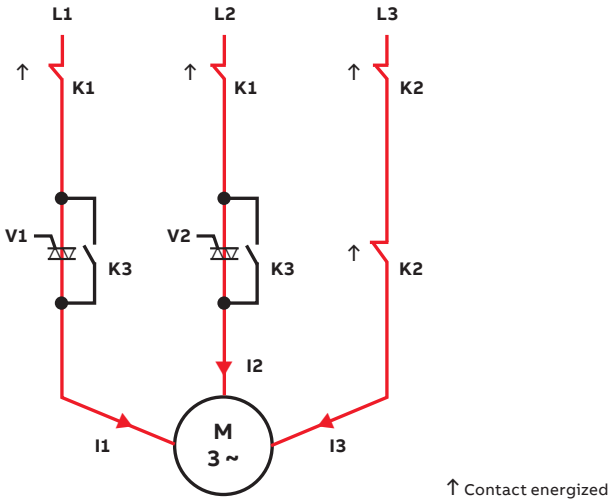
02 Equivalent circuit diagram 2

The microcontroller powers the V1 and V2 semiconductors. Currents I1, I2 and I3 flow so that the motor runs, as highlighted in red in figure 3.

Semiconductors generate significant losses in the form of heat dissipation. In order to reduce this loss of power, V1 and V2 are now bypassed by the K3 relays and hence turned off. The bypass relays now carry the current while the motor is running, reducing power losses.

The same method is used for switching off the motor: the semiconductors are activated by the microcontroller and take over the current from the bypass relays that then open. After that, the motor is switched off by de-energizing V1 and V2 so that the current equals zero. At the end, the K1 and K2 relays are opened.



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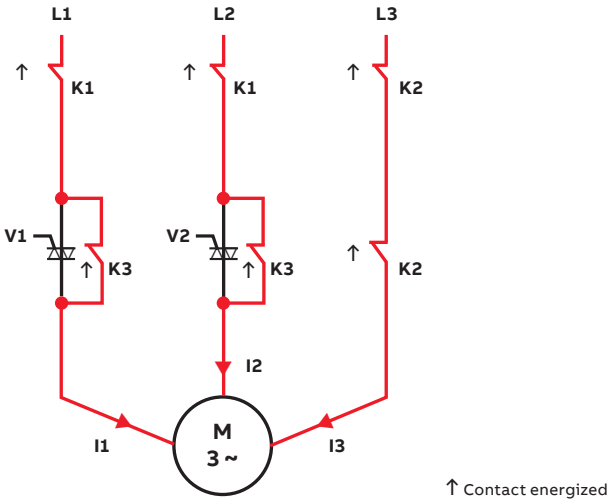
03 Equivalent circuit diagram 3



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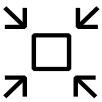
04 Equivalent circuit diagram 4

Hybrid technology enables arc-free switching and helps extend the lifespan because the relay switching that would usually cause arcs is prevented.

The typical wearing away of contact material seen in standard electromechanical devices is eliminated thanks to the smart use of the semiconductors. Up to 30 million electrical switching lifecycles, 7200 switching cycles per hour and multifunctionality is provided in only 22.5 mm width.

1.1 Benefits



Space saving

Up to 90% less space required
ABB's electronic compact starter saves cabinet space, and is especially effective for group mounting. The starter is just 22.5 mm wide and yet still provides motor starting functionalities with motor protection and safety embedded.

Safety and protection

Integrated safety function
Protect your people with an emergency stop version that complies with SIL 3, PL e safety standards. Extend the life of your equipment and reduce maintenance costs with service lives that are ten times higher than electromechanical solutions.

Easy to install

Up to 75% reduced time in wiring
Wiring time during installation is cut to a minimum with motor protection, reversing function and emergency stop already integrated in the product. With just one component to install, the risk of wiring errors is lower. Separate overload protection is no longer needed.

1.2 Product combinations

In combination with the HF-range, ABB recommends using power supply CP-E 27/0.75 (1SVR427030R0000). With an output current of 0.75 A, it is possible to connect up to 18 electronic compact starters.

Function	Product	Description	Product name	Order code
Power supply	Power supply for compact starters	24 V DC rated output voltage	CP-E 24/0.75	1SVR427030R0000
Control input	Pilot devices	NO modular contact block	MCB-10	1SFA611610R1001
		Push button	MP2-10x	1SFA611101R100X
		Modular holder	MCBH-00	1SFA611605R1100
		DIN-rail adaptor	MA1-8131	1SFA611920R8131
Remote reset	Reset button	1 NO Contact block for rear mounting	MCB-10B	1SFA611610R2001
		Push button	MP1-10x	1SFA611100R100X
		Modular holder	MCBH-00	1SFA611605R1100
Emergency switching off	Emergency switch	Switch	CE4P-10R-02	1SFA619551R1051
Interlocking - switch	Switch	Two-position selector switch	M2SS5-10B	1SFA611204R100X
		Modular holder	MCBH-00	1SFA611605R1100
		NO modular contact block (2 pc.)	MCB-10	1SFA611610R1001
		NC modular contact block (2 pc.)	MCB-01	1SFA611610R1010
Safety related applications	Safety relay		Sentry SSR10	2TLA010050R0000
			Sentry USR 10	2TLA010070R0000

Table 1 Product combinations

1.3 Explanation of terminals

Divergent details are shown for each type in the following chapters, in which the various functions of the terminals are also explained.

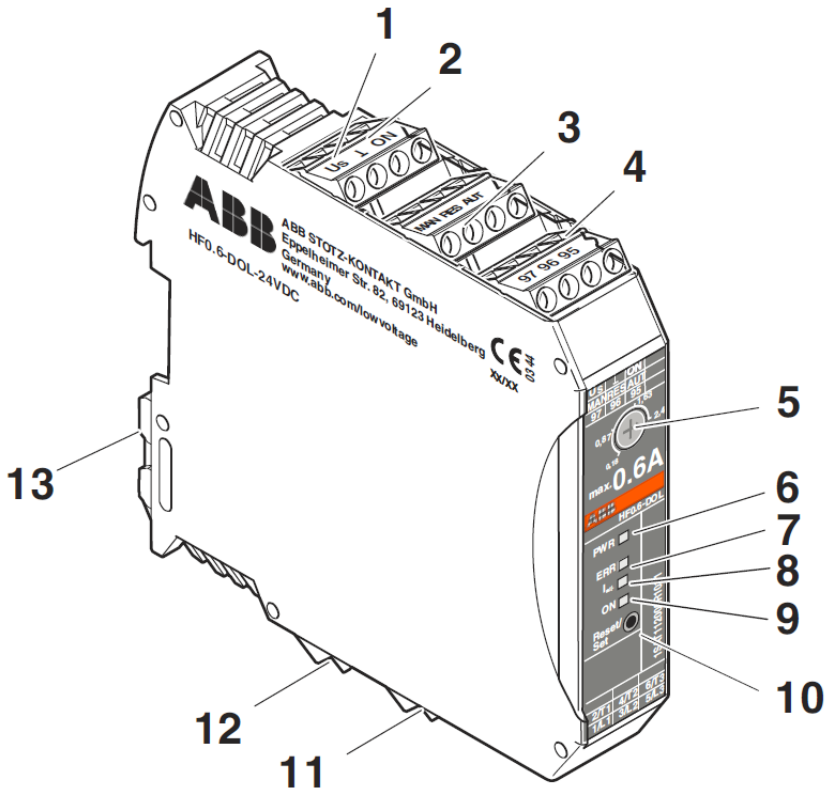
All settings and adjustments are made directly at the electronic compact starter. The exception is HF9-R-24VDC where no adjustments are possible and no protection function is integrated.

The LEDs have multiple functions, such as indicating the exact parametrized nominal current (see chapter 3.3), displaying the status for diagnostics (see chapter 4.4) and showing the operation status.

Terminal indications of DOL- and ROL- types

No.	Indication	HFxx-DOL-24 V DC	HFxx-ROL-24 V DC
1	U_s	Input control supply voltage	Input control supply voltage
2	HFxx-DOL: ON HFxx-ROL: R, L	Connection point for ECD - external control device for starting the motor	Connection point for ECD - external control device Right /Left rotation
3	MAN, RES, AUT	Acknowledgement inputs	Acknowledgement inputs
4	95,96,97	Switch over contact - fault signaling output	Switch over contact - fault signaling output
5	Potentiometer	Potentiometer for the rated operational current "I_e" of the motor	Potentiometer for the rated operational current "I_e" of the motor
6	PWR LED	PWR LED (green)	PWR LED (green)
7	ERR LED	ERR LED (red)	ERR LED (red)
8	Iadj LED	Iadj LED (yellow)	Iadj LED (yellow)
9	DOL: ON LED ROL: R-, L-LED	ON LED (Rotation)	R-LED (Right rotation) L-LED (Left rotation)
10	Reset button	Reset after trip	Reset after trip
11	2/T1, 4/T2, 6/T3	Main circuit output	Main circuit output
12	1/L1, 3/L2, 5/L3	Main circuit input	Main circuit input
13	Metal latch	Metal latch for fixation to the DIN rail	Metal latch for fixation to the DIN rail

Table 2 Explanation of terminals and LED status indicator of DOL, ROL types



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05 Explanation of terminals and LED status indicator of DOL-ROL- types

Additional explanation
No. 1: The input terminal for control supply voltage is 24 V DC. Its reference potential is the terminal right next to it, labeled with '⊥'.

No. 2: For DOL-types there is only one control input, which starts the motor. For ROL-types, the 'R' terminal is for forward running (right rotation), whereas the 'L' is for reverse running (left rotation) of the motor.

No. 3: For manual reset, press the reset button. Remote reset needs a connection of a button (N/O contact) between MAN an RES terminals. After the overload function has tripped, the electronic compact starter can be reset automatically, manually and remotely using these terminals. For manual or remote reset, connect a button (N/O contact) between the MAN and RES terminals. Establish an electrical connection between the RES and AUT terminals for an automatic reset. (See chapter 5)

No. 4: The feedback relay is activated as soon as the electronic compact starter detects an error or indicates a message: the N/O contact between terminals 96 and 97 is closed or the N/C contact between terminals 95 and 96 is opened.

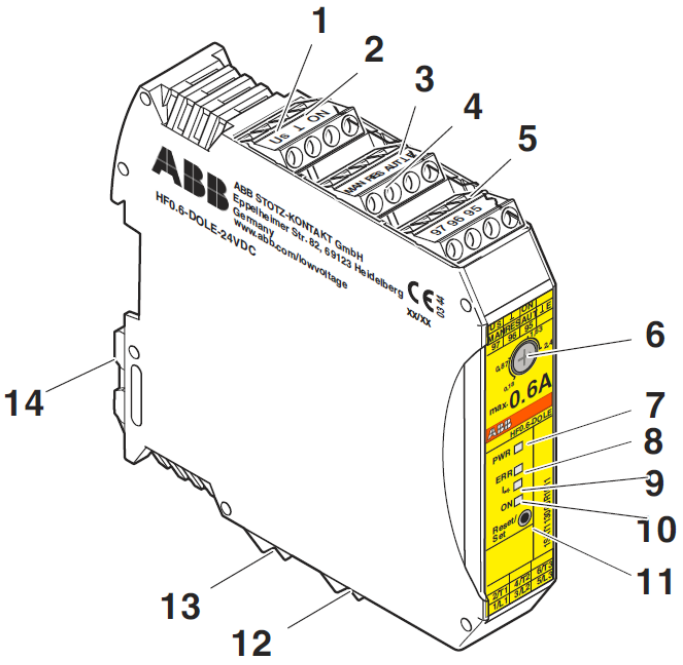
No. 11: The main circuit output terminal must be connected with the motor.

No. 12: The main circuit input terminal must be connected with the 3-phase supply network. Please also establish short circuit protection.

LED status indicators of DOLE- and ROLE- types

No.	Indication	HFxx-DOLE-24 V DC	HFxx-ROLE-24 V DC
1	U_s	Input control supply voltage	Input control supply voltage
2	DOLE: ON ROLE: R, L	Connection point for ECD - external control device for starting the motor	Connection point for ECD - external control device Right /Left rotation
3	⊥E	Reference point control input (emergency -stop)	Reference point control input (emergency-stop)
4	MAN, RES, AUT	Acknowledgement inputs	Acknowledgement inputs
5	95,96,97	Control circuit fault signaling output	Control circuit fault signaling output
6	Potentiometer	Potentiometer for the rated operational current "Ie" of the load	Potentiometer for the rated operational current "Ie" of the load
7	PWR LED	PWR LED (green)	PWR LED (green)
8	ERR LED	ERR LED (red)	ERR LED (red)
9	Iadj LED	Iadj LED (yellow)	Iadj LED (yellow)
10	DOL: ON LED ROL: R-, L-LED	ON LED (Rotation)	R-LED (Right rotation) L-LED (Left rotation)
11	Reset button	Reset after trip	Reset after trip
12	2/T1, 4/T2, 6/T3	Main circuit output	Main circuit output
13	1/L1, 3/L2, 5/L3	Main circuit input	Main circuit input
14	Metal latch	Metal latch for fixation to the DIN rail	Metal latch for fixation to the DIN rail

Table 3 HMI of DOLE, ROLE types



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06 HMI of DOLE- ROLE- types

Additional explanation
No. 1: The input terminal for the control supply voltage is 24 V DC. Its reference potential is the terminal right next to it, labeled with '⊥'.

No. 2: For DOLE-types there is one control input, which starts the motor. For ROLE-types, the 'R' terminal is for forward running (right rotation); 'L' is for reverse running (left rotation) of the motor.

No. 3: Regardless of whether it is a DOLE or a ROLE device, there is one reference potential terminal for the control input (ON/ R, L).

No. 4: After the overload function has tripped, the compact starter can be reset automatically, manually and remotely using these terminals. For manual reset, press the reset button. Remote reset requires the connection of a button (N/O contact) between MAN an RES terminals. Establish an electrical connection between the RES and AUT terminals for automatic reset.

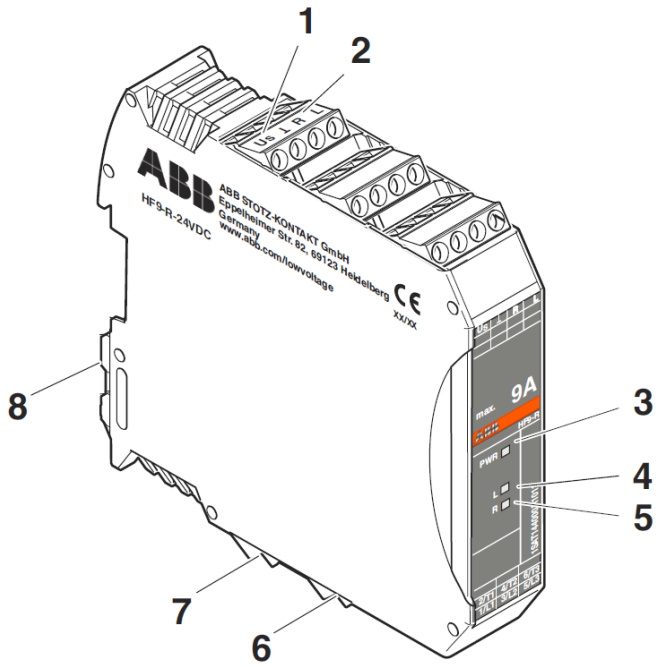
No. 5: The feedback relay is activated as soon as the electronic compact starter detects an error or indicates a message: the N/O contact between terminals 96 and 97 is closed or the N/C contact between terminals 95 and 96 is opened.

No. 12: The output voltage terminal has to be connected with the motor.

No. 14: The input voltage terminal has to be connected with the 3-phase supply network. Please also establish device and wire protection.

LED status indicator of R- type

No.	Indication	HFxx-ROLE-24 V DC
1	U_s	Input Control supply voltage
2	R: Right L: Left	Control input for direct and reversed start
3	PWR LED	PWR LED (green)
4	L LED	L-LED (yellow), Left rotation
5	R LED	R-LED(yellow), Right rotation
6	2/T1, 4/T2, 6/T3	Main circuit output to motor or resistive load
7	1/L1, 3/L2, 5/L3	Main circuit input
8	Metal latch	Metal latch for fixation on DIN rail



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07 HMI of R- type

Additional explanation

No. 1: The input terminal for the control supply voltage is 24 V DC. Its reference potential is the terminal immediately next to it, labeled with '⊥'.

No. 2: The control input terminal 'R' is for forward running (right rotation); 'L' is for reverse running (left rotation) of the motor.

No. 6: The output voltage terminal has to be connected with the motor.

No. 7: The input voltage terminal has to be connected with the 3-phase supply network. Please also establish device and wire protection.

2 Safety and conformity

Disregarding these safety regulations may result in death, serious personal injury or damage to equipment.

Attention!
Hazardous voltage! The installation and the operation of this device and any maintenance must be carried out by a qualified person in accordance with specific local standards and safety regulations. Before installing this device, read these operating instructions carefully. Do not touch live parts. To prevent harm to persons and materials, the devices must be replaced in case of mechanical and/or electrical damage. These operating and installation instructions cannot claim to contain complete, detailed information of this product and can not take into account every possible product application. All statements serve exclusively to describe the product and must be understood not to be assured characteristics with legal force. Further information and data can be obtained from the relevant product catalogues and data sheets, available from local ABB sales organizations as well as the ABB homepage: abb.com. Subject to change without prior notice. In case of doubt, the English text applies.

2.1 General safety arrangements

- During all work on the device, adhere to your national safety and accident prevention regulations.
- Startup, mounting, modifications, and upgrades should only be carried out by a skilled electrical engineer and/or trained employees.
- Keep the instruction sheet in a safe place.
- Before working on the device, disconnect the power.
- During operation, parts of electrical switching devices carry hazardous voltages.
- Protective covers must not be removed when electrical switching devices are operating.
- If the 'Automatic RESET' mode is used, the load is switched on again after the cooling time has elapsed – if a control signal is still present. The cooling time is 20 minutes.
- The device may not be subjected to mechanical or thermal stress that exceeds the thresholds specified in the operating manual. To protect the device against mechanical or electrical damage, install it in a suitable housing with the appropriate level of protection as per IEC 60529/EN 60529, if required.
- The installation has to be performed in accordance with the instructions in the operating manual. Access to the circuit inside the device is not permitted during operation.
- The item cannot be repaired by the user and has to be replaced by an equivalent device. Repairs can only be carried out by the manufacturer.
- The device performs a diagnosis of functions when the load is first switched on or switched off. In addition, an appropriately trained skilled worker, well acquainted with the relevant standards, can conduct a 'Motor overload protection' safety function test. For this test, the load must be activated (DOL, DOLE- types) / operated with right or left rotation (forward or reverse running) (R-, ROL-, ROLE- types), and the current flow in a conductor interrupted, for example by removing the fuse in the L1 or L3 phase. The electronic compact starter then switches off the load within 1.5 to 2 seconds. The LEDs for right or left rotation (forward or reverse running) go out and the ERR-LED and the reply output are set.
- The device must be secured with the help of an access protection device during safety-related applications.
- Only use power supply units with safe isolation and PELV in accordance with EN 50178/VDE 0160 (PELV). This prevents short circuits between primary and secondary sides.

2.2 Safety arrangements in explosive areas

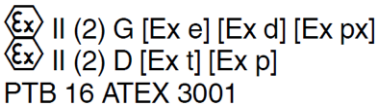
- All HF range devices are associated equipment and may not be installed in potentially explosive areas. When installing and operating the device, the applicable safety directives for associated equipment must be observed.
- In circuits in potentially dust-explosive areas of zones 21 and 22, it must be guaranteed that the equipment connected to this circuit complies with the category 2D or 3D or is certified as such.
- If the "Automatic RESET" mode is used, the load is switched on again after the cooling time has expired if a control signal is still present. The cooling time is 20 minutes.
- For applications in explosion-protection areas, automatic restart is not permitted.

2.3 Conformity

All HF range devices are in accordance with following conformity standards:
- IEC 60947-1:2007
- IEC 60947-4-2
- UL 508 Standard for Industrial Control Equipment
- UL 60947-4-1 (A)/UL 60947-1(A)
- SS-EN 50178. (NLDX File: E191658)

The DOLE- and ROLE-types with emergency stop integrated are in accordance with ATEX, SIL 3 and PL e:
- Safe shutdown: Safety Integrity Level according to IEC 61508-1: SIL 3
- Motor protection: Safety Integrity Level according to IEC 61508-1: SIL 2
- Performance level according to ISO 13849-1: e

EU type-examination certificate:



Explanation:

:	European Commission mark for Ex products; in case of the HF-Starter for motor control in potentially explosive environments
Group II:	Equipment group: II for surface industry
(2):	Product category 2: Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapors, mists or air/dust mixtures are likely to occur.
G:	Equipment category: G for explosive gas environment
D:	Equipment category: D for explosive dust environment
[Ex e]	Equipment protection by increased safety 'e' EN 60079-7
[Ex d]	Equipment protection by flameproof enclosures "d" EN 60079-1
[Ex px]	Equipment protection by pressurized enclosure "p" EC60079-2
[EX t]	Equipment dust ignition protection by enclosure IEC 60079-31
[EX p]	Equipment protection by pressurized enclosure IEC 60079-2
PTB 16 ATEX 3001:	Type examination certificate

3 Functions

ABB's electronic compact starter, up to 3 kW/400 V AC, is 22.5 mm wide with direct-on-line, reversed starting, motor overload protection, and emergency switching off integrated. ABB offers a standard and safety range.

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08 Left: HF9-DOLE; Right: HF9-DOL

The table below shows an overview of functionality of the HF-range:

Order code	Type	Direct on-line starter	Reversing starter	Electronic overload protection	Emergency switching off
1SAT116000R1011	HF0.6-ROLE-24VDC	X	X	X	X
1SAT126000R1011	HF2.4-ROLE-24VDC	X	X	X	X
1SAT146000R1011	HF9-ROLE-24VDC	X	X	X	X
1SAT115000R1011	HF0.6-ROL-24VDC	X	X	X	-
1SAT125000R1011	HF2.4-ROL-24VDC	X	X	X	-
1SAT145000R1011	HF9-ROL-24VDC	X	X	X	-
1SAT112000R1011	HF0.6-DOL-24VDC	X	-	X	-
1SAT122000R1011	HF2.4-DOL-24VDC	X	-	X	-
1SAT142000R1011	HF9-DOL-24VDC	X	-	X	-
1SAT113000R1011	HF0.6-DOLE-24VDC	X	-	X	X
1SAT123000R1011	HF2.4-DOLE-24VDC	X	-	X	X
1SAT143000R1011	HF9-DOLE-24VDC	X	-	X	X
1SAT144000R1011	HF9-R-VDC-24VDC	X	X		

Table 4 Electronic compact starter range functionality

- Motor with a power range of up to 3 kW/400 V AC can be operated with the electronic compact starter. A frequency of 2 Hz - 2 starts per second, 120 starts per minute, 7200 stars per hour is realizable.
- An AC-51 utilization category up to 9 A with a frequency of 2 Hz is also possible.

Please note that frequent switching means high starting currents for the motor. This leads to temperature increases in the motor windings. As the electronic compact starter calculates a model of the thermal load on the motor dependent on the operating time and current load, tripping can occur.

After tripping, the motor memory module is discharged after two minutes. You must wait for this cooling time to elapse before the manual reset can be done. An automatic reset takes place after 20 minutes.

Frequency converters, single- phase motors, DC-motors:
Usage of the HF range in combination with a frequency converter is not admissible.

Single-phase motors are only allowed to be switched with the HF9-R. All other variants provide internal measuring technology. The internal measuring technology evaluates this combination as an error and the device indicates a fault. Please use a frequency of 50/60 Hz.

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3.1 Direct on-line starters

All listed products can be used as direct on-line starters. Versions with HFxx-DOLE-24VDC in the type description are also usable for emergency stop functions. Please refer to the table below.

Order code	Type	Direct on-line starter	Reversing starter	Electronic overload protection	Emergency switching off
1SAT112000R1011	HF0.6-DOL-24VDC	X	-	X	-
1SAT122000R1011	HF2.4-DOL-24VDC	X	-	X	-
1SAT142000R1011	HF9-DOL-24VDC	X	-	X	-
1SAT113000R1011	HF0.6-DOLE-24VDC	X	-	X	X
1SAT123000R1011	HF2.4-DOLE-24VDC	X	-	X	X
1SAT143000R1011	HF9-DOLE-24VDC	X	-	X	X

For switching non-inductive loads it is recommended to use a HF9-R-24VDC. This range offers no overload protection and no monitoring functionality.

Thresholds
The threshold values describe the value where the electronic compact starter switches the motor on or off.
- Threshold level 'high' is 19.2 V…30 V
- Threshold level 'low' is -3 V…9.6 V

As can be seenn figure 9, the electronic compact starter recognizes different control input voltages. All values between 19.2 V and 30 V leads to switching on the motor. For values between 9.6 V and -3 V the motor will be switched off.

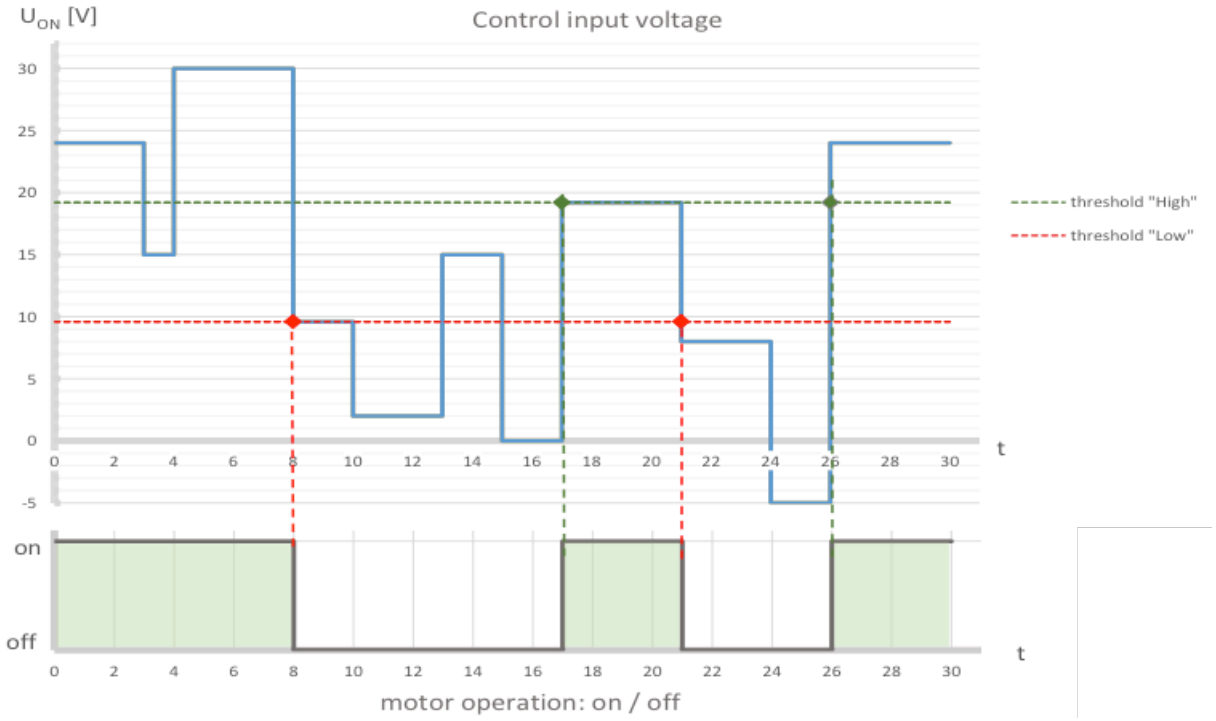
This means that the control voltage, applied in terminal ‘ON’, must be
- > 19.2 V to switch the motor on
- < 9.6 V to switch the motor off

Automatic restart

For applications in explosion-protection areas, automatic restart is not permitted!

- If the 'Automatic RESET' mode is used, the load is switched on again after the cooling time of 20 minutes has elapsed – if a control signal is still present. In order to prevent this event, there is an option to use the manual RESET (via button or remote acknowledgement point.

The following diagram shows an exemplary voltage characteristic for direct-on-line starters. Please note that this is a simplified diagram.



09 Voltage characteristic of direct on-line starter

Diagram 1 – explanation:

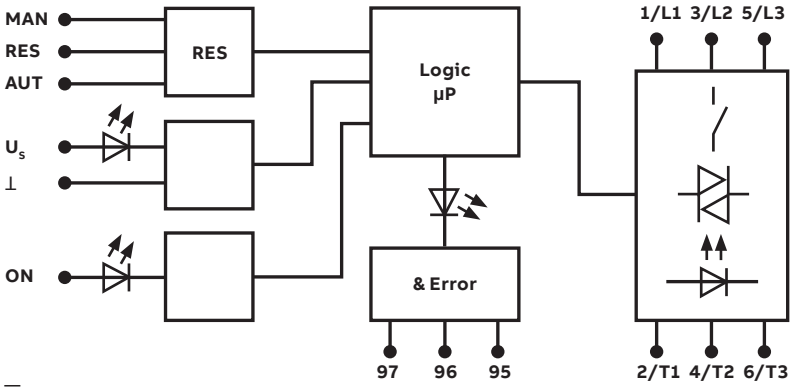
- t_0: Control voltage U_{ON} > threshold 'high'→ motor starts
- t_{3-4}: Voltage fluctuations → motor runs
- t_8: Control voltage U_{ON} < threshold 'low' → motor stops
- t_{17}: Control voltage U_{ON} > threshold 'high' → motor starts
- t_{21}: Control voltage U_{ON} < threshold 'low' → motor stops
- t_{26}: Control voltage U_{ON} > threshold 'high' → motor starts

t_0

t_8

DOL- type

The HMI of the DOL device is described in chapter 1.9.1. The following figure 10 shows the corresponding drawing for the device.



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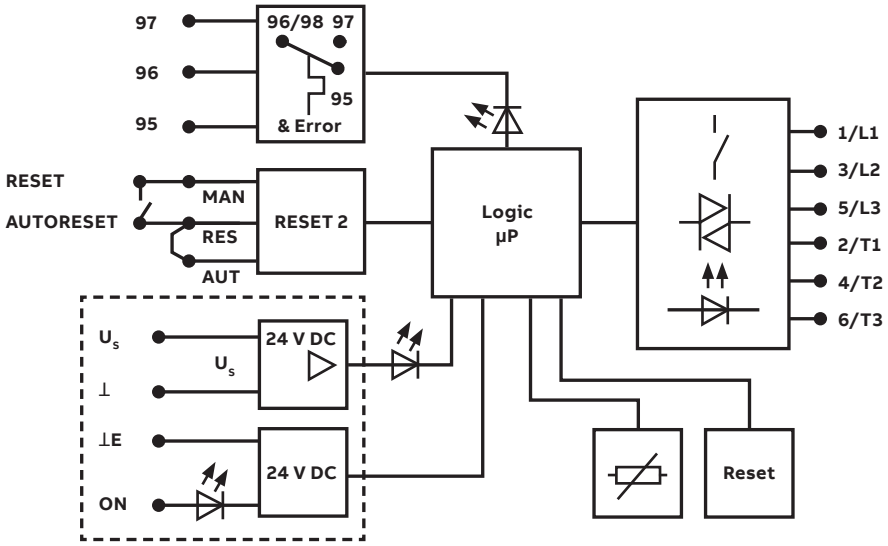
10 Circuit diagram of DOL

DOLE- type

For applications in explosion-protection areas, automatic restart is not permitted!

- If the 'Automatic RESET' mode is used, the load is switched on again after the cooling time of 20 min. has elapsed – if a control signal is still present.

The HMI of the DOLE device is described in chapter 1.9.2. The following figure 11 shows the corresponding drawing for the device. The main difference to DOL-types is the connection point ⊥E. This is one possible connection point for the safety relay Sentry SSR10/USR10 for emergency stop application.



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11 Circuit diagram of DOLE types

3.2 Reversing starters

All listed products can be used as reverse starters. Versions with HFxx-ROLE-24VDC in the type description can also be used for emergency switching off functions. Please see the table below.

Order code	Type	Direct on-line starter	Reversing starter	Electronic overload protection	Emergency switching off
1SAT115000R1011	HF0.6-ROL-24VDC	X	X	X	-
1SAT116000R1011	HF0.6-ROLE-24VDC	X	X	X	X
1SAT125000R1011	HF2.4-ROL-24VDC	X	X	X	-
1SAT126000R1011	HF2.4-ROLE-24VDC	X	X	X	X
1SAT144000R1011	HF9-R-24VDC	X	X	-	-
1SAT145000R1011	HF9-ROL-24VDC	X	X	X	-
1SAT146000R1011	HF9-ROLE-24VDC	X	X	X	X

For switching non-inductive loads up to 9 A it is recommended to use the HF9-R. This range offers no overload protection and no monitoring functionality as needed for motors.

Reversing starters can reverse motors up to 3kW / 400V AC with a frequency up to 2 Hz.

Thresholds:

- Threshold level 'high' is 19.2 V…30 V
- Threshold level 'low' is -3 V…9.6 V

The control input voltage, applied in terminal ‘L’, must be:
- > 19.2 V to switch the motor on in reverse running (left rotation)
- < 9.6 V to switch the motor off

The control input voltage, applied in terminal ‘R’, must be:
- > 19.2 V to switch the motor on in forward running (right rotation)
- …be < 9.6 V to switch the motor off

If a signal is present at the same time on “R” and “L” there is no specified direction of rotation. The HF-Starter will recognize one of the signals as first signal and start to rotate in the respective direction. The second signal will be locked. While the motor is running, applying signals in the second terminal has no effect.

Automatic restart

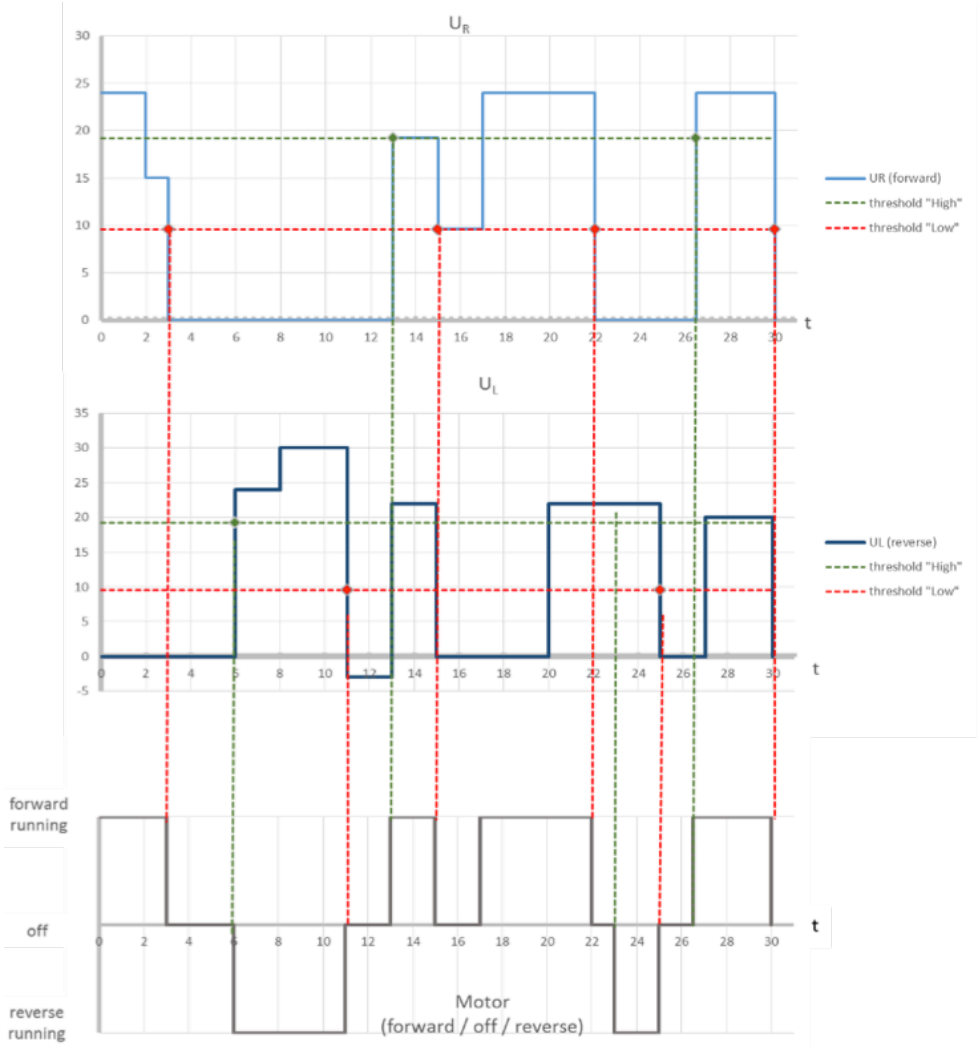
For applications in explosion-protection areas, automatic restart is not permitted!

Reversing starters restart automatically in two cases:

Automatic reset: If the 'Automatic RESET' mode is used, the load is switched on again after the cooling time of 20 min. has elapsed – if a control signal is still present.

Interlocking: one of two control input signals (e.g. left rotation) is still applied when the other one (e.g. right rotation) comes below the threshold 'low'. The motor is switched off but takes a restart after a short break (time < 1 sec.) (in this case in left rotation).

The following figure 12 shows an example voltage characteristic for reversing starters. Please note that this is a simplified diagram.



—
12 Voltage characteristic of reversing starter

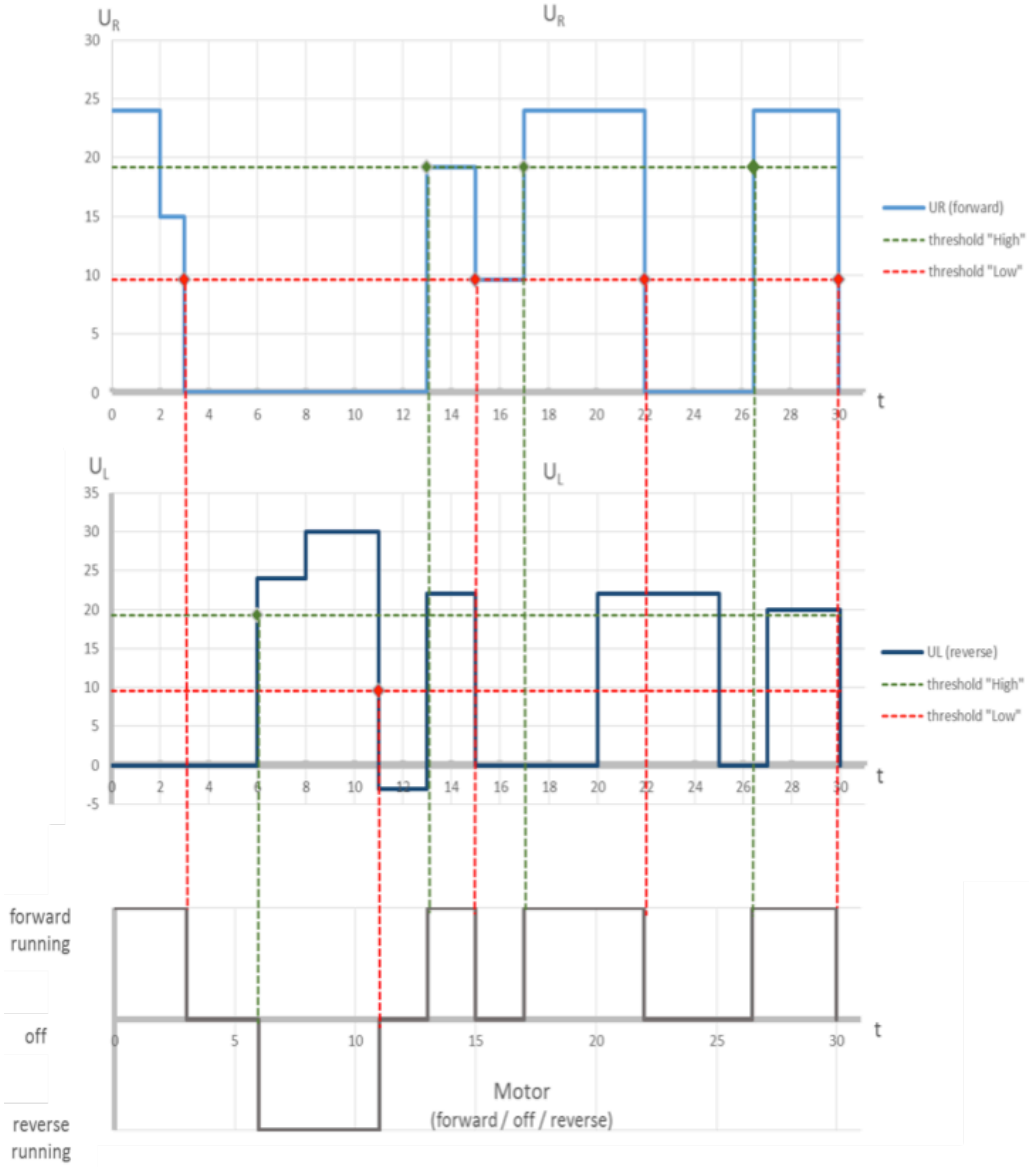
Explanation for diagram 3:

- t_0: Control voltage applied on U_R > threshold 'high' → motor starts (forward running)
- t_3: Control voltage applied on U_R < threshold 'low' → motor is switched off
- t_6: U_L > threshold 'high' → motor is switched on (reverse running)
- t_{11}: U_L < threshold 'low' → motor is switched off
- t_{13} U_R and U_L > threshold 'high' → motor is switched on (forward running)
- t_{15} U_R < threshold 'low' → motor is switched off
- t_{17} U_R > threshold 'high' → motor is switched on (forward running)
- t_{22} U_R < threshold 'low' → motor is switched off
- t_{23}: U_L > threshold 'high' (since t_{20}) → motor is switched on (reverse running) because of automatic restart after short pause time (< 1 sec.)
- t_{25}: U_L < threshold 'low' → motor is switched off
- t_{26} U_R > threshold 'high' → motor is switched on (forward running) (because signal U_R is applied earlier than U_L)
- t_{30}: U_R < threshold 'low' → motor is switched off

—
t_0

—
t_3

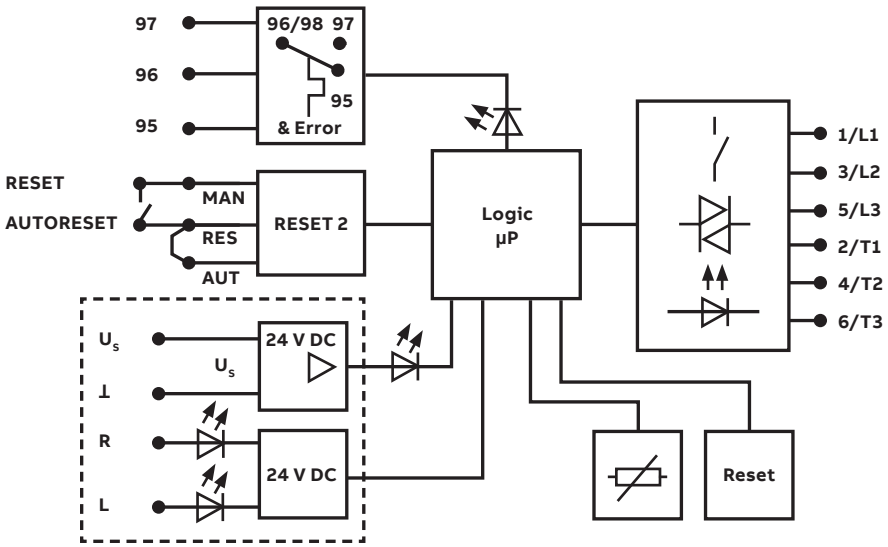
—
t_6



—
13 Voltage characteristic of reversing starter

ROL- types

The following figure 14 shows the corresponding block diagram for the device. Each box represents a functionality.

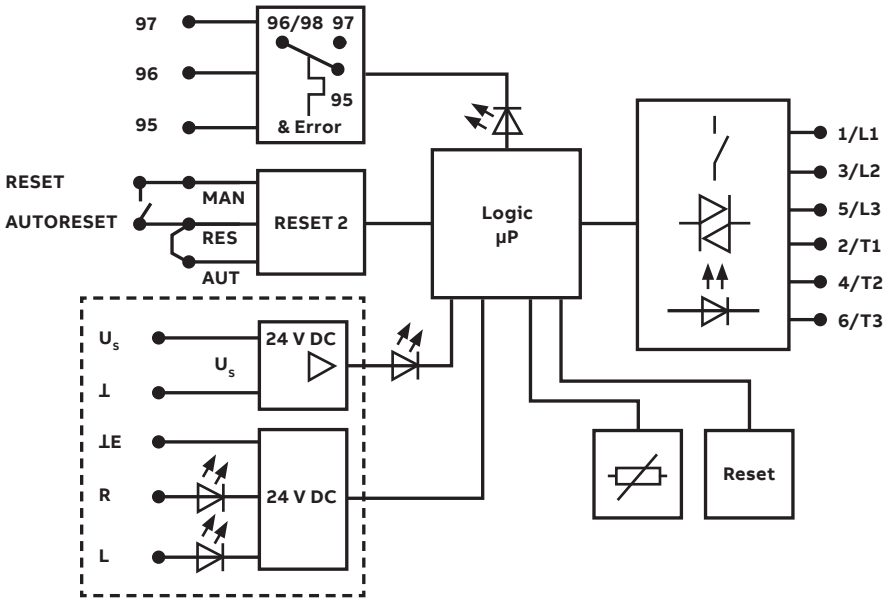


—

14 Circuit diagram of ROL-types

ROLE- types

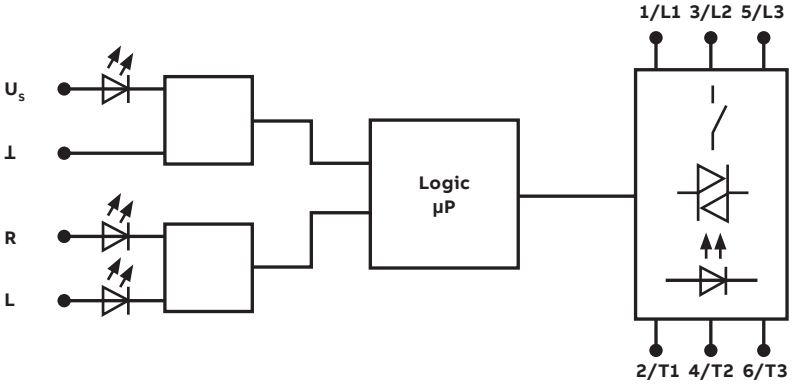
The HMI of the ROLE device is described in chapter 1.10.2. The following figure 15 shows the corresponding block diagram for the device.



—

15 Circuit diagram of ROLE-types

R-type
The HMI of the R- device is described in chapter 1.10.3. The following figure 16 shows the corresponding drawing for the device. Each box represents a functionality.



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16 Circuit diagram of R- type

—
3.3 Setting the nominal current

For setting the nominal current, please proceed as outlined below:
1. Press the Reset / Set button for more than six sec. to change to setting mode. The green ‘PWR'-LED flashes once.
2. Set the nominal load current with the potentiometer. The nominal current is specified in 16 stages as shown in the following table 5 Setting the nominal overload current and on the side of the device. The four LEDs signal the set current.
3. Store this value by pressing the Reset/ Set button again.
4. Press the Reset/ Set button for more than 2 sec. AND less than 6 sec. to display the set current (shown for 3 sec.). This function is only possible if the device is not activated and there are no device errors.

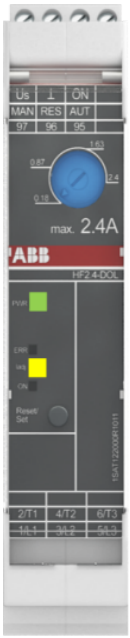
Table 5 shows the nominal current codification that is applicable for all HF types.

Please note that the LEDs are switched off every two sec. for 0.3 sec. to distinguish this mode from other operating modes.

LED's on the front side				**Nominal current [A]**		
PWR	ERR	Iadj	ON	HF0.6-DOL-24VDC HF2.4-DOLE-24VDC	HF0.6-DOLE-24VDC HF9-DOL-24VDC	HF2.4-DOL-24VDC HF9-DOLE-24VDC
		L	R	HF0.6-ROLE-24VDC HF2.4-ROL-24VDC	HF0.6-ROL-24VDC HF9-ROLE-24VDC	HF2.4-ROLE-24VDC HF9-ROL-24VDC
Green	Red	Yellow				
0	0	0	0	0.075	0.18	1.5
0	0	0	1	0.110	0.25	2.0
0	0	1	0	0.145	0.41	2.5
0	0	1	1	0.180	0.56	3.0
0	1	0	0	0.215	0.71	3.5
0	1	0	1	0.250	0.87	4.0
0	1	1	0	0.285	1.02	4.5
0	1	1	1	0.320	1.17	5
1	0	0	0	0.355	1.33	5.5
1	0	0	1	0.390	1.48	6.0
1	0	1	0	0.425	1.63	6.5
1	0	1	1	0.460	1.79	7.0
1	1	0	0	0.495	1.94	7.5
1	1	0	1	0.530	2.09	8.0
1	1	1	0	0.565	2.25	8.5
1	1	1	1	0.600	2.40	9

Table 5 Setting the nominal overload current

Example:
Following figure shows a HF-2.4-DOL-24VDC device with a set nominal current of 1.63 A.



‘PWR’ LED lights in green.

‘ERR’ LED is switched off.

‘Iadj’ / ‘L’ LED lights in yellow.

‘ON’ / ‘R’ LED is switched off.

—
17 Example for nominal current setting

LEDs on the front side				**Nominal current [A]**
PWR	ERR	Iadj	ON	HF2.4-DOL-24VDC HF2.4-DOLE-24VDC
		L	R	HF2.4-ROLE-24VDC HF2.4-ROL-24VDC
1	0	1	0	1.63

Table 6 Illuminated LED at nominal current of 1.63 A

4 Motor protection

The electronic compact starter protects electrical three-phase motors against:
- Thermal overload
- Phase asymmetry
- Phase failure

Order code	Type	Thermal overload (over current)	Phase asymmetry	Phase failure
1SAT115000R1011	HF0.6-ROL-24VDC	Yes	Yes	Yes
1SAT116000R1011	HF0.6-ROLE-24VDC	Yes	Yes	Yes
1SAT125000R1011	HF2.4-ROL-24VDC	Yes	Yes	Yes
1SAT126000R1011	HF2.4-ROLE-24VDC	Yes	Yes	Yes
1SAT145000R1011	HF9-ROL-24VDC	Yes	Yes	Yes
1SAT146000R1011	HF9-ROLE-24VDC	Yes	Yes	Yes
1SAT144000R1011	HF9-R-24VDC	No	No	No

Table 7 HF Types with motor protection functions

The following table 8 shows the rated operational current AC-51 and AC-53a for the HF range. The maximum load, important for overload protection, can be set. The minimum load current is important for protection against phase failure.

HF-Types/ Technical data	HF0.6-DOL-24VDC HF0.6-DOLE-24VDC HF0.6-ROLE-24VDC HF0.6-ROL-24VDC	HF2.4-DOL-24VDC HF2.4-DOLE-24VDC HF2.4-ROLE-24VDC HF2.4-ROL-24VDC	HF9-DOL-24VDC HF9-DOLE-24VDC HF9-ROLE-24VDC HF9-ROL-24VDC
Rated operational current AC-51 (I_e)	0.6	2.4	9
Rated operational current AC-53a (I_e)	0.6	2.4	6.5
Minimum operational current AC-53a (I_e)	0.075	0.18	1.5
Rated operational voltage (U_e)	500 V AC		
Rated frequency (f)	50 Hz / 60 Hz		

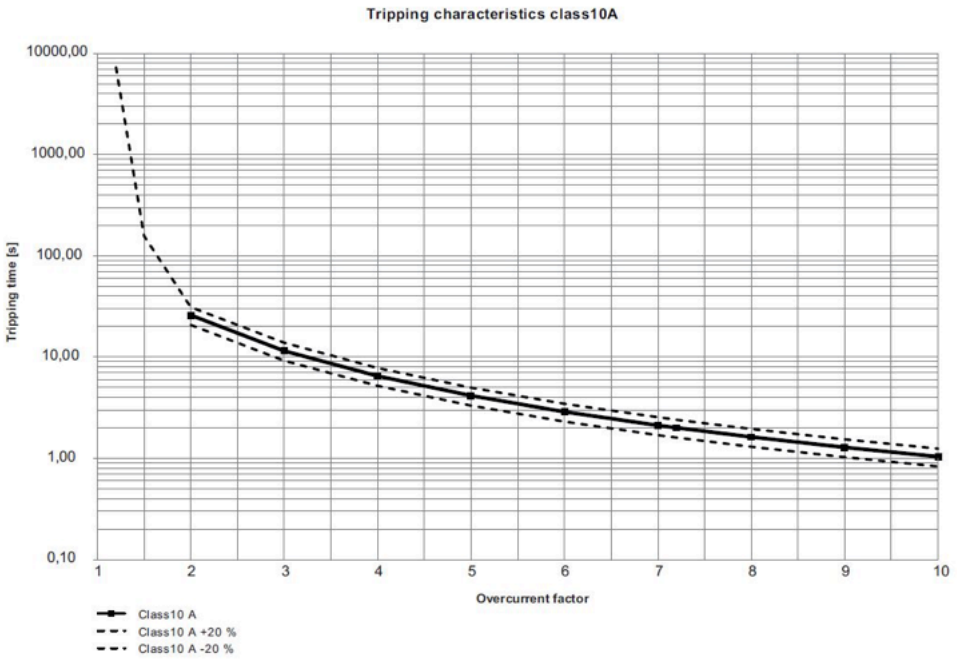
Table 8 Minimum and maximum load current

4.1 Thermal overload protection

The electronic compact starter to protect three-phase motors against overload.

If the current exceeds the set value – see chapter 3.3 for setting the nominal current – the motor starter trips with class 10A within the specified tripping time.

The following figure 18 shows the tripping characteristics for 20°C ambient temperature, tripping class 10A. The overload current factor is the ratio between the actual current and the parameterized nominal current.



18 Tripping characteristics class 10A

As soon as the electronic compact starter detects an error:
- The feedback relay is activated: the NO (95-96) contact is closed or the NC (96-97) contact is opened.
- The LEDs provide visual confirmation of the error (Please see chapter 4.4 for diagnostics)

If the current exceeds 45 A for more than two sec., the electronic compact starter will switch off the motor. The trip will be indicated through the LED and the switchover contact will be switched. This functions protects against stall and jam.

Function principle: thermal calculation method
The electronics continuously calculate a model of the thermal load on the motor, dependent on operating time and load current. The motor memory module charges when the motor is switched on, and discharges by switching off the motor. After an overload trip, the motor memory module is discharged after two minutes. You have to wait for this cooling time to elapse before you can proceed with a manual reset. If the control supply voltage fails, the HF-starter stores the remaining cooling time. When the control supply voltage is restored, the remaining cooling time elapses before the motor can be switched on again. Otherwise automatic reset takes place after 20 minutes.

When initiating a restart very shortly after switching off the motor, the motor memory module may not yet have fully discharged. This can result in an overload trip after restarting. During continuous operation, tripping times are reduced depending on the prior load.

If supply and control voltage are present after resetting the overload trip, the electronic compact starter restarts.

4.2 Phase asymmetry

The electronic compact starter protects 3-phase motors against phase asymmetry. The motor currents are measured at phases L1 and L3 and monitored for symmetry.

- In the event of a deviation of the current in L1 and L3 by ≥ 33 % the motor shuts down after two minutes. The cause of the trip is indicated by the LEDs. The switchover contact switches: the N/O (96-97) contact closes or the N/C (96-95) opens.
- In the event of a deviation of the current in L1 and L3 by ≥ 67% (e.g., phase failure), the motor shuts down after 1.8 seconds and the cause of the trip is indicated by the LEDs. The switchover contact switches: the N/O (96-97) contact closes or the N/C (96-95) opens.

The LED indications are as follows: The PWR LED is switched on continuously, the ERR LED flashes. All other LED: Iadj and ON (DOL- and DOLE–devices) and L and R (ROL- and ROLE–devices) are switched off.

HF9-R-24VDC has no phase asymmetry and overload protection integrated.

Example:
Manual error acknowledgment after phase asymmetry tripping.

The device can be manually reset in two different ways: by pressing the reset button in front of the device; or remotely with a push button.

- **Pressing the manual reset button**
  Press the reset button on the front of the device. By pressing the reset button for more than two sec., the device returns to the error state. Pressing the reset button for more than six sec. activates the device's "parameterization" mode.

- **Pressing a remote manual reset push button**
  Connect a push button (N/O contact) between the MAN and RES terminals.
  An acknowledgement is triggered as soon as a positive edge is detected at the MAN input. If no negative edge is detected after approximately two sec., the device adopts an error state since manipulation or an error in the acknowledgment circuit may have occurred.

4.3 Phase failure

The electronic compact starter protects 3-phase motors against phase failure and prevents excessive temperature increases in double phasing if phase failure occurs. Phase failure is detected through current measurements while the motor is running. When phase failure occurs, the motor starter switches off the motor after 1.5-2 sec.. Phase failure is indicated by the LEDs and the signaling relay, as shown in table 9.

Phases			LED visualization	Signal relay 	Power path switch off
L1	L2	L3			
$I_L >= I_{min}$	$I_L >= I_{min}$	$I_L >= I_{min}$			
$I_L < I_{min}$	$I_L < I_{min}$	$I_L < I_{min}$	■	■	
$I_L < I_{min}$	$I_L < I_{min}$	$I_L >= I_{min}$	■	■	
$I_L < I_{min}$	$I_L >= I_{min}$	$I_L < I_{min}$	■	■	
$I_L >= I_{min}$	$I_L < I_{min}$	$I_L < I_{min}$	■	■	
$I_L >= I_{min}$	$I_L >= I_{min}$	$I_L < I_{min}$	■	■	■
$I_L < I_{min}$	$I_L >= I_{min}$	$I_L >= I_{min}$	■	■	■
$I_L >= I_{min}$	$I_L < I_{min}$	$I_L >= I_{min}$	■	■	■

I_L = load current; I_{min} = minimal load current

Table 9 Under current and phase failure

4.4 Signaling

The electronic compact starter provides visual confirmation of the operating status with four LEDs. The functions of the LEDs follow NAMUR NE 44 recommendations.

LED		Meaning
PWR	Green	General device status Indicates a message
ERR	Red	Internal or external error
Iadj / L	Yellow	Device is active
ON / R	Yellow	Device is active

After the control supply voltage U_s is applied, all LEDs light up once for 0.5 sec., as an LED test.

Signaling for DOL-types

The following table shows the LED codes for

- HF0.6-DOL-24VDC
- HF2.4-DOL-24VDC
- HF9-DOL-24VDC

Operation Status

The electronic compact starter uses the LEDs to indicate the status messages for operation, fault and test:

Status	Description	PWR	ERR	$I_{adj.}$	ON	Error acknowledgment
LED colors on HMI (human machine interface)		Green	Red	Yellow		
OFF	Supply voltage not present	OFF	OFF	OFF	OFF	-
Ready to operate	Supply voltage present	ON	OFF	OFF	OFF	-
Drive switched on	Forward running motor	ON	OFF	OFF	ON	
Internal error	Internal device error – device replacement required	ON	ON	OFF	OFF	Not possible
External error in the controller or I/O devices (maintenance requirement)	**Motor protection function:** The motor current is higher than the nominal motor current specification (e.g. Class 10A): Cooling time is running (20 min.)	ON	Flashes	OFF	ON	Automatic[1)]
	After two min., 'ON' flashes: a manual reset is possible	ON	Flashes	OFF	Flashes	Manual
	Error restoring the system state: Checksum error. The thermal memory of the motor protection function is set to the maximum value. The error must be manually acknowledged.	ON	Flashes	Flashes	Flashes	Manual
	Symmetry: The two motor currents deviate from each other by more than 33%.	ON	Flashes	OFF	OFF	Manual
	Blocking: The max. measurable motor current is exceeded for more than two sec..	ON	Flashes	OFF	Flashes	Manual
Message (power path remains switched on)	Message with pending control signal: - Two or more phases are missing - No motor connected - Motor current in at least two phases > two sec. minimum current value that can be set	Flashes	Flashes	OFF	ON	Automatic[2)]

Table 10 Signaling DOL-types

1) Bridge between the terminals 'RES' and 'AUT';
2) No other measures necessary

Signaling for DOLE-types

The following table shows the LED codes for

- HF0.6-DOLE-24VDC
- HF2.4-DOLE-24VDC
- HF9-DOLE-24VDC

Operation Status

The electronic compact starter uses the LEDs to indicate the status messages for operation, fault and test:

Status	Description	PWR	ERR	$I_{adj.}$	ON	Error acknowledgment
LED colors on HMI (human machine interface)		Green	Red	Yellow		
OFF	Supply voltage not present	OFF	OFF	OFF	OFF	-
Ready to operate	Supply voltage present	ON	OFF	OFF	OFF	-
Drive switched on	Forward running motor	ON	OFF	OFF	ON	
Internal error	Internal device error – device replacement required	ON	ON	OFF	OFF	Not possible
External error in the controller or the I/O devices (maintenance requirement, NE44)	**Motor protection function:** The motor current is higher than the nominal motor current specification (e.g. Class 10A): Cooling time is running (20 min.)	ON	Flashes	OFF	ON	Automatic
	After 2 min., 'ON' flashes: a manual reset is possible	ON	Flashes	OFF	Flashes	Manual
	Error restoring the system state: Checksum error. The thermal memory of the motor protection function is set to the maximum value. The error must be manually acknowledged.	ON	Flashes	Flashes	Flashes	Manual
	Symmetry: The two motor currents deviate from each other by more than 33%.	ON	Flashes	OFF	OFF	Manual
	Blocking: The max. measurable motor current is exceeded for more than 2 sec..	ON	Flashes	OFF	Flashes	Manual
Message (power path remains switched on)	Message with pending control signal: - Two or more phases are missing - No motor connected - Motor current in at least two phases > 2 sec. minimum current value that can be set	Flashes	Flashes	OFF	ON	Automatic

Table 11 Signaling DOLE-types

Signaling for ROL-types

The following table shows the LED codes for ROL- and ROLE-device diagnostics. An equivalent table can be found in the package insert.

- HF0.6-ROL-24VDC
- HF2.4-ROL-24VDC
- HF9-ROL-24VDC

Operation status

The electronic compact starter uses LEDs to indicate status messages for operation, fault and test:

Status	Description	PWR	ERR	L	R	Error acknowledgment
LED colors on HMI (human machine interface)		Green	Red	Yellow		
OFF	Supply voltage not present	OFF	OFF	OFF	OFF	-
Ready to operate	Supply voltage present	ON	OFF	OFF	OFF	-
Drive switched on	Reverse running (L)	ON	OFF	ON	OFF	
	Forward running (R)	ON	OFF	OFF	ON	
Internal error	Internal device error – device replacement required	ON	ON	OFF	OFF	Not possible
External error in the controller or the I/O devices (maintenance requirement, NE44)	**Motor protection function:** The motor current is higher than the nominal motor current specification (e.g. Class 10A): Cooling time is running (20 min.)					
	• An error occurred with left rotation (reverse running)	ON	Flashes	ON	OFF	Automatic[1)]
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	ON	Automatic[1)]
	After 2 minutes, the 'L' or 'R' flashes: a manual reset is possible					
	• An error occurred with left rotation (reverse running)	ON	Flashes	Flashes	OFF	Manual
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	Flashes	Manual
	Error restoring the system state: Checksum error. The thermal memory of the motor protection function is set to the maximum value. The error must be manually acknowledged, also in automatic operation.	ON	Flashes	Flashes	Flashes	Manual
	Symmetry: The two motor currents deviate from each other by more than 33%.	ON	Flashes	OFF	OFF	Manual
	Blocking: The max. measurable motor current is exceeded for more than 2 sec..					
	• An error occurred with left rotation (reverse running)	OFF	Flashes	Flashes	OFF	Manual
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	Flashes	Manual
Message (power path remains switched on)	Message with pending control signal: - Two or more phases are missing - No motor connected - Motor current in at least two phases >2 sec. below the minimum current value that can be set					
	• A message occurred during reverse running.	Flashes	Flashes	ON	OFF	Automatic[2)]
	• A message occurred during forward running.	Flashes	Flashes	OFF	ON	Automatic[2)]

Table 12 Signaling ROL-types

1) Bridge between the terminals 'RES' and 'AUT',
2) No other measures necessary

Signaling for ROLE-types

The following table shows the LED codes for ROL- and ROLE- device diagnostics. An equivalent table can be found in the package insert.

- HF0.6-ROLE-24VDC
- HF2.4-ROLE-24VDC
- HF9-ROLE-24VDC

Operation Status

The electronic compact starter uses LEDs to indicate status messages for operation, fault and test:

Status	Description	PWR	ERR	L	R	Error acknowledgment
LED colors on HMI (human machine interface)		Green	Red	Yellow		
OFF	Supply voltage not present	OFF	OFF	OFF	OFF	-
Ready to operate	Supply voltage present	ON	OFF	OFF	OFF	-
Drive switched on	Reverse running (L)	ON	OFF	ON	OFF	
	Forward running (R)	ON	OFF	OFF	ON	
Internal error	Internal device error – device replacement required	ON	ON	OFF	OFF	Not possible
External error in the controller or the I/O devices (maintenance requirement, NE44)	**Bimetal function:** The motor current is higher than the nominal motor current specification (e.g. Class 10A): Cooling time is running (20 min.)					
	• An error occurred with left rotation (reverse running)	ON	Flashes	ON	OFF	Automatic[1)]
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	ON	Automatic[1)]
	After 2 minutes, the 'L' or 'R' flashes: a manual reset is possible					
	• An error occurred with left rotation (reverse running)	ON	Flashes	Flashes	OFF	Manual
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	Flashes	Manual
	Error restoring the system state: Checksum error. The thermal memory of the motor protection function is set to the maximum value. The error must be manually acknowledged, also in automatic operation.	ON	Flashes	Flashes	Flashes	Manual
	Symmetry: The two motor currents deviate from each other by more than 33%.	ON	Flashes	OFF	OFF	Manual
	Blocking: The max. measurable motor current is exceeded for more than 2 sec..					
	• An error occurred with left rotation (reverse running)	OFF	Manual	Flashes	OFF	Manual
	• An error occurred with right rotation (forward running)	ON	Flashes	OFF	Flashes	Manual
Message (power path remains switched on)	Message with pending control signal: - Two or more phases are missing - No motor connected - Motor current in at least two phases >2 sec. below the minimum current value that can be set					
	• A message occurred during reverse running.	Flashes	Flashes	ON	OFF	Automatic[2)]
	• A message occurred during forward running.	Flashes	Flashes	OFF	ON	Automatic[2)]

Table 13 Signaling ROLE-types

1) Bridge between the terminals 'RES' and 'AUT'
2) No other measures necessary

4.5 Function Test

General function test when U_s is applied: After the control supply voltage U_s is applied, all the LEDs light up once. The device performs a diagnosis of the functions when the load is being switched on or when it is switched off.

Motor overload protection safety function test:

A skilled worker, well acquainted with the relevant standards, can conduct a 'motor overload protection' safety function test. For this test, the load must be activated and the current flow in a conductor interrupted (e.g. by removing L1 or L3 phase). The Electronic Compact Starter then switches off the load within 1.5-2 sec.. The LED for right rotation (forward running) goes out and the ‘ERR’-LED and the reply output are set.

5 Installation and de-installation

Startup, mounting, modifications and upgrades should only be carried out by a skilled electrical worker! Please read the installation instruction inserted in the package box.

5.1 Installation

Installation requirements

Requirements for installing DOL-, ROL-, DOLE-, ROLE-types:
To install DOL-, ROL-, DOLE-, or ROLE-types, please mount the following DIN-rails horizontally.
- TH35-15 (35x15 mm mounting rail) acc. IEC 60715
- TH35-7.5 (35x7.5 mm mounting rail) acc. IEC 60715

Requirements for installing the R-type:
To install the R-type, please use the following DIN-rails. The DIN-rail can be mounted in any position.
- TH35-15 (35x15 mm mounting rail) acc. IEC60715
- TH35-7.5 (35x7.5 mm mounting rail) acc. IEC 60715

Order code	Type	DIN-rails		DIN-rail mounting position	Position compact starter
1SAT116000R1011	HF0.6-ROLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT126000R1011	HF2.4-ROLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT146000R1011	HF9-ROLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT115000R1011	HF0.6-ROL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT125000R1011	HF2.4-ROL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT145000R1011	HF9-ROL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT112000R1011	HF0.6-DOL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT122000R1011	HF2.4-DOL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT142000R1011	HF9-DOL-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT113000R1011	HF0.6-DOLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT123000R1011	HF2.4-DOLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT143000R1011	HF9-DOLE-24VDC	TH35-15	TH35-7.5	horizontal	vertical
1SAT144000R1011	HF9-R-VDC-24VDC	TH35-15	TH35-7.5	any position	any position

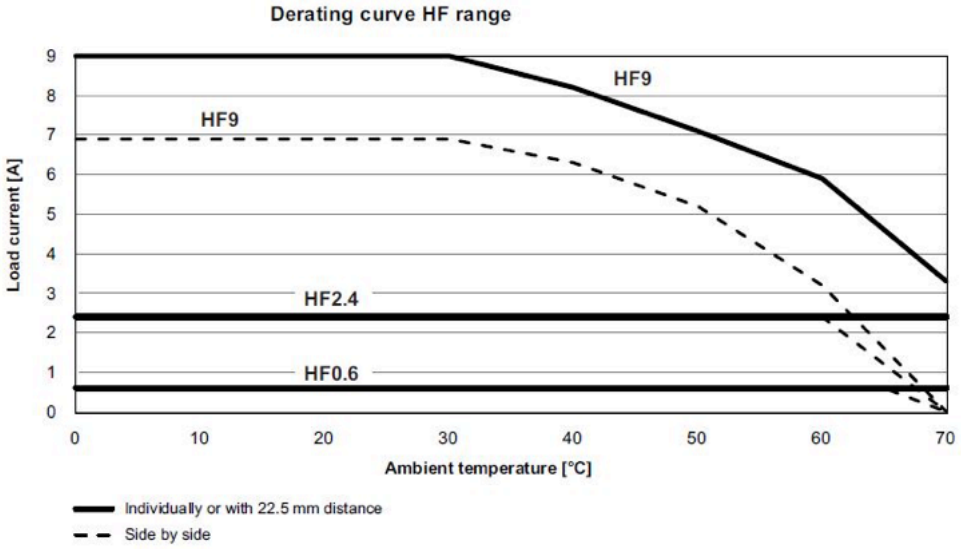
Table 14 Position possibilities of the HF-starters

Installation steps
1. Hang the back of the device onto the upper edge of the DIN rail
2. Press the lower half of the device against the DIN rail
   - DOL-, ROL-, DOLE-, and ROLE- types must be installed vertically.
   - The R-type may be installed in any position.

5.2 Derating

All HF range types may be installed in rows. Please find below the derating curve for each type in order to load current, ambient temperature and spacing.

Derating curve for R-, DOL–, ROL-, DOLE and ROLE- types:



19 Derating curve for R-, DOL–, ROL-, DOLE and ROLE- types

5.3 De-installation

De-installation requirements
All terminals must be removed or disconnected.

Steps for de-installing from DIN-rail
1. Press the device downwards.
2. Pull the lower half of the device away from the DIN-rail.
3. Lift the device from the upper edge of the DIN-rail.

Disposal
All electronic compact starters comply with 'ROHS', the directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
Please contact de-electroniccompactstarter@abb.com for any questions regarding disposal.

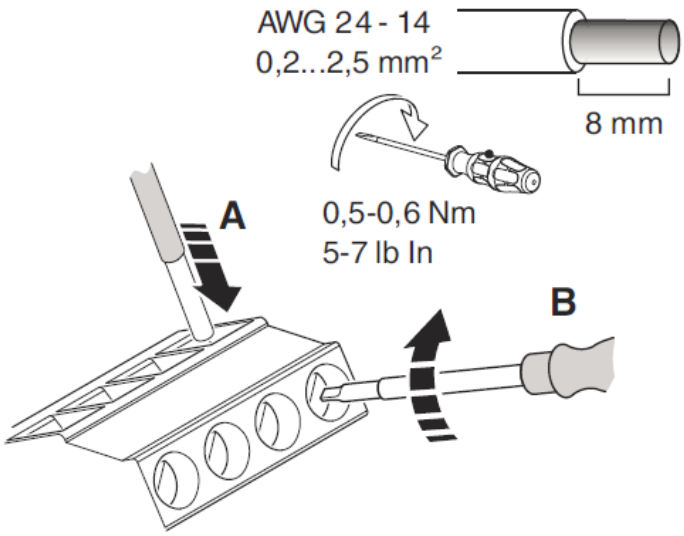
6 Commissioning

Before working on the device, disconnect the power.
CAUTION: Danger to life! Never carry out installation work when the voltage is turned on!
When connecting the 3-phase network, it is essential to observe the terminal identification!
If you want to clamp two conductors under one terminal point, you must use conductors with the same conductor cross-section.

6.1 Commissioning the terminals

In order to avoid inductive or capacitive coupling of noise emissions where long control wires are used, the use of shielded conductors is recommended.

Commissioning steps for all terminals:
1. Plug the conductor into the appropriate terminal point. See figure 20, A.
2. Tighten the screw in the opening above the terminal with a screwdriver. See figure 20, B.



20 Commissioning procedure

6.2 Main and load terminal connection

Main terminal side
The main terminal side, or infeed side, is marked with 1/L1, 3/L2 and 5/L3 on the bottom of the device. These input voltage terminals must be connected with the 3-phase supply network. Please also establish short circuit protection.

Load terminal side
Terminals 2/T1, 4/T2 and 6/T3 on the bottom are for the load (e.g. motor).
These output voltage terminals must be connected with the motor/load.

6.3 Control terminals

Terminal U_s
The HF range is supplied by the rated control supply voltage U_s with 24 V DC. The voltage may range from 19.2 V DC to 30 V DC.

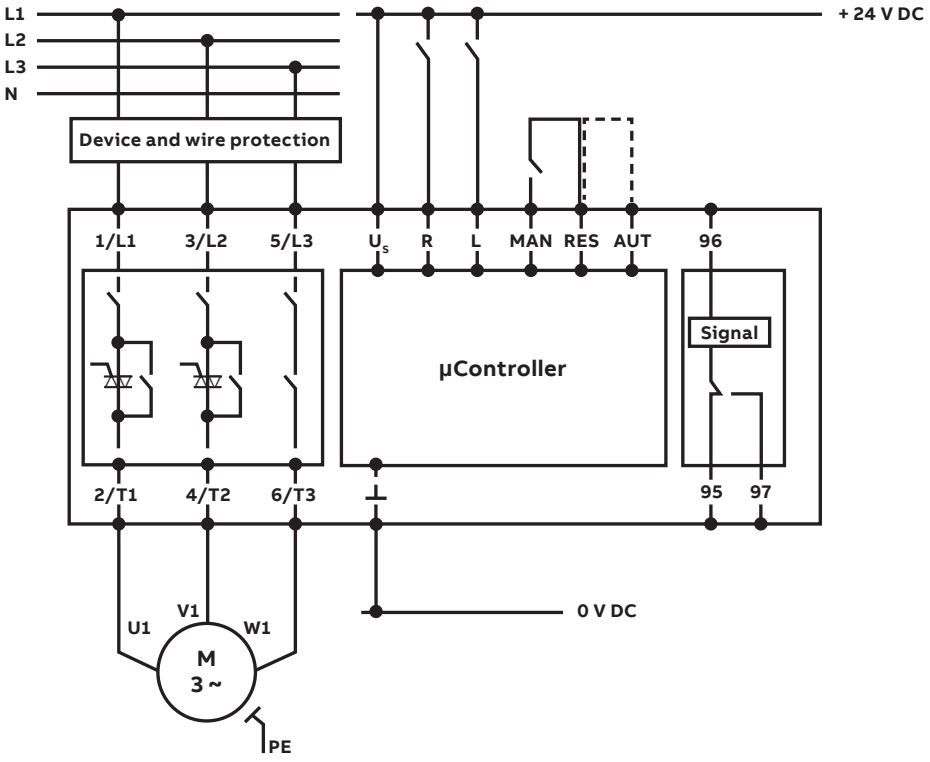
U_s may be 32 V DC for a maximum of one minute.

Control terminals for DOL-, ROL- and R- types
The same voltage source (potential) must be used for the control supply voltage U_s and the control inputs ON/R, L. Please see Figure 21 Commissioning the control inputs of DOL-, ROL- and R- types. The reference point for the control inputs (U_s, ON/ R, L) is terminal ⊥.

Control terminals for DOLE- and ROLE- types
The control inputs (ON / R, L) are electrically isolated from the control supply voltage (U_s, ⊥). The same voltage source (potential) may be used for the control supply voltage and the control inputs. Please see wiring diagram in figure 21 commissioning the control inputs of DOL-, ROL- and R- types.

Terminal ON / R, L
The signal for starting or switching off the motor is applied at the control input.
For direct on-line starters there is one control input, labeled 'ON'.
For reversing types terminal 'R' is for forward running (right rotation), 'L' is for reverse running (left rotation).

As can be seen in the following figures, the control input(s) must be connected with:
- A switch
- A 24 V DC power supply
- The reference point for the control inputs (U_s, ON/ R, L) is terminal ⊥.

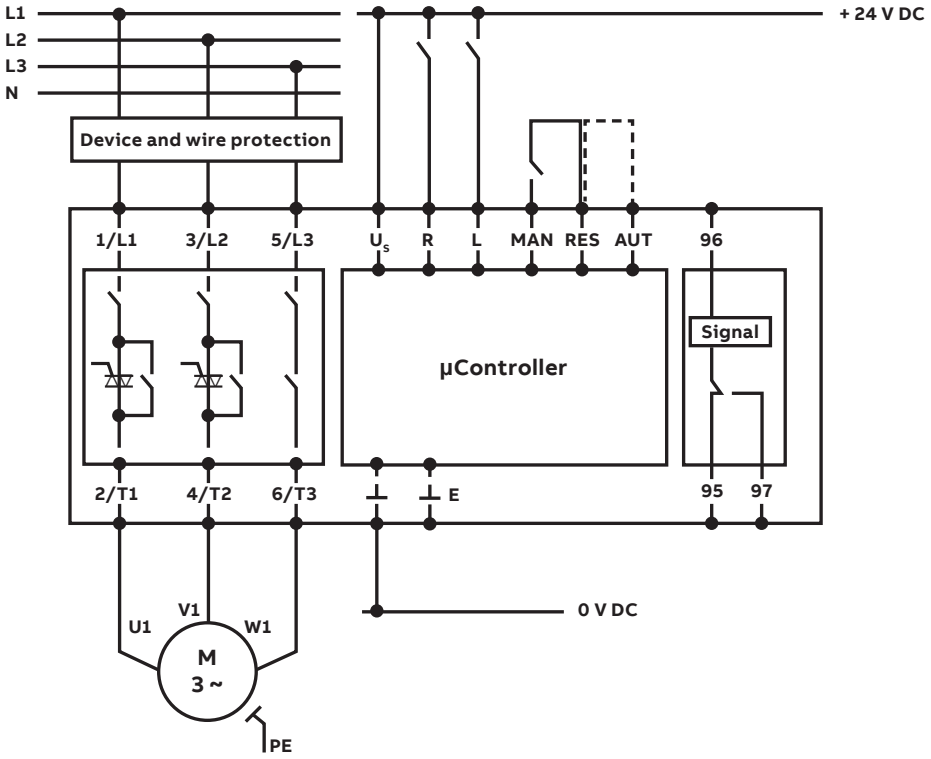


21 Commissioning the control inputs of DOL-, ROL- and R- types

DOLE- and ROLE- types

The control inputs (ON / R, L) are electrically isolated from the control supply voltage (U_S, ⊥). The same voltage source (potential) may be used for the control supply voltage and the control inputs. (Please see figure 22).

The reference point for the control inputs (ON/ R, L) is terminal ⊥E.



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22 Wiring the supply and control inputs of DOLE- and ROLE- types

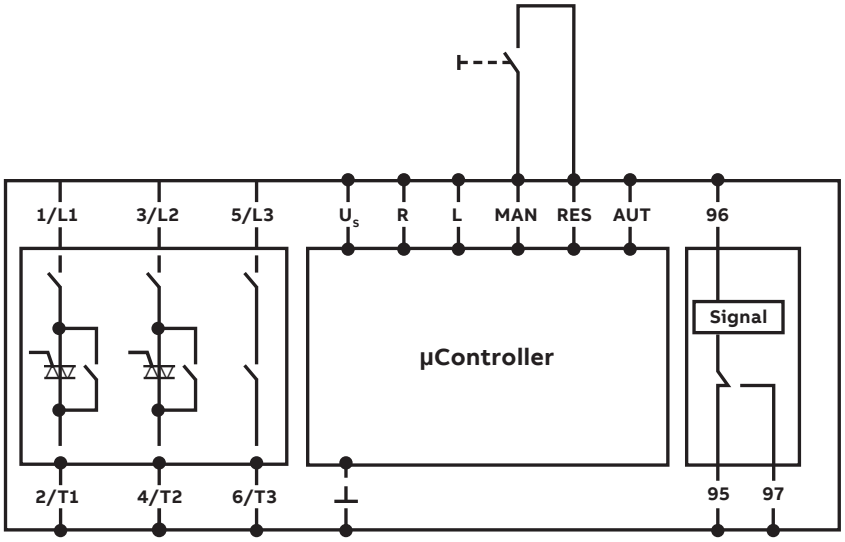
6.4 Reset terminals

You can choose between threeways to reset the device:
- Manual reset (via Reset/Set button)
- Remote reset (via remote acknowledgement point)
- Automatic reset (bridge connection)

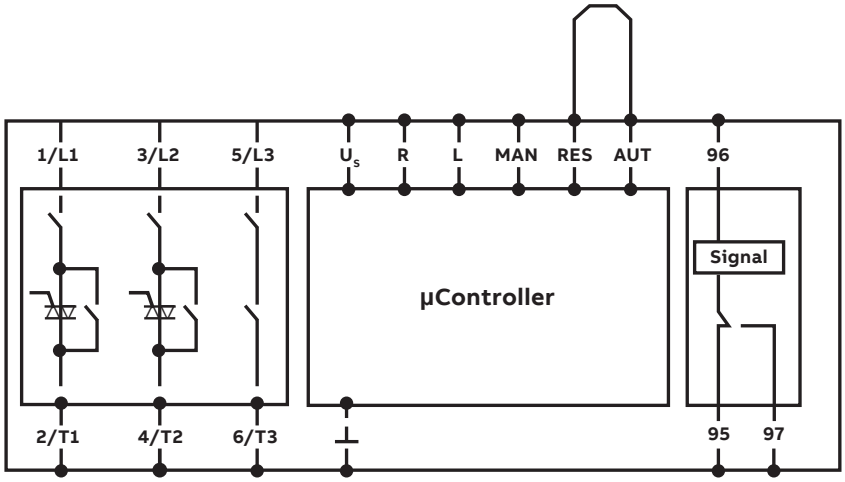
'RES' terminal provides the voltage for the reset. (24 V DC)

Detailed information for pilot devices is provided at: http://new.abb.com/low-voltage/products/pilot-devices.

It is suggested to use e.g. the ABB push-buttons MP1-10x, MCBH-00, MCB-10



23 Wiring the manual reset with a push button



24 Wiring the automatic reset

6.5 Signaling relay terminals

An auxiliary relay for activating external brakes or acknowledgements, such as to the PLC, must be connected to the system's 4T2 and N connections.

6.6 Short circuit protection

Single mounting

Single mounting means that one manual motor starter protects one HF-Starter. The maximal current of the motor defines the size of the short circuit protection device (SCPD) and which HF-Starter is best to take.
Please find all installation proposals in table 15 for 500 V AC and table 16 for 415 V AC.

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	35	MO132-0.63	0.075	500
HF0.6	35	MO132-0.63	0.63	500
HF2.4	35	MO132-0.63	0.63	500
HF2.4	35	MO132-1.0	1	500
HF2.4	35	MO132-1.6	1.6	500
HF2.4	35	MO132-2.5	2.4	500
HF9	35	MO132-1.6	1.6	500
HF9	35	MO132-2.5	2.4	500
HF9	35	MO132-4.0	4.0	500
HF9	35	MO132-6.3	6.5	500
HF9	35	MO132-10	9[1)]	500

Table 15 Type 1 coordination of HF-Starter with Manual Motor Starter MO132 at 500 V AC

1) HF9 variants are able to switch 6.5 A in utilization category AC-53a and 9 A in AC-51.

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	70	MO132-0.63	0.075	415
HF0.6	70	MO132-0.63	0.63	415
HF2.4	70	MO132-0.63	0.63	415
HF2.4	70	MO132-1.0	1	415
HF2.4	70	MO132-1.6	1.6	415
HF2.4	70	MO132-2.5	2.4	415
HF9	70	MO132-1.6	1.6	415
HF9	70	MO132-2.5	2.5	415
HF9	70	MO132-4.0	4.0	415
HF9	70	MO132-6.3	6.5	415
HF9	35	MO132-10	9[2)]	415

Table 16 Type 1 coordination of HF-Starter with Manual Motor Starter MO132 at 415 V AC

2) HF9 variants are able to switch 6.5 A in utilization category AC-53a and 9 A in AC-51.

Group mounting

Group mounting HF-Starter results in significant space savings in control cabinets. One MO132 can be used to protect several electronic compact starters. Please find all tested results in table 17 for 500 V AC and table 18 for 415 V AC. Two installation proposals for group protection are shown in figure 25 and figure 26.

Please consider the sum of current of all HF-Starter must not exceed the max. current of the MO132 chosen. For example, if the max. current is 20 A, a MO132-20 must be chosen and the sum of HF-Starter current must not exceed 20 A in total.

Max. sum of current of HF-Starter in group	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
6.5	35	MO132-6.3	6.5	500
10	3	MO132-10	10	500
12	3	MO132-12	12	500
16	3	MO132-16	16	500
20	3	MO132-20	20	500
25	3	MO132-25	25	500
32	3	MO132-32	32	500

Table 17 Type 1 coordination of HF-Starter with Manual Motor Starter MO132 at 500 V AC

Max. sum of current of HF-Starter in group	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
6.5	70	MO132-6.3	6.5	415
10	35	MO132-10	10	415
12	3	MO132-12	12	415
16	3	MO132-16	16	415
20	3	MO132-20	20	415
25	3	MO132-25	25	415
32	3	MO132-32	32	415

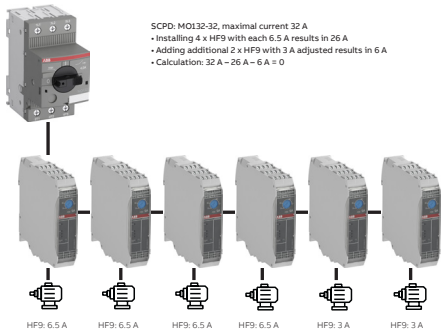
Table 18 Type 1 coordination of HF-Starter with Manual Motor Starter MO132 at 415 V AC

Group mounting – example 1

As visualized in figure 25, as a short-circuit protection device the MO132-32 is chosen. The nominal current is 32 A. Customers now have the option to combine different current sizes and variants of HF-starters until the maximum nominal current of 32 A is reached. The sum of the nominal currents of the HF-starters must not exceed the nominal current of MO132.

Figure 25 shows that in all six units of HF9-Starter are used. The complete sum of the current of these four electronic compact starters equals 4 * 6.5 A = 26 A. There are still 6 A 'available'. So, two additional HF9-Starter with 3 A are able to be controlled and protected.

SCPD: MO132-32, maximal current 32 A
- Installing 4 x HF9 with each 6.5 A results in 26 A
- Adding additional 2 x HF9 with 3 A adjusted results in 6 A
- Calculation: 32 A – 26 A -6 A = 0



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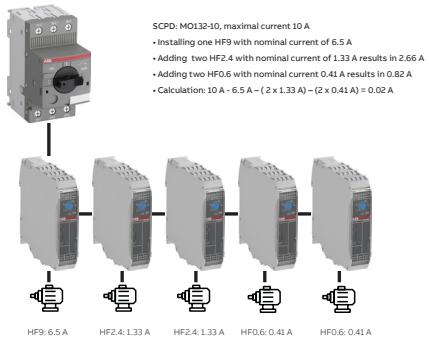
25 Group mounting protection example with MO132-32 A

Group mounting – example 2
It is possible to combine all variants of HF-starters with all MO132 up to 32 A (DOL, ROL, DOLE, ROLE, R). It is important that the sum of currents must not exceed the nominal current of the MO132.

SCPD: MO132-10, maximal current 10 A
- Installing one HF9 with nominal current of 6.5 A
- Adding two HF2.4 with nominal current of 1.33 A results in 2,66 A
- Adding two HF0.6 with nominal current 0.41 A results in 0.82 A
- Calculation: 10 A - 6.5 A – (2 x 1.33 A) – (2 x 0.41 A) = 0,02 A



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26 Group mounting protection example with MO132-32 A

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6.6.1 Protection with fuses

Single mounting fused design
All variants of HF-starters can be combined with the following fuses for short-circuit protection. Please find results for 500 V AC in table 19 and for 415 V AC in table 20.

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	35	Fuse 25 A gG	0.63	500
HF2.4	35	Fuse 25 A gG	2.4	500
HF9	35	Fuse 25 A gG	9[3)]	500

Table 19 Type 1 coordination of HF-Starter with Fuses at 500 V AC

3) HF9 variants are able to switch 6.5 A in utilization category AC-53a and 9 A in AC-51.

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	50	Fuse 25 A gG	0.63	415
HF2.4	50	Fuse 25 A gG	2.4	415
HF9	50	Fuse 25 A gG	9[4)]	415

Table 20 Type 1 coordination of HF-Starter with Fuse 25 A gG at 415 V AC

4) HF9 variants are able to switch 6.5 A in utilization category AC-53a and 9 A in AC-51.

Group mounting fused design

Group mounting HF-starters results in significant space savings in control cabinets. Please find all installation proposals in table 21 for 500 V AC and in table 22 for 415 V AC.

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	35	Fuse 25 A gG	25	500
HF2.4	35	Fuse 25 A gG	25	500
HF9	35	Fuse 25 A gG	25	500

Table 21 Type 1 coordination of HF-Starter with Fuse 25 A gG at 500 V AC

HF-Starter	Iq [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	50	Fuse 25 A gG	25	415
HF2.4	50	Fuse 25 A gG	25	415
HF9	50	Fuse 25 A gG	25	415

Table 22 Type 1 coordination of HF-Starter with Fuse 25 A gG at 415 V AC

Short-circuit protection for use in UL market

For single or group protection the following fuses can be used for UL application according to UL 60947-1/-4-1 Type 1 coordination.

HF-Starter	FLA [A / V AC]	Iq [kA]	SCPD	Max. current [A]	Max. Voltage [V AC]
HF0.6	0.6 / 500	100	Fuse class J or CC	30	480
HF2.4	2.4 / 500	100	Fuse class J or CC	30	480
HF9	6.5 / 500	100	Fuse class J or CC	30	480
HF0.6	0.6 / 500	5	Fuse RK 5	20	480
HF2.4	2.4 / 500	5	Fuse RK 5	20	480
HF9	6.5 / 500	5	Fuse RK 5	20	480

Table 23 Type 1 coordination of HF-Starter with fuses according to UL60947-1/-4-1

7 Circuits with brakes

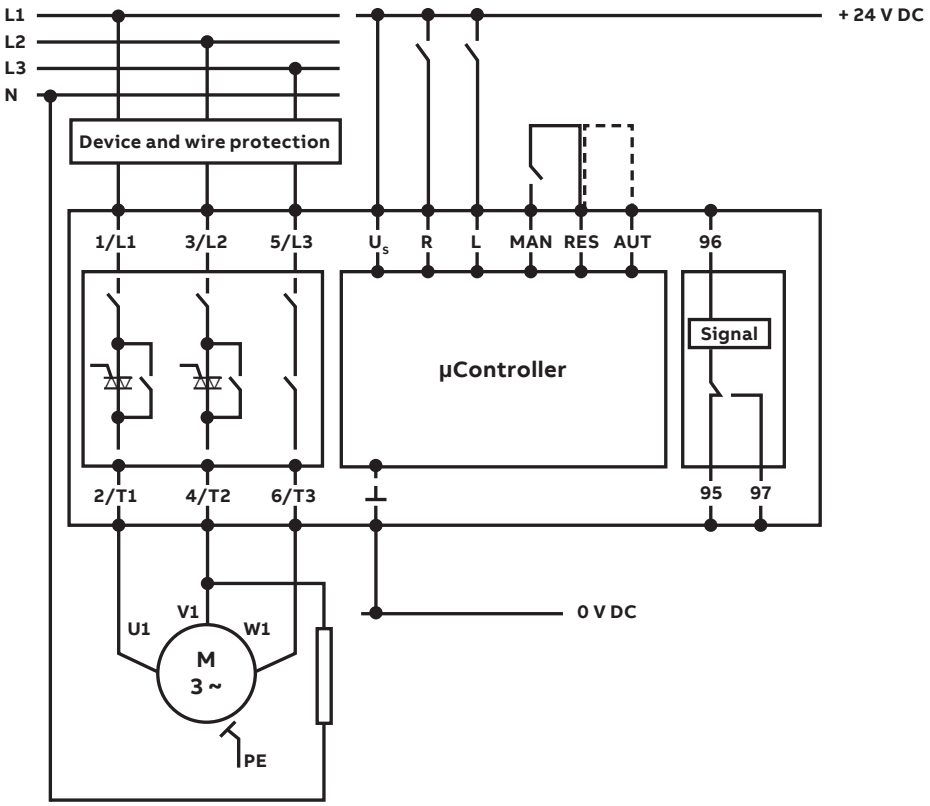
This is a product for environment A (industry). The device can cause unwanted radio interference if used in domestic class B environments. In this case, the user may be obligated to take the necessary precautionary measures.

Auxiliary relays
Auxiliary relays for activating external brakes or acknowledgements, e.g. to the PLC, must be connected between 4/T2 and N connections of the system.

7.1 Motors with a 230 V AC brake

A 230 V AC brake must be connected to the 4/T2 terminals and the star point of the motor. The current for braking is taken from one phase and the neutral conductor, see figure 27, which is valid for the following types:
- DOL- types
- ROL- types
- R- type

The motor current monitoring must be increased by the brake value (nominal value of the brake). This has to be set at the electronic compact starter. For setting the nominal current, please refer to chapter 3.3.



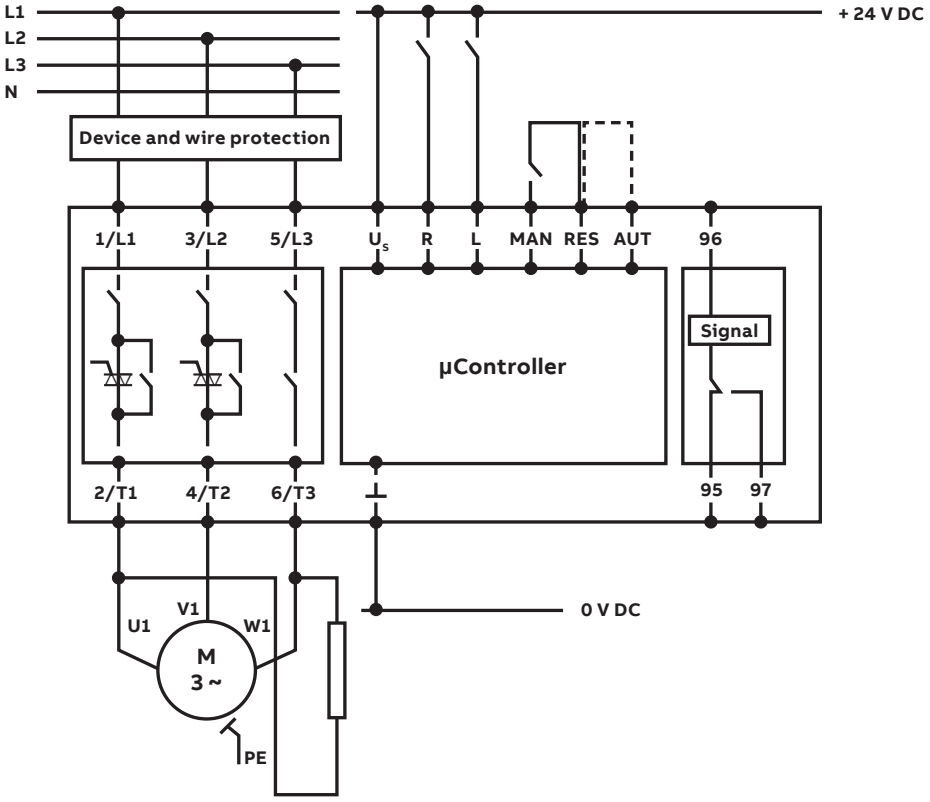
27 Commissioning a motor with a 230 V AC brake

7.2 Motors with a 400 V AC brake

If a motor with a brake (connection in the motor terminal board) is connected, the 400 V AC brake must be linked to the 2/T1 and 6/T3 terminals. The current for braking is taken from two phases (see figure 28) and is valid for:

- DOL- types
- ROL- types
- R- type

The motor current monitoring must be increased by the brake value (nominal value of the brake). This has to be set at the electronic compact starter. For setting the nominal current, please refer to chapter 3.3.



28 Commissioning a motor with a 400 V AC brake

8 Typical circuits for HF range types with integrated emergency stop

In circuits in potentially dust/gas-explosive areas of zones 21 and 22, equipment connected to this circuit must be guaranteed to comply with category 2D or 3D or be certified as such.

A zone 21 area is classified as a place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of powder or dust is likely to occur in normal operation occasionally. (Typical North American Marking to NEC 500)

A zone 22 area is classified as an atmosphere where a mixture of air and flammable substances in the form of powder or dust is not likely to occur in normal operation, but if it does occur, it will persist for a short period only.

8.1 Prevention of cross-error circuit

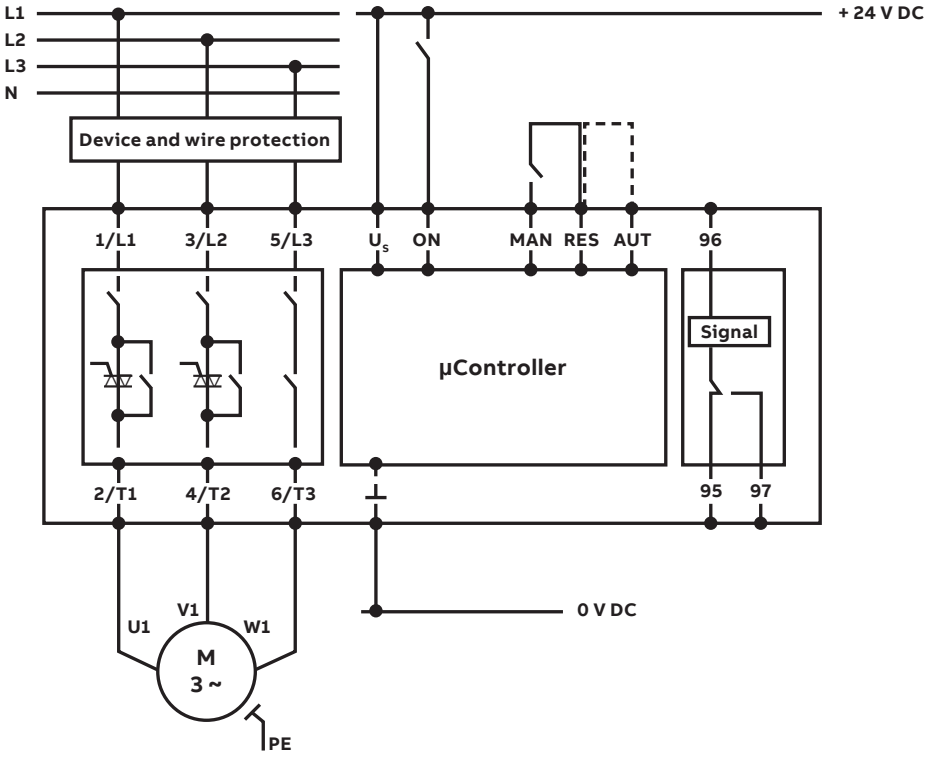
Since the control supply voltage or the control input voltage of the hybrid motor starter is disconnected via a single channel to the safety relay, this type of installation is allowed according to SIL 3, only if error prevention for cross circuits is permitted. A cross-circuit happens if the connecting wire is bruised or damaged.

Error prevention of cross-circuit is permitted, if the hybrid motor starter and the safety relay are installed in the same control cabinet.

If the hybrid motor starter and safety relays are not in the same control cabinet a dual channel connection is recommended.

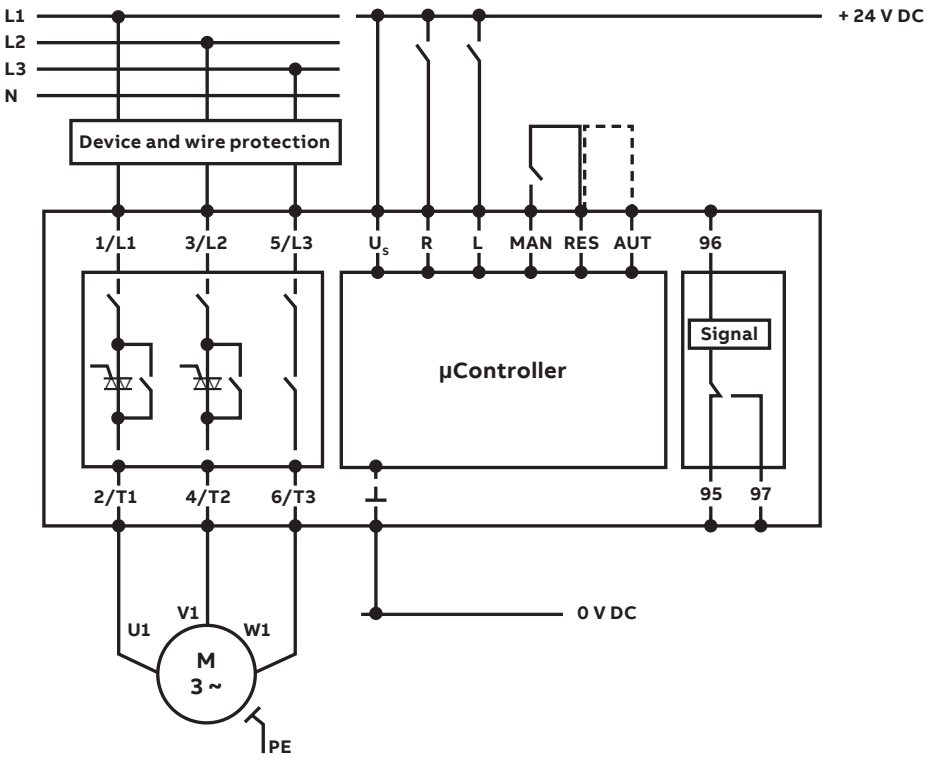
8.2 Wiring standard variants

Wiring DOL



29 Wiring diagram DOL

Wiring ROL

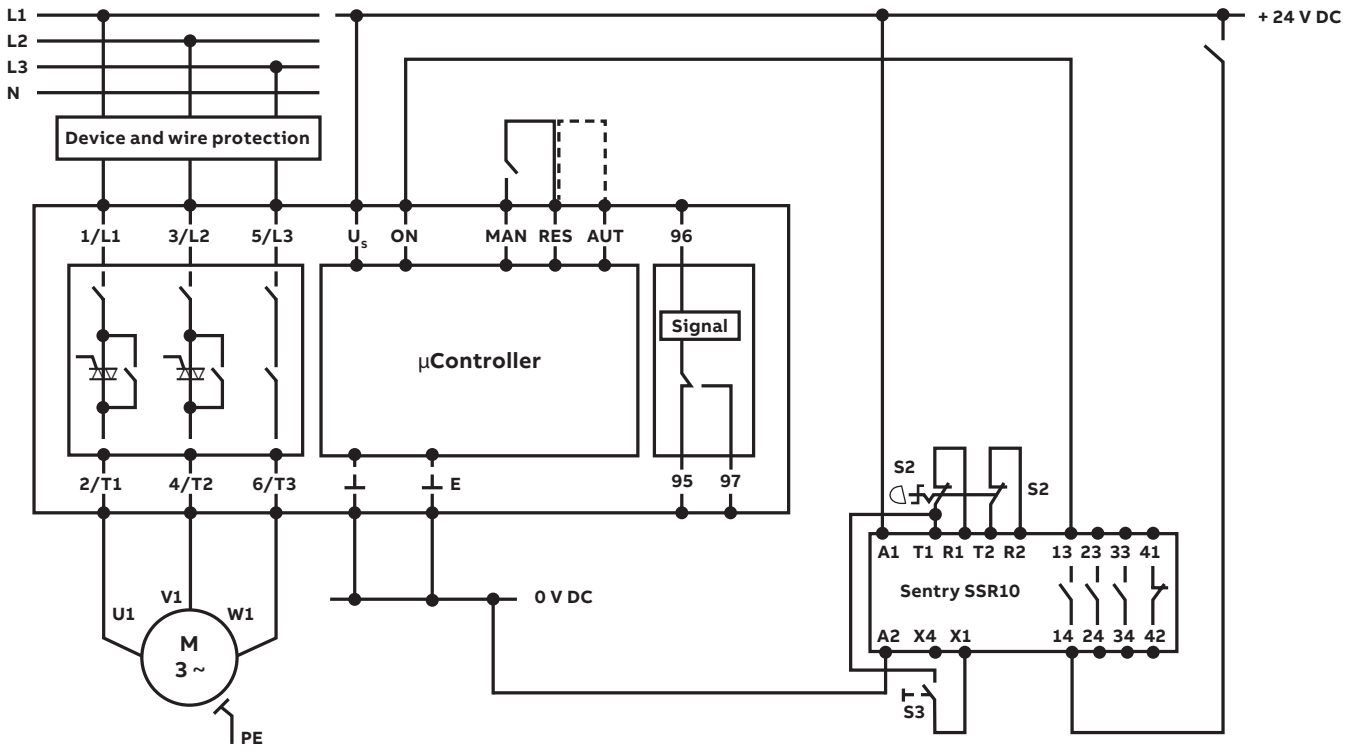


30 Wiring diagram ROL

8.3 Wiring safety variants - DOLE

8.3.1 Disconnecting control input voltage (ON) to safety relay

The safety relay and the electronic compact starter can be connected to the same supply voltage. It is not necessary to connect to two different supplies.

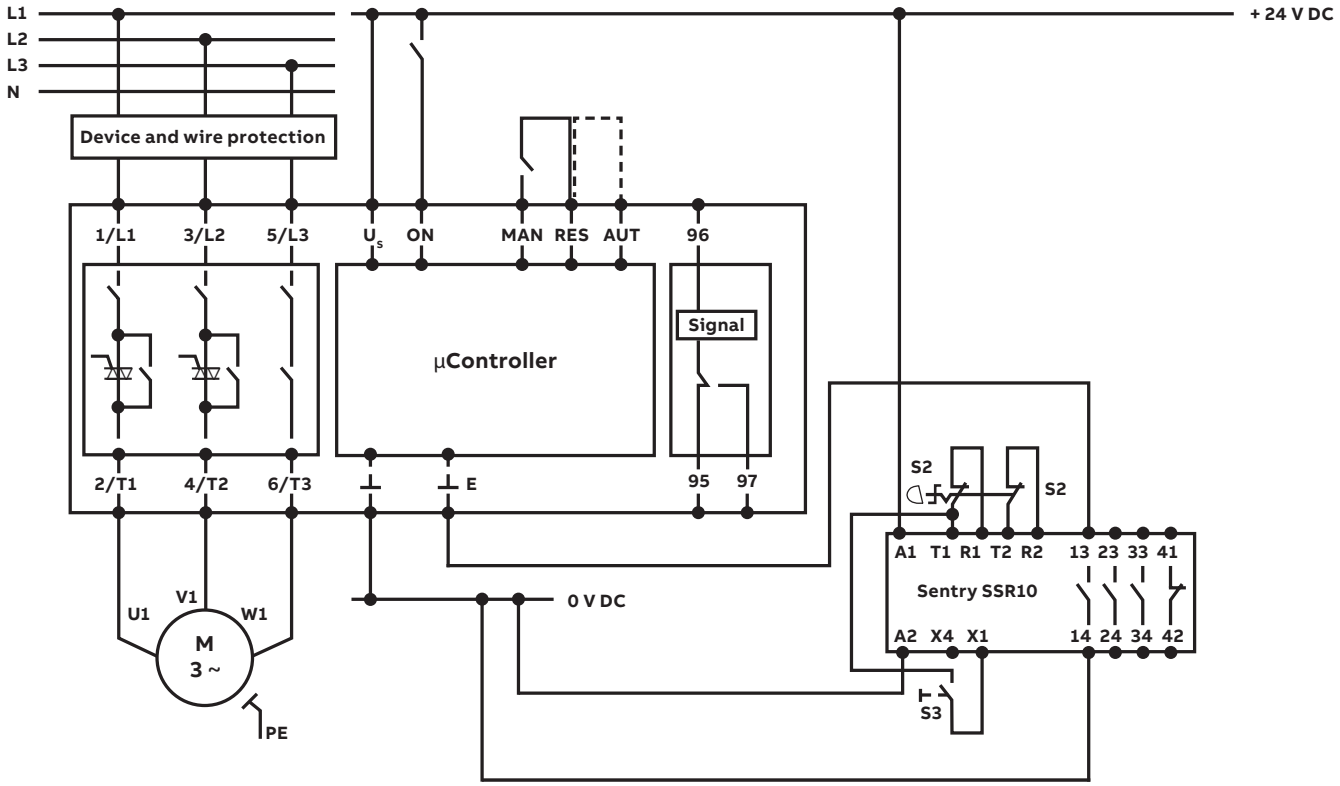


31 SSR single channel connection to ON

To learn more about the different wiring types please follow this link.

8.3.2 Disconnecting ground E (⊥E) to safety relay

The safety relay and the electronic compact starter can be connected to the same supply voltage. It is not necessary to connect to two different supplies.



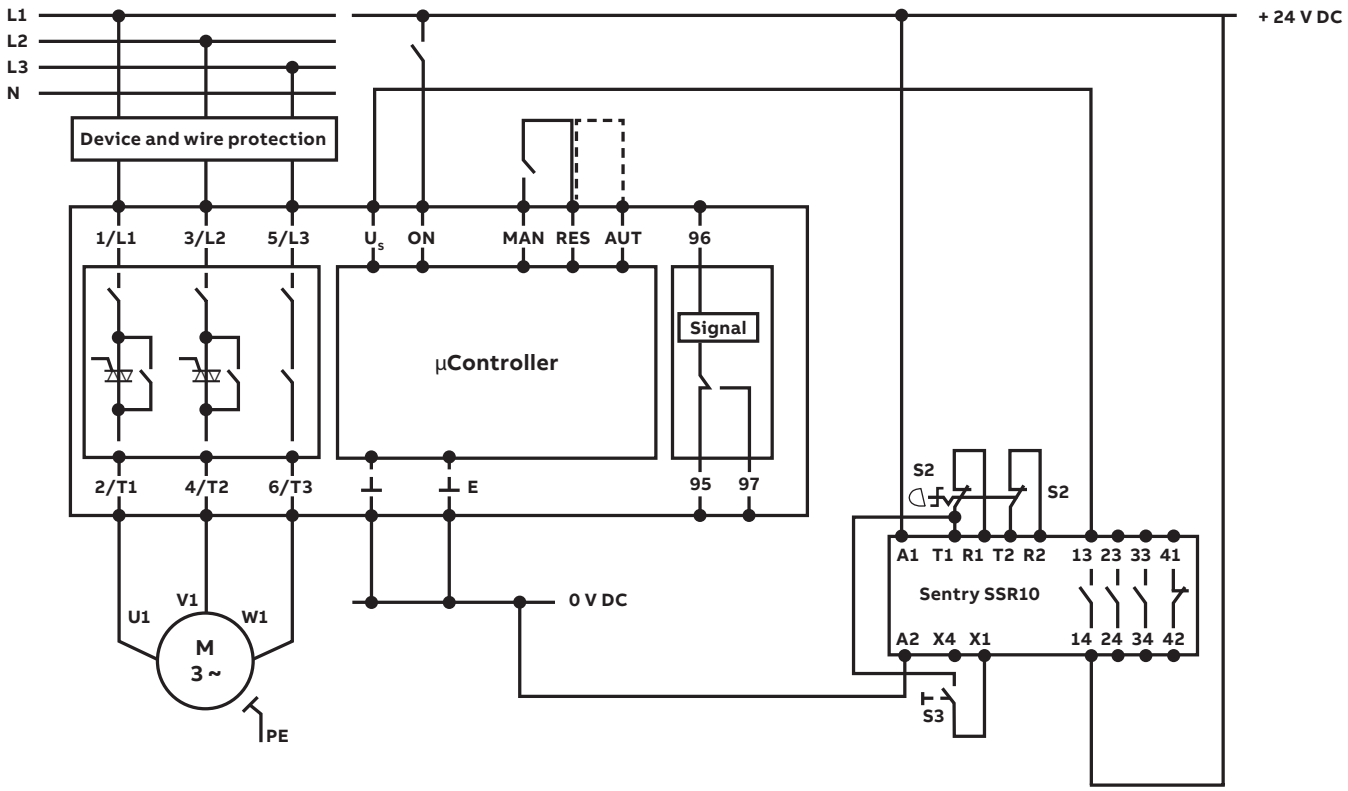
32 SSR single channel connection to ⊥ E

To learn more about the different wiring types please follow this link.

8.3.3 Disconnecting control supply voltage (U_s) to safety relay

Switching off the control voltage supply (U_s) with a controlled motor always results in wear to the electronic compact starter. This type of switching off should only be used if no more than 10,000 shutdowns can be expected over the systems entire lifetime.

The safety relay and the electronic compact starter can be connected to the same supply voltage. It is not necessary to connect to two different supplies.



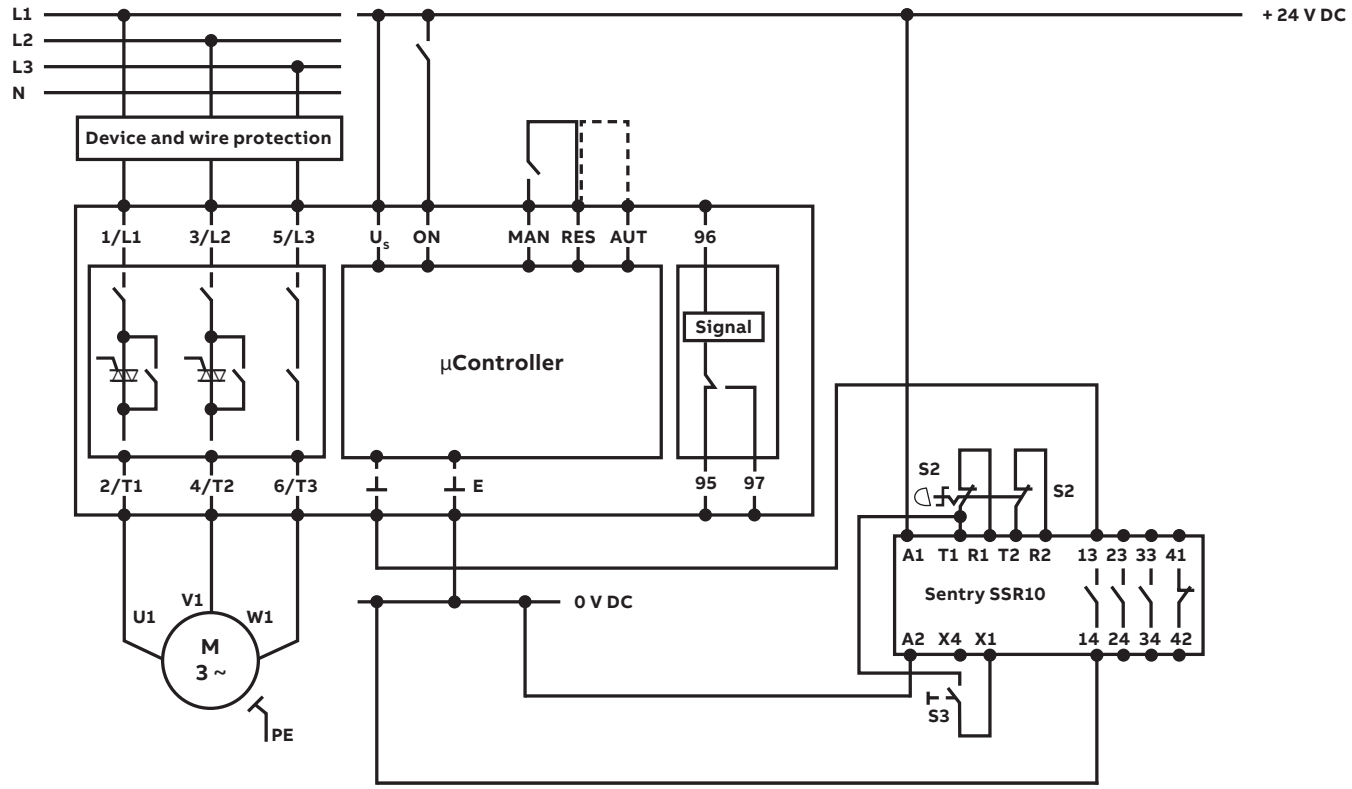
33 SSR single channel connection to U_s

To learn more about the different wiring types please follow this link.

8.3.4 Disconnecting ground (⊥) to safety relay

Switching off the ground (⊥) with a controlled motor always results in wear to the electronic compact starter. This type of switching off should only be used if no more than 10,000 shutdowns can be expected over the systems entire lifetime

The safety relay and the electronic compact starter can be connected to the same supply voltage. It is not necessary to connect to two different supplies



34 Single channel connection to ⊥

To learn more about the different wiring types please follow this link.

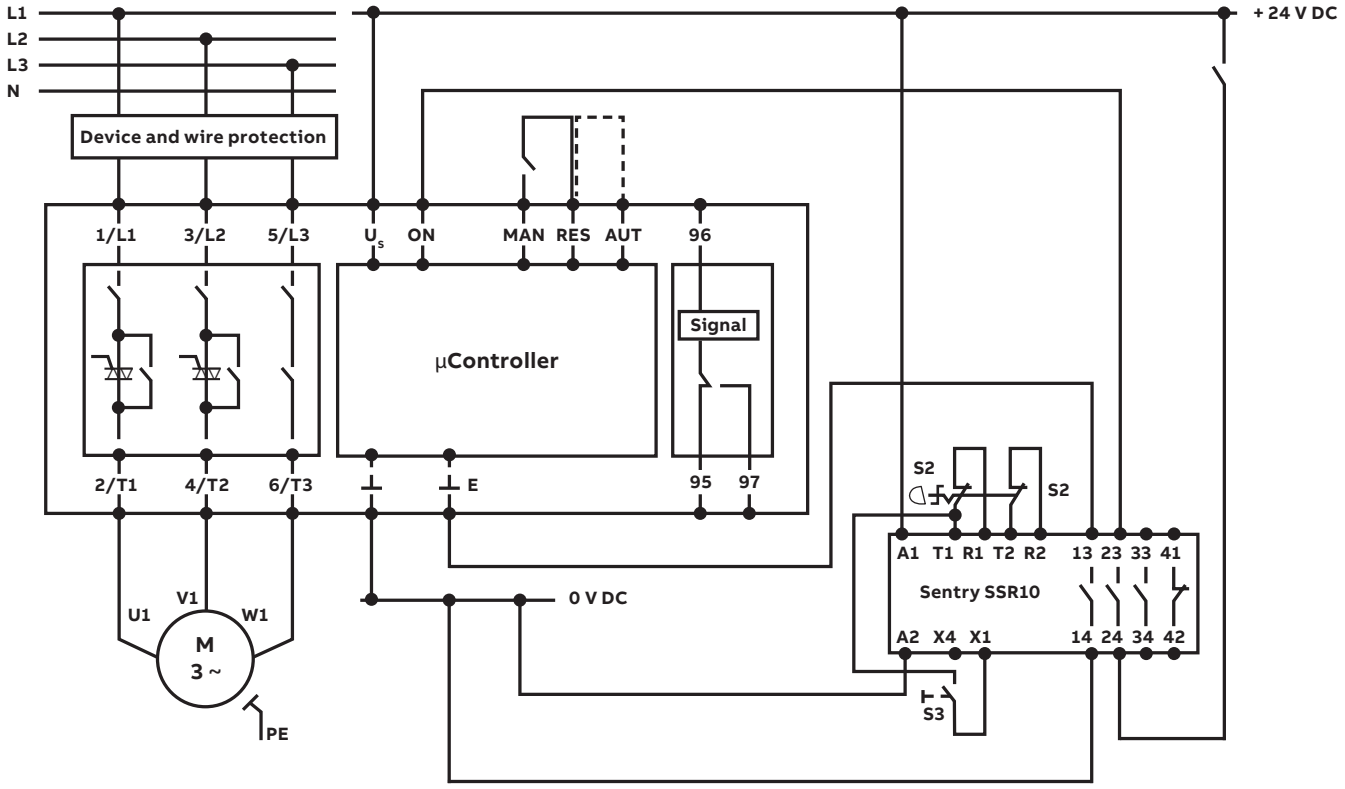
8.3.5 Disconnecting control input voltage (ON) and ground E (⊥E) to safety relay - two channel connection

In applications for which the emergency stop is a normal operation status such as two-hand applications or safety doors, the control current circuit is switched instead of the control voltage. If possible, use this circuit example in order to achieve the maximum lifespan.

Switching off the control voltage supply with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.

Please use two channel connection to prevent from cross-circuit failure.



35 SSR two channel connection to ON and ⊥E

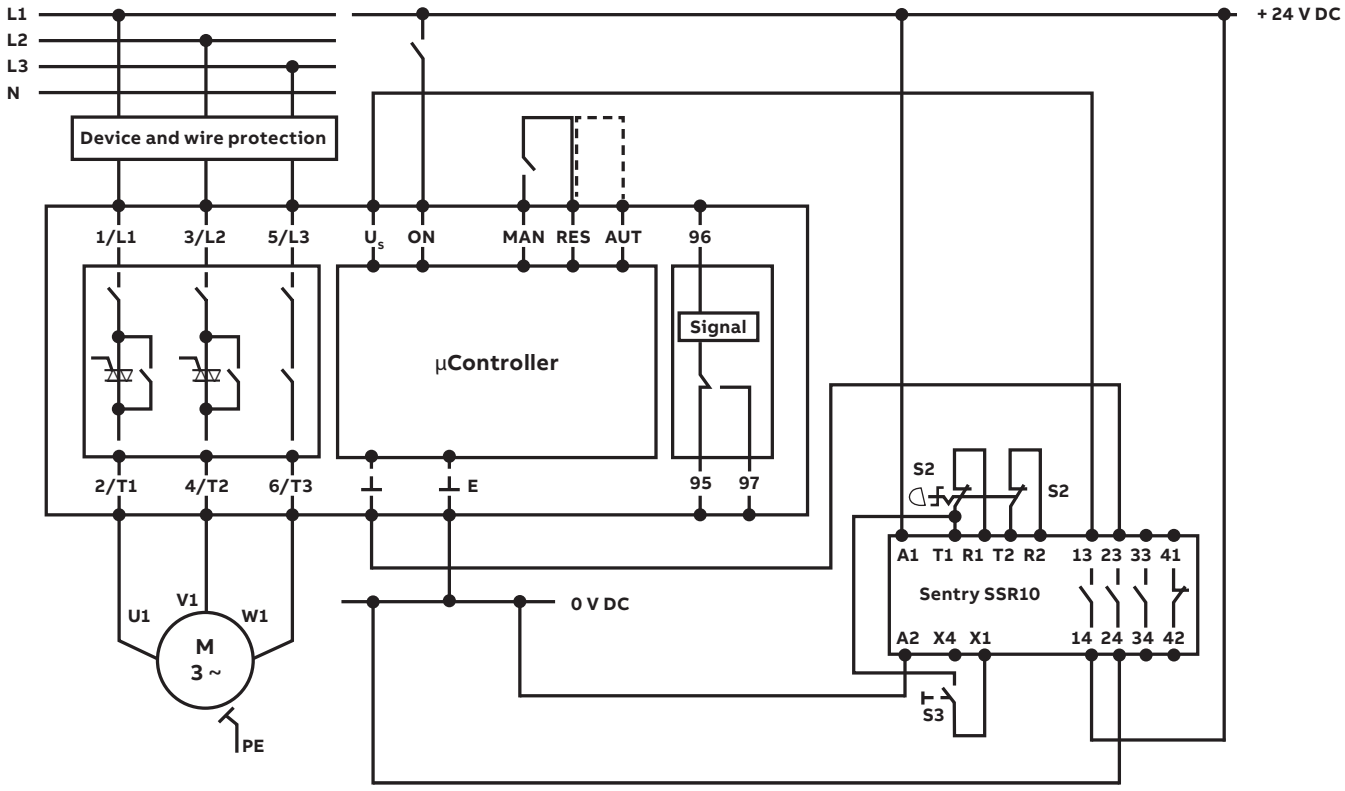
To learn more about the different wiring types please follow this link.

8.3.6 Disconnecting Control supply voltage (Us) and ground (⊥) to safety relay- two channel connection

Switching off the control voltage supply with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.

Please use two channel connection to prevent from cross-circuit failure.



36 SSR two channel connection to U_s and ⊥

To learn more about the different wiring types please follow this link.

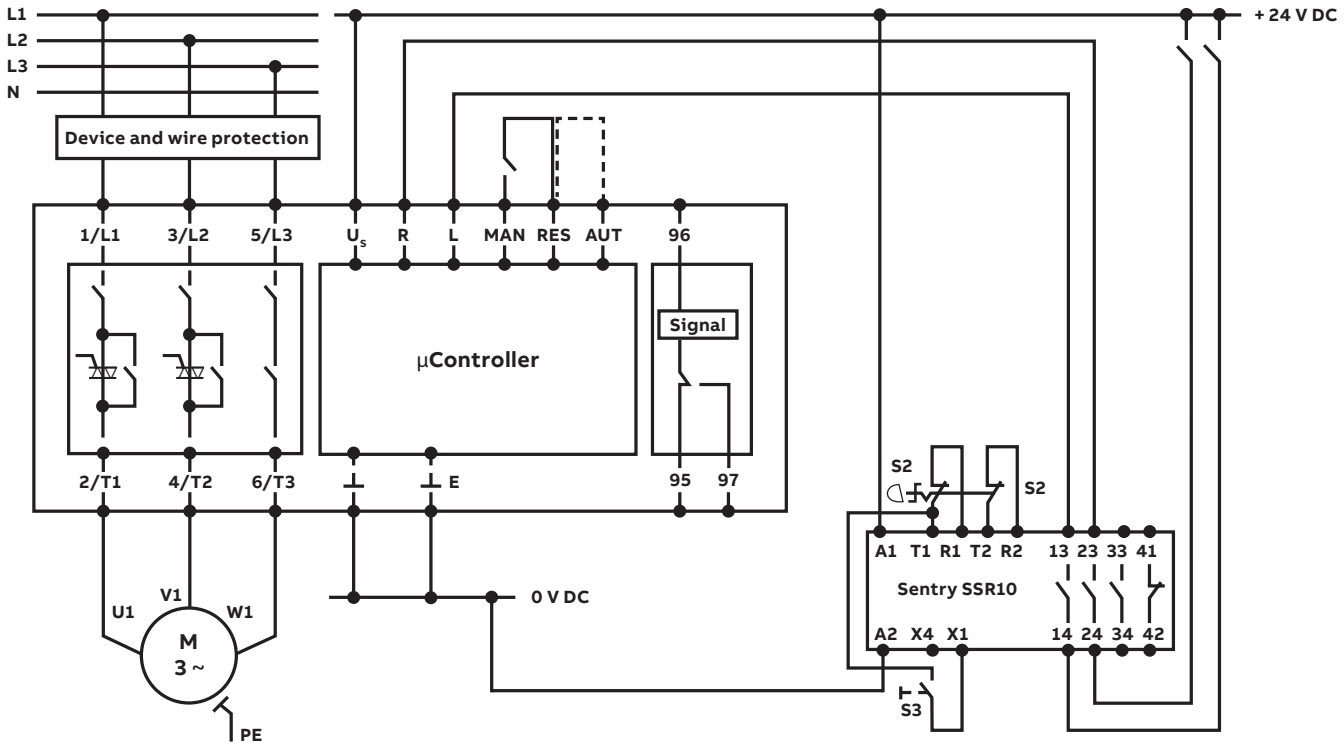
8.4 Wiring safety variants - ROLE

8.4.1 Disconnecting control input voltage (R and L) to safety relay

In applications where the emergency stop is a normal operation status, such as two-hand applications or safety doors, the control current circuit (R and L) is switched instead of the control voltage. If possible, use this circuit example in order to achieve the maximum lifespan.

Switching off the control supply voltage with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.

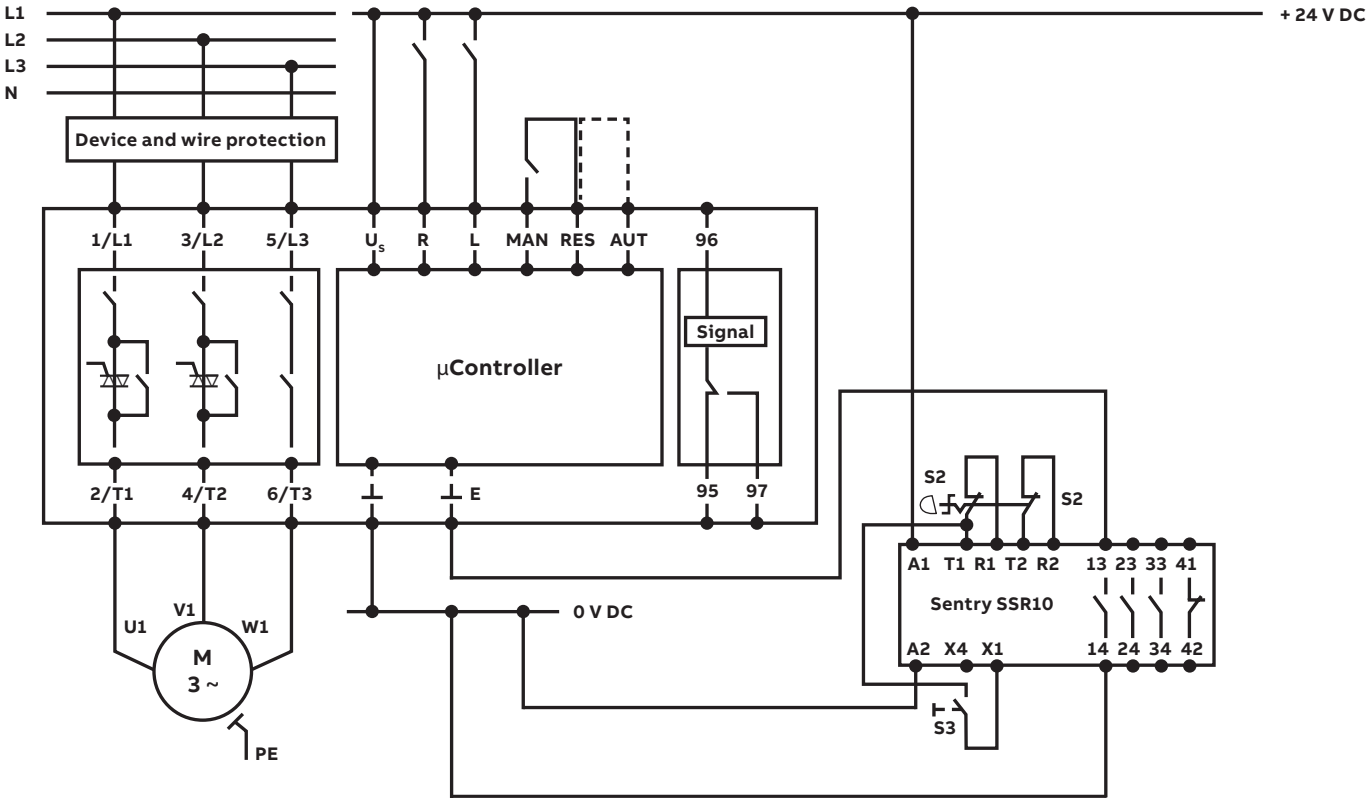


37 ROLE - SSR two channel connection to R and L

To learn more about the different wiring types please follow this link.

8.4.2 Disconnecting ground E (⊥E) to safety relay

In applications where the emergency stop is a normal operation status, such as two-hand applications or safety doors, the control current circuit (R, L and ground E) is switched instead of the control supply voltage. If possible, use this circuit example in order to achieve the maximum lifespan.



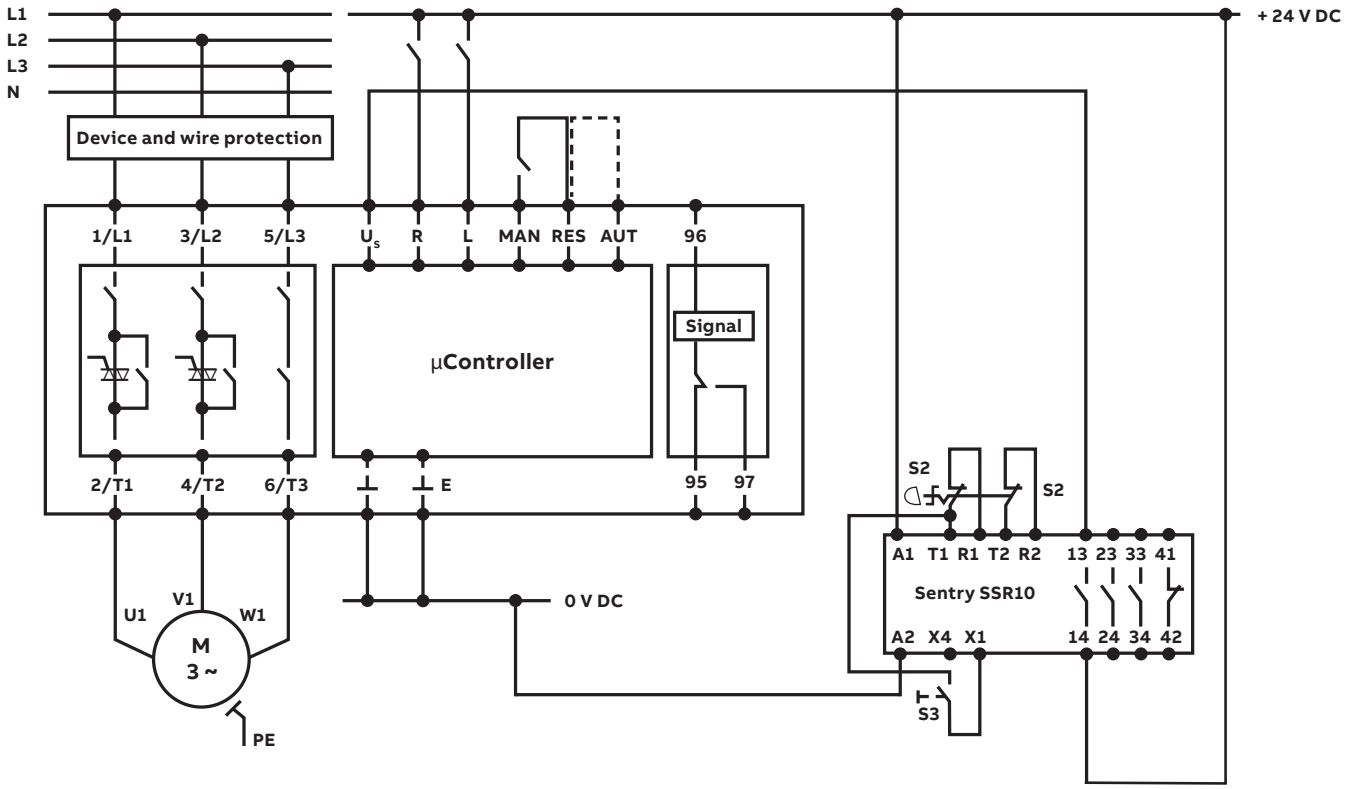
38 ROLE - SSR single channel connection to ⊥E

To learn more about the different wiring types please follow this link.

8.4.3 Disconnecting control supply voltage (Us) to safety relay

Switching off the control supply voltage with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.



39 ROLE - SSR single channel disconneting U_s

To learn more about the different wiring types please follow this link.

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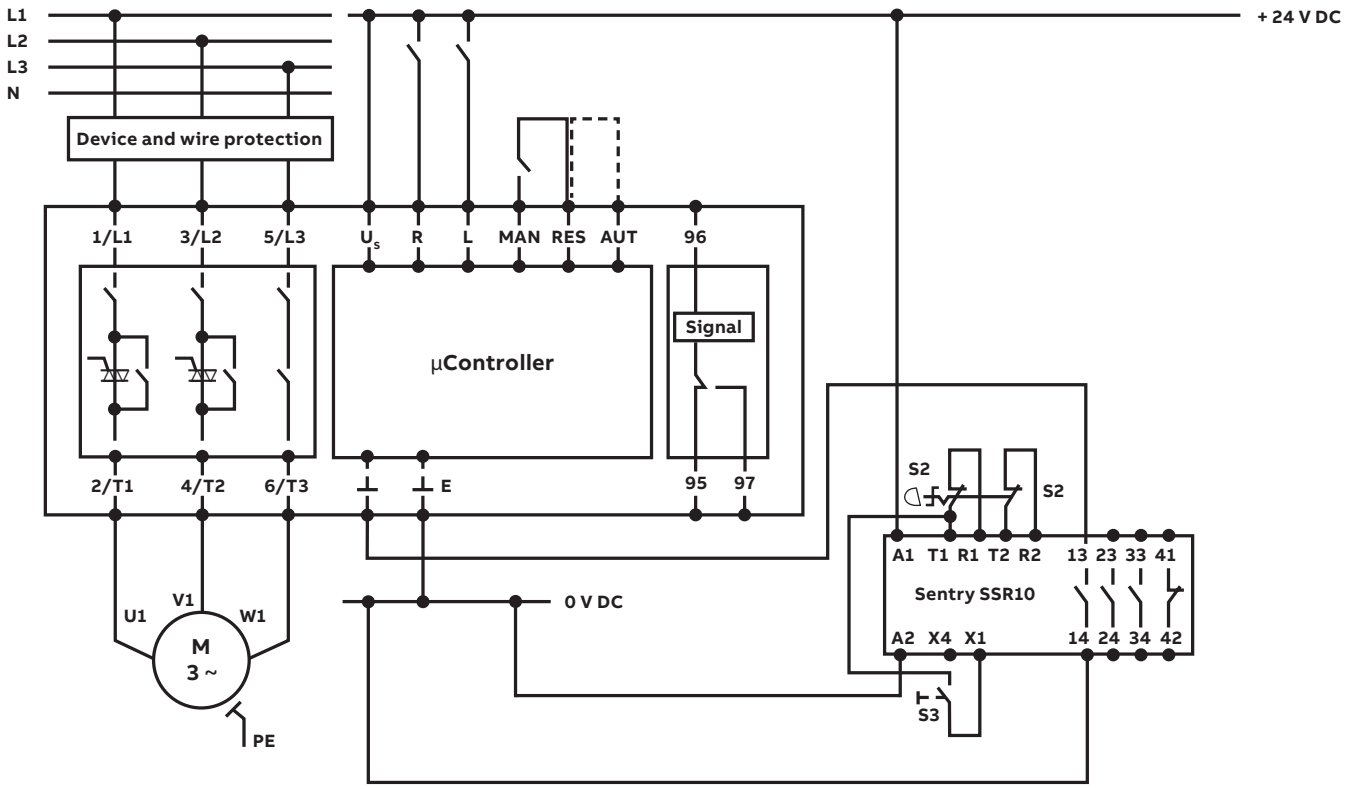
8.4.4 Disconnecting ground (⊥) to safety relay

Switching off the control supply voltage with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.



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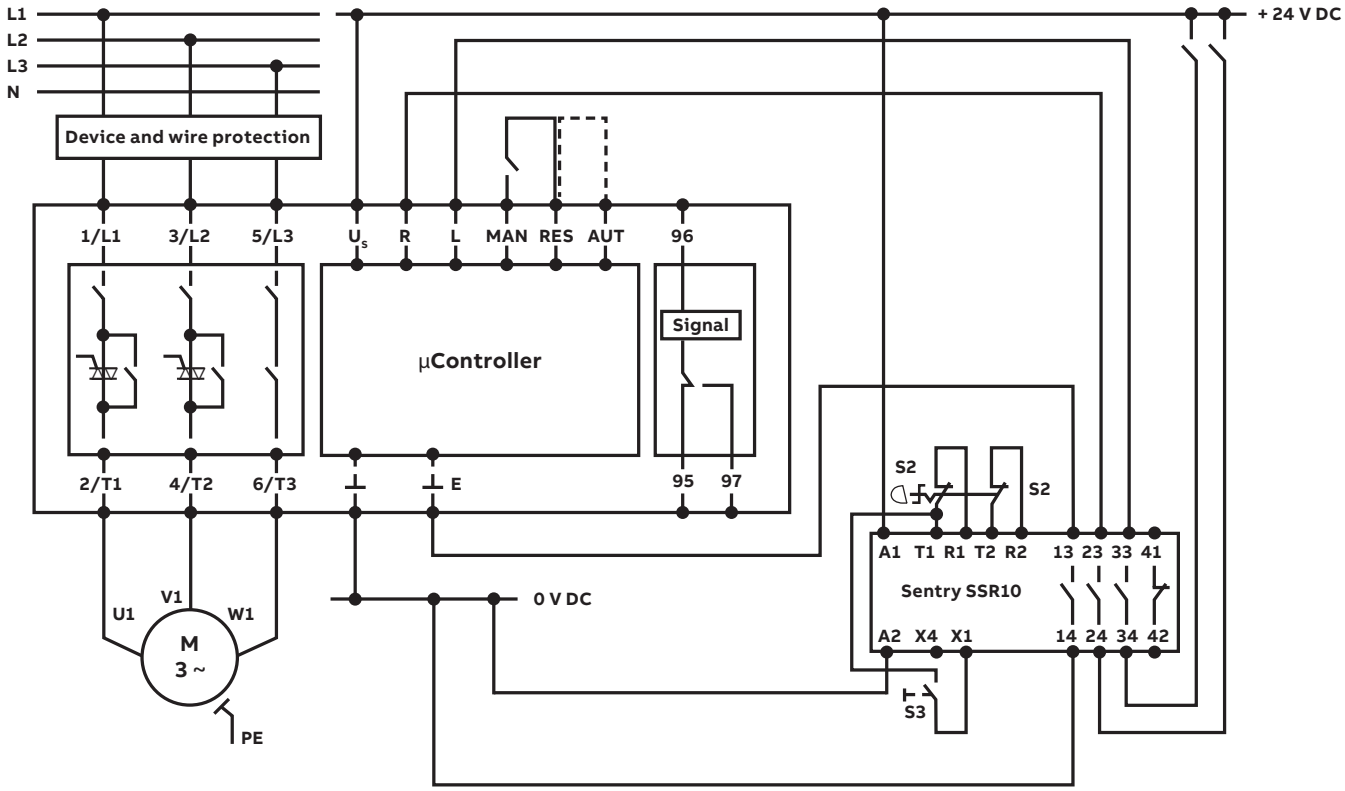
40 ROLE - single channel connection to ⊥

To learn more about the different wiring types please follow this link.

8.4.5 Disconnecting ground E (⊥E) and control input terminals (L and R) to safety relay

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.



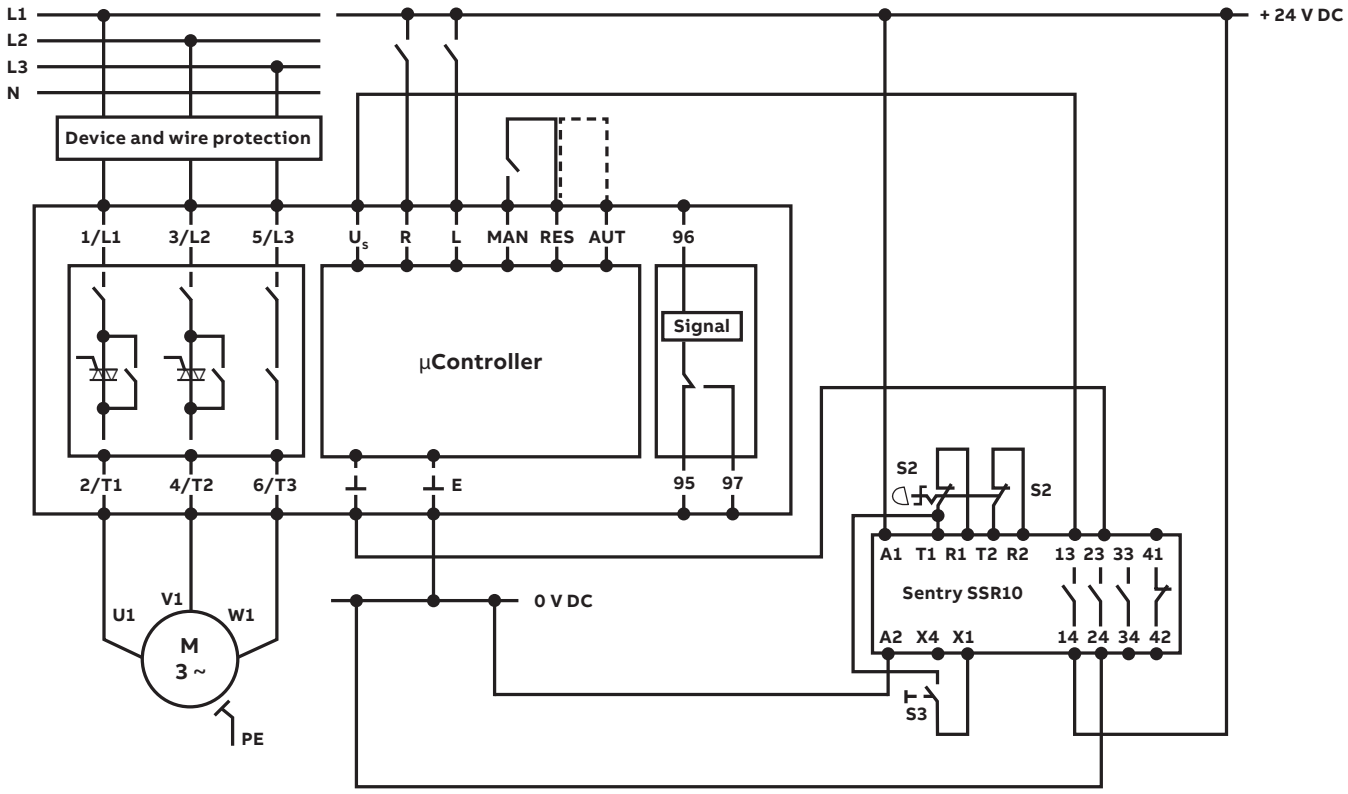
41 ROLE - SSR connection to ⊥E, R and L

To learn more about the different wiring types please follow this link.

8.4.6 Disconnecting control supply voltage (U_s) and ground (⊥) to safety relay

Switching off the control supply voltage with a controlled motor always results in wear to the electronic compact starter.

The safety relay and the electronic compact starter can be connected to the same supply. It is not necessary to connect to two different supplies.



42 ROLE - SSR connection to U_s and ⊥

To learn more about the different wiring types please follow this link.

9 Technical data

Please find important technical data on our homepage by following the links in the table.

Order code	Type
1SAT112000R1011	HF0.6-DOL-24VDC
1SAT113000R1011	HF0.6-DOLE-24VDC
1SAT115000R1011	HF0.6-ROL-24VDC
1SAT116000R1011	HF0.6-ROLE-24VDC
1SAT122000R1011	HF2.4-DOL-24VDC
1SAT123000R1011	HF2.4-DOLE-24VDC
1SAT125000R1011	HF2.4-ROL-24VDC
1SAT126000R1011	HF2.4-ROLE-24VDC
1SAT142000R1011	HF9-DOL-24VDC
1SAT143000R1011	HF9-DOLE-24VDC
1SAT144000R1011	HF9-R-VDC-24VDC
1SAT145000R1011	HF9-ROL-24VDC
1SAT146000R1011	HF9-ROLE-24VDC

The device may not be subjected to mechanical or thermal stress that exceeds the thresholds specified in the operating manual.

To protect the device against mechanical or electrical damage, install it in a suitable housing with appropriate degree of protection as per EN/IEC 60529, if required.

Maximum operating altitude
The maximum operating altitude without derating is 2000 m (6,561 ft.).

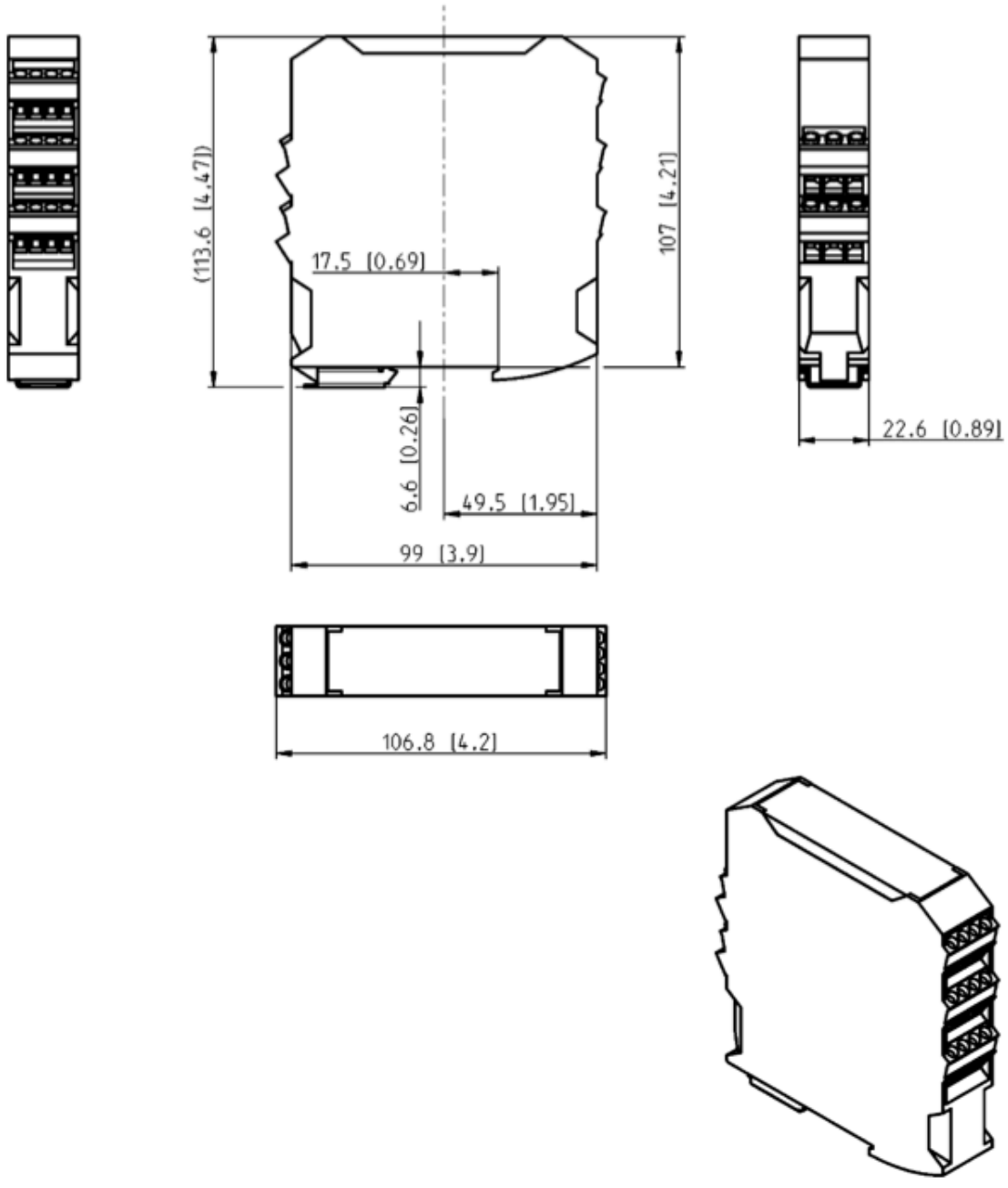
Mechanical vibration
The HF range is tested according to IEC/EN 60068-2-6 for vibration resistance 10 – 150 Hz up to 5 g (5 gn) starter OFF and 5 g (5 gn) starter ON.

Mechanical shock
The HF range is tested according to IEC/EN 60068-2-27 in a mechanical vibration test. It is designed to be shock resistant ½ sine wave (=18 sec.) with a value of 30 g (30 gn) starter OFF and 30 (30 gn) starter ON.

10 Dimensional drawings

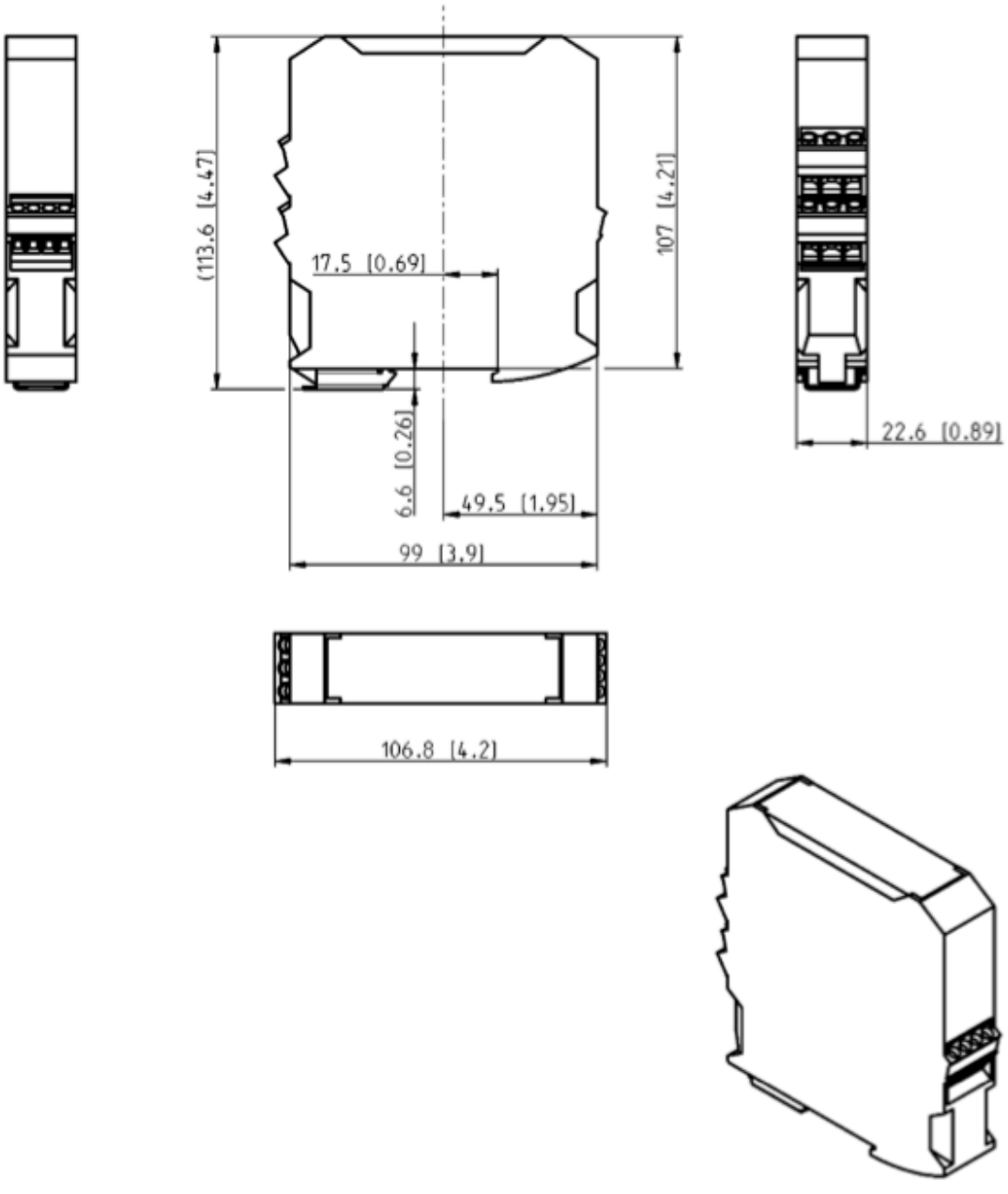
Dimension drawings for all HF- types with integrated overload protection

in mm [inch]



Dimensional drawings for R- type

in mm [inch]

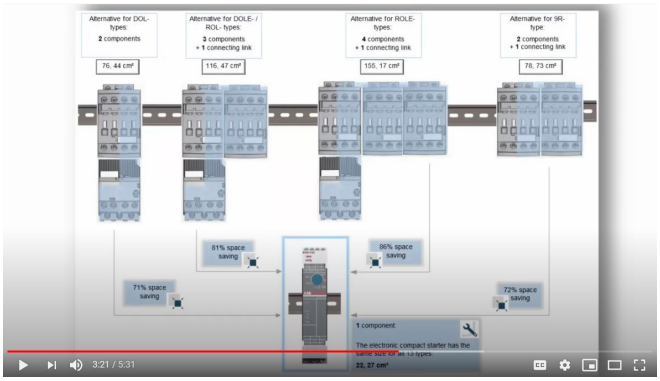


11 Annex

For more information and download material, please visit our homepage or find our videos about the HF range.

- new.abb.com/low-voltage

- Episode 1: Product introduction and benefits - HF range
  youtube.com/watch?v=y_WtX5FYOis
- Episode 2: Hybrid technolog of HF range
  youtube.com/watch?v=OtQ1zkhHMEk
- Episode 3: HMI and wiring HF range
  youtube.com/watch?v=P6F3pW_0_Yg
- Episode 4: Setting the nominal current HF range
  youtube.com/watch?v=Q4kO3PBoqZw



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You can find the address of your local sales organization on the ABB homepage

abb.com/lowvoltage

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