

WHITEPAPER

Electronic Compact Starter

Short-circuit protection



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1. Introduction

Electronic Compact Starters (HF-Starters) are multifunctional devices for motor control and protection up to 3 kW/400 V AC. The HF-Starter is useful where space is limited but high functionality is required. HF-Starters provide direct on-line and reverse start, over-load protection and emergency stop features all in one device which is only 22.5 mm in width.

This white paper is to show which short-circuit protection devices should be used in combination with the Electronic Compact Starter.

1.1 Explanation - Hybrid technology

HF-Starters use hybrid technology - a combination of semiconductors (Triac) and relays. As the HF-Starter is used for AC switching, two Thyristors must be combined. This anti-parallel combination of two Thyristors is called a Triac.

The integrated microprocessor coordinates two Triacs (V1 and V2), two pairs of relays (K1 and K2) and two bypass relays (K3) in one device. The switching principle of the switch-on process takes place in three steps. First, the relays K1 and K2 are switching. Until this time there is no current flow in phases L1, L2 and L3 since the Triacs (V1 and V2) have not switched. In the second step, the Triacs V1 and V2 are switching. Now the inrush current is conducted through all three phases and the motor starts. The Triacs are generating high power losses, which results in heat dissipation. To avoid heat dissipation the microprocessor starts with the third step and switch the bypass relays (K3) on. The bypass relays K3 are conducting now the nominal current of the motor.

The all in one hybrid technology results in a high lifetime of 30 Mio. electrical switching cycles, a high switching frequency of 7200x per hour, reduced power loss, galvanic isolation and finally the ability to save space in the control cabinet.

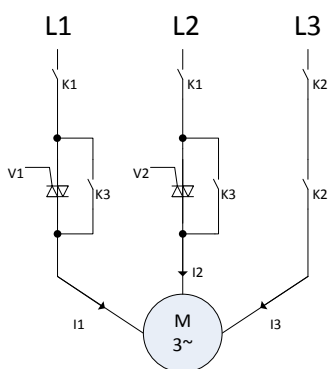


Figure 1
Main circuit of the HF-Starter

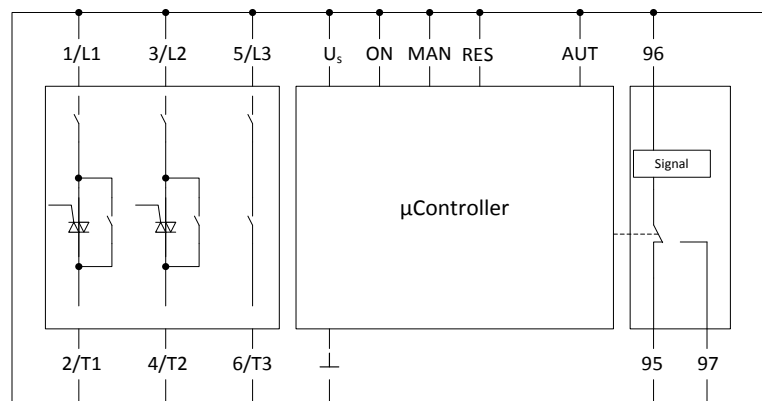


Figure 2
Connection diagram of HF-DOL

1.2 Applications

You can find the HF-Starter for applications such as:

- OEMs for lifters, where the lifted good needs to be positioned up/down and left/right
- OEMs for straightening machines to position coils and cooling motors
- Panel builders for integration into control cabinets, e.g. for snow guns which needs to be controlled to the left and right side
- Controlling machine axis

All four applications listed above require a long electrical lifetime, low space consumption in control cabinets and multi-functionality. To provide our customers with the best possible short-circuit protection, ABB decided to combine its well-known Manual Motor Starter MO132 with the outstanding Electronic Compact Starter for single and group mounting.

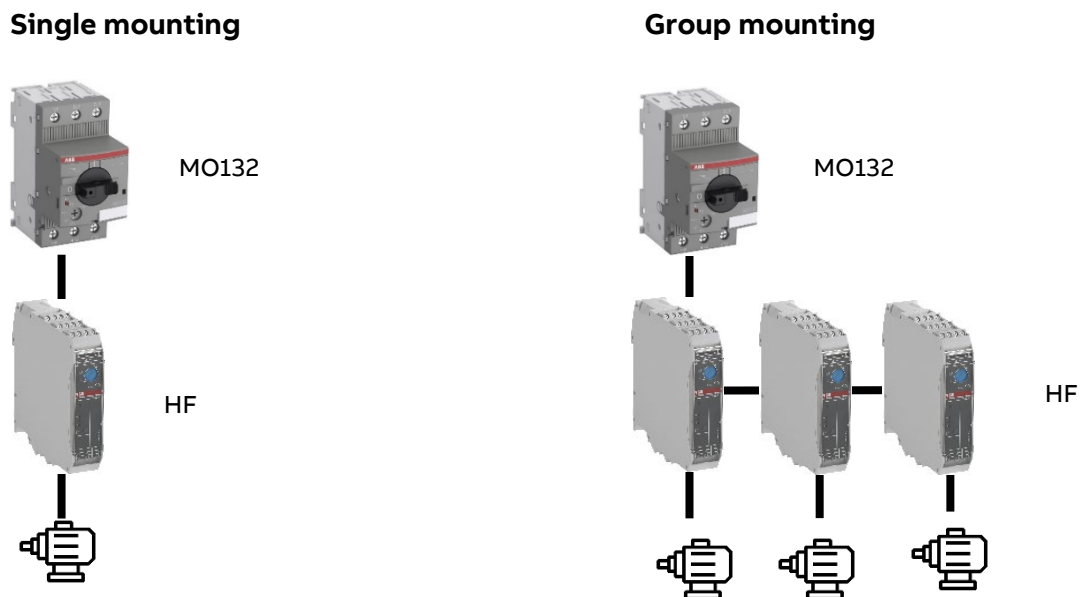


Figure 3
Single and group mounting with MO132 and Electronic Compact Starter
for fuseless short-circuit protection

2. Fuseless design

2.1 Description of MO132

The “MO132 Manual Motor Starter magnetic only” is a compact 45 mm width device available for different nominal currents. It provides short-circuit protection either to protect the motor and wires or additionally to protect control devices when used in a starter combination, e.g., with contactors or the Electronic Compact Starter.

2.2 What is meant by fuseless design?

A fuseless design means using a Manual Motor Starter like the MO132 for short-circuit protection in combination with the Electronic Compact Starter. After the tripping of the MO132 starter due to a short-circuit no fuse replacement is needed.

Please note it is important to change the Electronic Compact Starter after a short-circuit has occurred.

2.3 Benefits of fuseless design

One favorable attribute of using a fuseless design, which is an advantage of the MO132, is that it can be used as power disconnect and can provide isolation from the network. For any application that may require regular service this is an attractive benefit. Even the rotary handle can be locked to ensure power reconnection during service.

The second benefit for the customer is the visual indication. The rotary handle will stop in the “Trip” position to show that a short-circuit occurred. This feature saves diagnostic time.

The third benefit is the possibility to broaden the functionality with accessories such as auxiliary contacts, signaling contacts, undervoltage releases and more.

2.4 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 use. Please find all the installation proposals in **Table 1 for 500 V AC** and **Table 2 for 415 V AC**.

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Table 1:

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

HF-Starter	I_q [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

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

—
Table 2:

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

HF-Starter	I_q [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 ¹⁾	415

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

2.5 Group mounting

Group mounting HF-Starters provides significant space saving in control cabinets. One MO132 can be used to protect several Electronic Compact Starters. Test results are presented in **Table 3 for 500 V AC** and **Table 4 for 415 V AC**. Two installation proposals for group protection are shown in **Figure 5** and **Figure 6**.

Please note that the sum of the current for all of the HF-Starters must not exceed the maximum current of the MO132 chosen. E.g., if the maximum current is 20 A, then the MO132-20 must be chosen and the sum of the HF-Starter current must not exceed 20 A in total.

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Table 3:

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

Max. sum of current of HF-Starter in group	I_q [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

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Table 4:

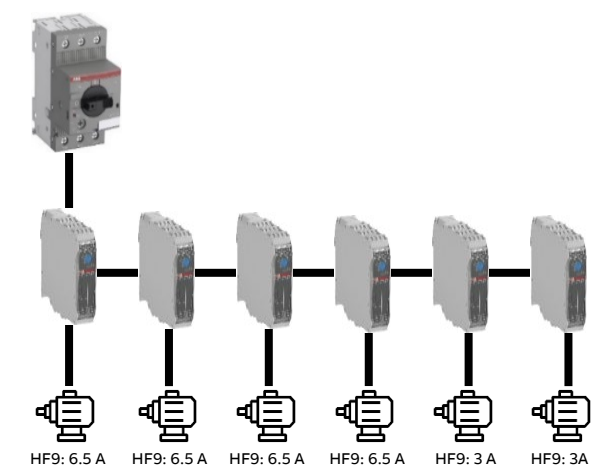
Type 1 coordination of HF-Starter with Manual Motor Starter MO132 at 415 V AC

Max. sum of current of HF-Starter in group	I_q [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

2.5.1 Group mounting – example 1

In **figure 4** the MO132-32 is chosen as the short-circuit protection device. The nominal current is 32 A. Our customer now has the possibility to combine different current sizes and variants of the HF-Starter until the maximum nominal current of 32 A is reached. The sum of the nominal currents of the HF-Starter must not exceed the nominal current of the MO132.

Figure 4 shows six units of the HF9-Starter in use. The complete sum of the current of these four Electronic Compact Starters equals $4 \times 6.5 \text{ A} = 26 \text{ A}$. There is still 6 A “available”. So, two additional HF9-Starters with 3 A can be controlled and protected.

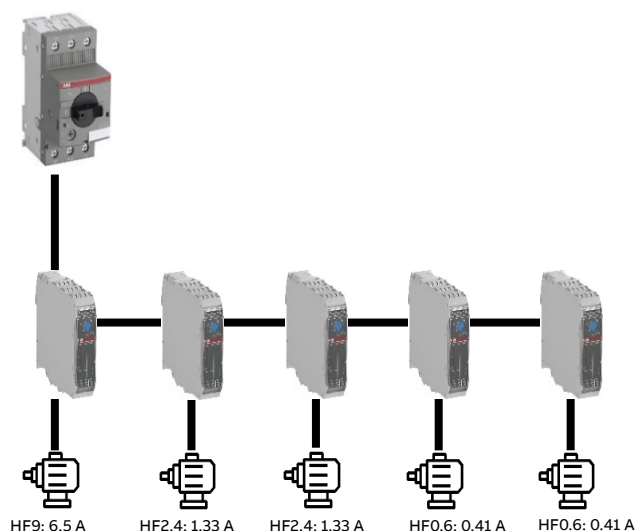


SCPD: MO132-32, maximal current 32 A

- Installing 4 x HF9 with each 6.5 A results in 26 A
- Adding an additional 2 x HF9 with 3 A adjusted results in 6A
- Calculation: $32 \text{ A} - 26 \text{ A} - 6 \text{ A} = 0$

Figure 4 Group mounting protection example with MO132-32 A

2.5.2 Group mounting – example 2



SCPD: MO132-10, maximal current 10 A

- Installing one HF9 with a nominal current of 6.5 A
- Adding two HF2.4 with a nominal current of 1.33 A results in 2,66 A
- Adding two HF0.6 with a nominal current 0.41 A results in 0.82A
- Calculation: $10 \text{ A} - 6.5 \text{ A} - (2 \times 1.33 \text{ A}) - (2 \times 0.41 \text{ A}) = 0,02 \text{ A}$

Figure 5 Group mounting protection example with MO132-32 A

It is possible to combine all the variants of the HF-Starter with all the MO132 models up to 32A (DOL, ROL, DOLE, ROLE, R). The most important point to note is that the sum of the currents must not exceed the nominal current of the MO132.

3. Protection with fuses

3.1 Single mounting fused design

All variants of the HF-Starter can be combined with the following fuses for short-circuit protection. **Table 4** shows test results for **500 V AC** and **Table 5** shows the results for **415 V AC**.

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Table 4:
Type 1 coordination of HF-Starter with Fuses at 500 V AC

HF-Starter	I_q [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	35	Fuse 25A gG	0.63	500
HF2.4	35	Fuse 25A gG	2.4	500
HF9	35	Fuse 25A gG	9 ¹⁾	500

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

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Table 5:
Type 1 coordination of HF-Starter with Fuse 25AgG at 415 V AC

HF-Starter	I_q [kA]	SCPD	Max. Current [A]	Max. Voltage [V AC]
HF0.6	50	Fuse 25A gG	0.63	415
HF2.4	50	Fuse 25A gG	2.4	415
HF9	50	Fuse 25A gG	9 ¹⁾	415

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

3.2 Group mounting fused design

Group mounting HF-Starters results in significant space saving in control cabinets. Installation proposals are shown in **Table 6 for 500 V AC** and **Table 7 for 415 V AC**.

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Table 6:

Type 1 coordination of HF-Starter with Fuse 25AgG at 500 V AC

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

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Table 7:

Type 1 coordination of HF-Starter with Fuse 25AgG at 415 V AC

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

4. Short-circuit protection for use in the UL market

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

Table 8:

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

HF-Starter	FLA [A / V AC]	I_q [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

5. Glossary

I_q According to IEC 60947-1:
The rated conditional short-circuit current of a piece of equipment is the value of the prospective current, stated by the manufacturer, which the equipment, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of this device under the test conditions specified in the relevant product standard.

SCPD The abbreviation “SCPD” is defined in IEC 60947-4-1 (3.7) as a “Short-circuit protective device”. It means the co-ordination of contactors and starters is characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD) that provide protection of the contactor and starter against short-circuit currents.

FLA Full Load Amps (sometimes also FLC= Full Load Current), rated-current at rated-load and rated-voltage. This is the amount of current (amps) the motor will draw from the electrical system when producing its rated output horsepower (UL 508).

Trip class This class number indicates the trip time from a cold state and should be selected according to the starting characteristics of the motor. The trip characteristics are defined in Table 4 of IEC60947-4-2. Please find a short extract in Table 9 below.

Table 8 Extract of IEC 60947-4-2 Table 4

Class	10A	10	20	30
Tripping time	$2 < T_p \leq 10$	$4 < T_p \leq 10$	$6 < T_p \leq 20$	$9 < T_p \leq 30$

All HF-Starters provide tripping class 10A except HF9-R-24VDC, which has no protection functionality.

AC-53a Conforming to IEC/EN 60947-4-2 utilization category AC-53a means the control of squirrel cage motors: 8 h of duty with on-load currents for starting, acceleration, and running by using AC semiconductors in motor controllers and starters.

AC-51 Conforming to IEC/EN 60947-4-3 utilization category AC-51 means the control of non-inductive or slightly inductive loads, or resistance furnaces by using an AC semiconductor controller and contactors for non-motor loads.

Device self-protection If the current exceeds 45 A for more than 2 s, the electronic compact starter switches off the motor and indicates the cause of the trip through the ERR LED and trip signaling contact.

6. Standards and Directives

The table below lists applicable standards and relevant guidelines for the presented solution.

IEC/EN 60947-1	Low-voltage switchgear and controlgear – Part 1: General rules
IEC/EN 60947-2	Low-voltage switchgear and controlgear – Part 2: Circuit breakers
IEC/EN 60947-4-1	Low-voltage switchgear and controlgear – Part 4-1: Contactors and Motor-Starters
IEC/EN 60947-4-2	Low-voltage switchgear and controlgear – Part 4-2: AC Semiconductor motor controllers and starters
IEC/EN 60947-4-3	Low-voltage switchgear and controlgear – Part 4-3: AC semiconductor controllers and contactors for non-motor loads
UL 508a	Standard for Industrial Control Panels
UL 60947-1	Low-Voltage Switchgear and Controlgear – Part 1: General rules

7. Safety Instructions



Safety instructions

- Attention! Hazardous voltage! Installation by trained people with electro technical expertise only.
- Mounting and installation may only be done by trained technical personnel, according to the recognized technical rules, regulations, and relevant standards!
- Insufficiently tightened locking screws will lead to an impermissible rise in temperature!
- Always observe the permitted ambient conditions (see technical data and catalog).
- Devices with visible transport damage must not be used.

Warnings

- ! If the short-circuit protection device (SCPD) has tripped, the Electronic Compact Starter must be replaced!
- ! The diagnostic function provided by LEDs on the front side of the HF-Starter has no significance after a short-circuit has occurred.
- ! Standard or safety variants of the HF-Starter can be used in combination with the mentioned short-circuit protection devices.

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