EMS2-…-SWD
Electronic motor starters with SWD

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Original operating manual
The German-language edition of this document is the original operating manual.

Translation of the original operating manual
All editions of this document other than those in German language are translations of the original operating manual.

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Danger!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally retriggered.
- Verify isolation from the supply.
- Ground and short-circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (IL) of the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalizing. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference do not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O connection so that a cable or wire breakage on the signal side does not result in undefined states in the automation device.
- Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supply units complying with IEC 60364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- Deviations of the mains voltage from the nominal value must not exceed the tolerance limits given in the technical data, otherwise this may cause malfunction and dangerous operation.
- Emergency-Stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency switching off devices must not cause restart.
- Built-in devices for enclosures or cabinets must only be run and operated in an installed state, desk-top devices or portable devices only when the housing is closed.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency switching off devices should be implemented.
- Wherever faults in the automation system may cause damage to persons or property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks, etc.).
- During operation, and depending on their degree of protection, variable frequency drives may have live, uninsulated, moving, and/or rotating parts, as well as hot surfaces.
- The impermissible removal of the required cover, improper installation or incorrect operation of the motor or variable frequency drive can cause the failure of the device and serious injury and/or material damage.
- Comply with all applicable national accident prevention regulations (e.g. BGV A3) when working with energized variable frequency drives.
- The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross sections, fuses, PE).
- All transport, installation, commissioning and maintenance work must only be carried out by trained personnel (observe IEC 60364, HD 384 or DIN VDE 0100 and national accident prevention regulations).
- If applicable, systems in which variable frequency drives are installed must be equipped with additional monitoring and protective devices in accordance with the applicable safety regulations, e.g., the German Equipment and Product Safety Act, accident prevention regulations, etc. Making changes to the variable frequency drives by using the operating software is allowed.
- Keep all covers and doors closed during operation.
- When designing the machine, the user must incorporate mechanisms and measures that limit the consequences of a drive controller malfunction or failure (an increase in motor speed or the motor sudden stop) so as to prevent hazards to people and property, e.g.:
  - Additional stand-alone devices for monitoring parameters that are relevant to safety (speed, travel, end positions, etc.)
  - Electrical and non-electrical safety devices (interlocks or mechanical locks) for mechanisms that protect the entire system
  - Due to the possibility of there being capacitors that are still holding a charge, do not touch live device parts or terminals immediately after disconnecting the variable frequency drives from the supply voltage. Heed the corresponding labels on the variable frequency drives

Content

0 About This Manual

This manual MN012008EN applies to device series EMS2-…-SWD with SmartWire-DT (SWD) electronic motor starters.

The manual describes the different product versions of the EMS2-…-SWD device series, their installation and operation, as well as their use to protect motors in potentially explosive (Ex e increased safety) areas.

As we do not know your application in detail, the application information and examples provided in this document are incomplete and serve only to provide you guidance, as an operator of safety-related control technology, in the implementation of safety standards and directives.
The information and examples in this document make no claim to be complete nor are they legally binding.
For more detailed information, refer to the prevailing standards and directives that are applicable to your application.

0.1 List of revisions

The following significant amendments have been introduced since previous issues:

Publication date	Page	Keyword	new	modified	deleted
07/23	8	Safety directives		✓	
06/23	8	Safety directives		✓	
	14	Motor starter with safety function…		✓	
	34	FLA for UL is added	✓		
	53	Status messages		✓	
01/21	37	Conditions when setting the motor protection	✓		
	39	Setting options for the motor nominal current	✓		
	46	Setting values for the motor nominal current		✓	
10/19		First edition	–	–	–

0.2 Target group

This manual is intended for qualified personnel installing, operating, and maintaining EMS2-…-SWD electronic motor starters.

CAUTION

Installation requires a qualified electrician

0.3 Additional documents

For further information, see the following documentation:

- Manual MN034003EN: "Electronic motor starter EMS2" (devices without SWD functionality)
- Instruction Leaflet IL120004ZU, "EMS2 – SWD"
- Instruction Leaflet IL120010ZU, "EMS2 – SWD – Safety"

0.4 Abbreviations and symbols

The following abbreviations are used in this manual:

Table 1: Abbreviationsused

Abbreviation	Meaning
DO	Direct Online
DOS	Direct Online Safety
EMS	Electronic Motor Starter
LED	Light-Emitting Diode
RO	Reverse Online
ROS	Reverse Online Safety
SWD	SmartWire-DT

The symbols used in this manual have the following meanings:

▶ indicates actions to be taken.

0.4.1 Risk of material damage

WARNING

Warns about the possibility of material damage.

0.4.2 Hazard warnings of personal injury

CAUTION

Warns of the possibility of hazardous situations that may possibly cause slight injury.

WARNING

Warns of the possibility of hazardous situations that could result in serious injury or even death.

DANGER

Warns of hazardous situations that result in serious injury or death.

0.4.3 Tips

Indicates useful tips.

1 General – EMS2-…-SWD electronic motor starter

1.1 Standards

In addition to the standards in accordance with EN 60079 / VDE 165-1, separate standards for the corresponding types of protection apply to the protection of motors in potentially explosive atmospheres.

Motors with type of protection for potentially explosive areas, "increased safety"

The standard EN 60079-7 requires additional measures in the case of motors with the type of protection for potentially explosive areas, "increased safety".

These measures ensure, with a high degree of certainty, that impermissible high temperatures, sparks and electric arcs are prevented on motors where these would not usually occur during normal operation.
The motor protection devices for this, which themselves are not located in a potentially explosive area, must be certified by an accredited admission office.

Motors in potentially explosive dust-air mixtures

For motors in potentially explosive dust-air mixtures, the standard EN 60079-14 specifies additional measures.

Directive 2014/34/EC (ATEX) on the approximation of the laws of the Member States concerning devices and protective systems intended for use in potentially explosive areas has been in force since 20.04.2016.

Area of application

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 category 2D or 3D or is certified as such.

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

1.2 Safety directives

1. The device executes a function diagnosis when the drive is switched on or is in the switched on state. In addition, an authorized electrician or a skilled worker who is well acquainted with the relevant standards can conduct the "Motor overload protection" safety function test.
   For this test, the drive must be operated withright or left rotation (forward or reverse running), and the current flow in a conductor is interrupted (e.g. by removing the fuse in the L1 or L3 phase).
   The EMS2 then switches off the drive within 1.5 to 2 s.
   The LEDs for right or left rotation go out, and the ERR-LED and the reply output are set and the confirmation can be retrieved via the bus.
2. The device is an associated item of equipment.
   Do not install the device in potentially explosive areas. When installing and operating associated equipment, the applicable safety directives must be observed.
3. When using devices with 230 V AC control, always use the same phase for the control supply voltage and the control inputs.
4. If you use the "Automatic RESET" mode, the drive 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 the Ex-protection area, automatic restart is not permitted.
5. For safety technical data, please refer to this document and certificates (EC type examination certificate and other approvals if appropriate).
6. Electronic motor starters are not allowed to operate with variable frequency drives.
7. For emergency stop applications, the machine must be prevented from restarting automatically by a higher-level control system.
8. Secure the electronic motor starter EMS2 during safety-related applications with an access protection.

1.3 Device overview EMS2-…-SWD

EMS2-…-SWD series electronic motor starters serve to switch and protect three-phase asynchronous motors.

Depending on the version, the following functions are available:

- Direct starter (DO = Direct Online)
- Reversing starter (RO = Reverse Online)
- Motor protection
  - Overload protection
  - Phase failure
  - Phase imbalance
- Category 3 controlled stop
  PL e DIN EN ISO 13849, SIL 3 IEC 61508

The compact devices contain the required interlocks which are necessary for the specified functions in order to reduce the wiring.

The supply of the device as well as the actuation of the operating direction takes place via the internal SmartWire-DT (SWD) interface. In addition, the motor starter uses this interface in order to provide additional information for a superordinate controller.

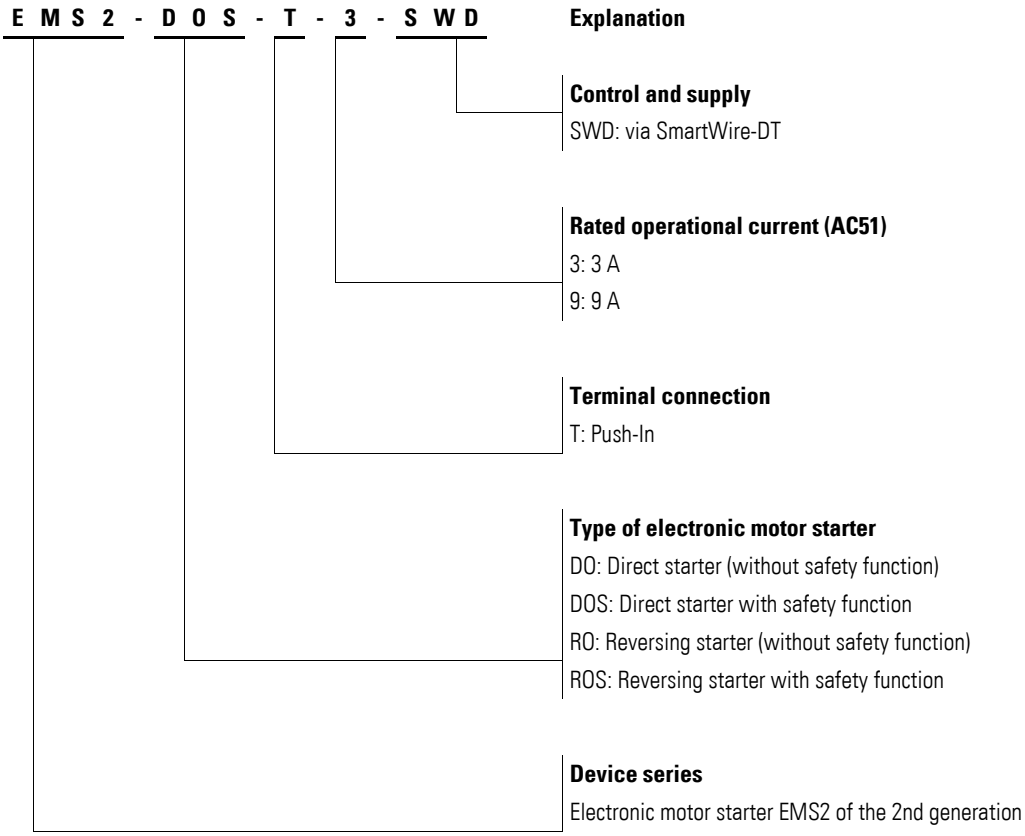
Notes on the application range

Do **not** operate single-phase motors in conjunction with an EMS2-…-SWD electronic motor starter.

It is not permitted to use the motor starters described in this Section in potentially explosive areas (ATEX).
Only motors in Ex e increased safety areas may be controlled.

1.4 Type code

The type designation of an electronic motor starter EMS2 with SWD (i. e. EMS2-…-SWD) is made up of the following type code (comprising five groups):



2 Motor starter – overview

EMS2-…-SWD devices are supplied via SmartWire-DT (SWD).

The cables are connected using push-in terminals.

2.1 Setup

The following drawing shows the designation for the EMS2-…-SWD electronic motor starter.

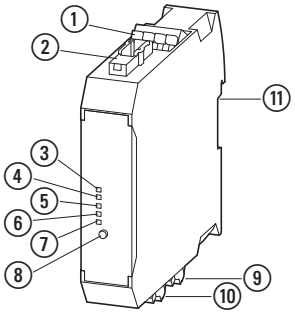


Figure 1: Designations on EMS2-…-SWD

① EMS2-DO/RO: Terminals without function
EMS2-DOS/ROS: safety-oriented enable
② Connection for SWD external device plug
③ LED **PWR** (green)
④ LED **SWD** (green)
⑤ LED **ERR** (red)
⑥ LED **L** (yellow) – for reversing starters
⑦ LED **R** (yellow) – for reversing starters; LED **ON** (yellow) – for direct starters
⑧ Set/reset button
⑨ Terminals for input voltage
⑩ Terminals for output voltage
⑪ Top-hat rail fitting

2.2 Motor starter without safety function (DO, RO)

The devices to actuate motors described in this Section must not be operated in potentially explosive Ex e increased safety (ATEX) areas.

Table 2: DO (direct starter) and RO (reversing starter) versions

Type	Minimum current	Rated operational current I_e	
		AC51 EN 60947-4-3	AC53a EN 60947-4-2
Direct starters			
EMS2-DO-T-3-SWD	0.18 A	3 A	3 A
EMS2-DO-T-9-SWD	1.5 A	9 A	7 A
Reversing starters			
EMS2-RO-T-3-SWD	0.18 A	3 A	3 A
EMS2-RO-T-9-SWD	1.5 A	9 A	7 A

Notes

→ Note, that the permissible continuous current for devices with a rated operational current I_e of 9 A depends on the type of mounting and the ambient temperature, → section 2.5, "Layout of devices with I_e = 9 A", page 17.

→ Currents under the minimum current specified in table 2 will not be detected by the motor protection. The motor must not be operated under this value.

The motor starter itself also works if the current is under this minimum value. This state is displayed by the flashing of both LEDs **PWR** and **ERR**.

2.2.1 Block diagrams

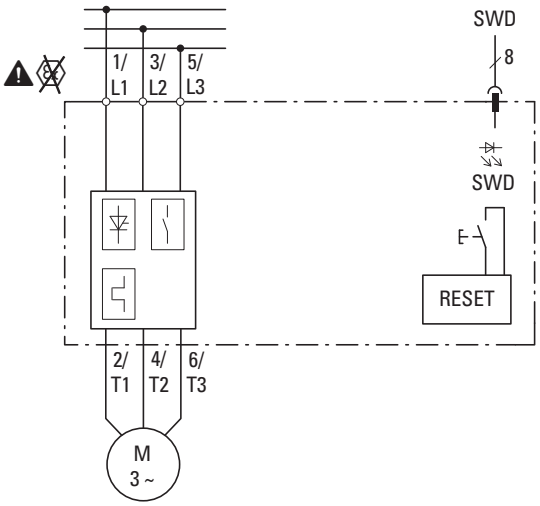


Figure 2: Block diagram: Direct starter with SWD

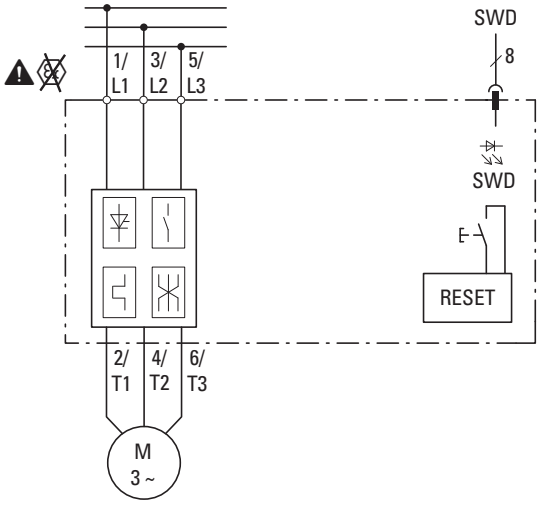


Figure 3: Block diagram: Reversing starter with SWD

2.2.2 Terminal assignment

The following table specifies the functions of the terminals of the switching operations shown in → section 2.2.1, "Block diagrams".

Table 3: Terminal assignment

Terminal	Function
1L1	three-phase incoming unit
3L2	three-phase incoming unit
5L3	three-phase incoming unit
2T1	three-phase motor connection
4T2	three-phase motor connection
6T3	three-phase motor connection
SWD	7-pole SmartWire-DT external device plug
NC	Not Connected

2.3 Motor starter with safety function (DOS, ROS)

The devices to actuate motors described in this section must not be operated in potentially explosive Ex e increased safety (ATEX) areas. Motors in the Ex-Area can be controlled.

Table 4: DOS (direct starter) and ROS (reversing starter) versions

Type	Minimum current	Rated operational current I_e	
		AC51 EN 60947-4-3	AC53a EN 60947-4-2
DOL starters			
EMS2-DOS-T-3-SWD	0.18 A	3 A	3 A
EMS2-DOS-T-9-SWD	1.5 A	9 A	7 A
Reversing starters			
EMS2-ROS-T-3-SWD	0.18 A	3 A	3 A
EMS2-ROS-T-9-SWD	1.5 A	9 A	7 A

Notes

→ Note that the permissible continuous current for devices with a rated operational current I_e of 9 A depends on the type of mounting and the ambient temperature, → section 2.5, "Layout of devices with I_e = 9 A", page 17.

→ Currents under the minimum current specified in the table 4 will not be detected by the motor protection.
It is therefore not permissible to operate the motor under this value – especially in applications which fall under the remit of the ATEX guideline.

The motor starter itself also works if the current is under this minimum value. This state is displayed by the flashing of both LEDs **PWR** and **ERR**.
Observe the minimum permissible load current in safety-related applications.

2.3.1 Block diagrams

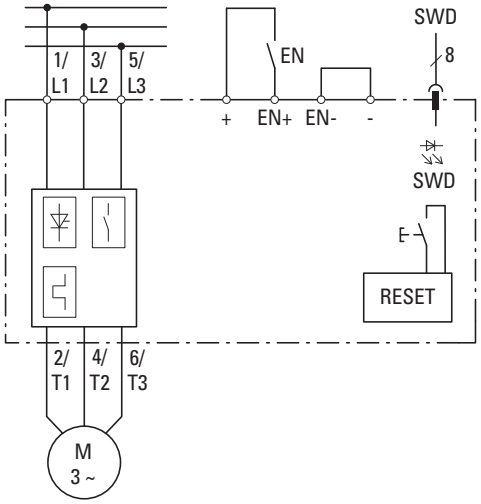


Figure 4: Block diagram: Direct starter with safety function and SWD

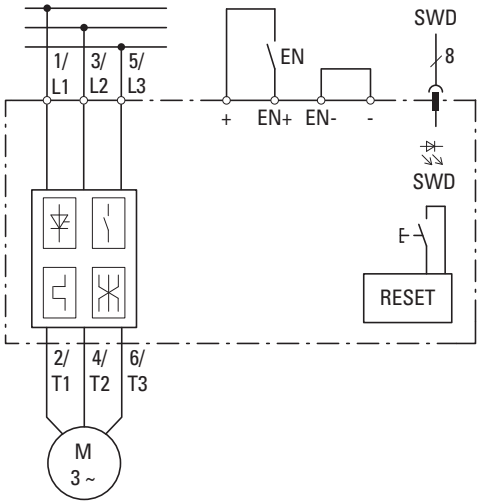


Figure 5: Block diagram: Reversing starter with safety function and SWD

Notes

→ The block diagrams in Figure 4 and 5 serve merely to represent the general functions. The actual wiring depends on the application case (→ chapter 5, "Application examples", page 49).

→ For a safety-oriented enable (EN) of the motor starter EMS2-**DOS**-…-SWD and EMS2-**ROS**-…-SWD, a voltage of 24 V is required between terminals EN+ and EN-.
This voltage can also be supplied from an external voltage source (see example below → section 2.3.2, "Safety-oriented enable"). If there is no signal, the start commands via SWD will not be accepted.

2.3.2 Safety-oriented enable

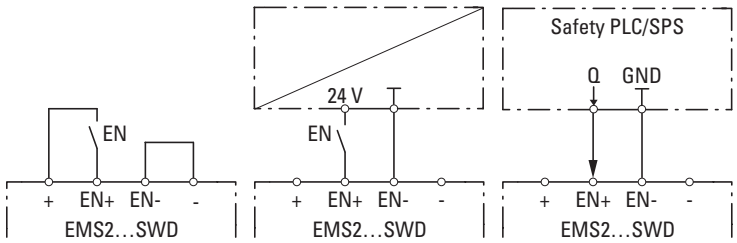


Figure 6: Safety-oriented enable (versions)
Left: with internal voltage from the EMS2-…-SWD motor starter
Middle: with external voltage
Right: via a safe PLC output

2.3.3 Terminal assignment

The following table specifies the functions of the terminals in the → section 2.3.1, "Block diagrams" shown switching operations.

Table 5: Terminal assignment

Terminal	Function
1L1	three-phase incoming unit
3L2	three-phase incoming unit
5L3	three-phase incoming unit
2T1	three-phase motor connection
4T2	three-phase motor connection
6T3	three-phase motor connection
EN+	Input for safety-oriented enable of the motor starter
EN-	Input for safety-oriented enable of the motor starter
+	Internal voltage 24 V
-	Internal voltage 24 V
SWD	7-pole SmartWire-DT external device plug

2.4 Mounting

EMS2-…-SWD motor starters are mounted on a 35-mm-top-hat rail.

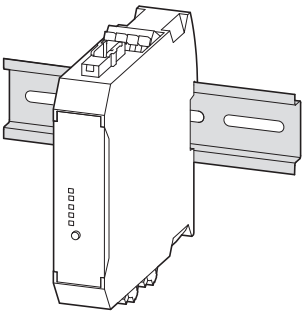


Figure 7: Mounting on top-hat rail

Notes

Note that the direct linking of devices with a rated operational current I_e of 9 A can lead to a reduction in performance (derating) under some circumstances (→ section 2.5, "Layout of devices with I_e = 9 A").

EMS2-XBR-T-… (→ section 9.1, "Three-phase current connector", page 67) three-phase current connectors can be used to connect the supply terminals 1L1, 3L2 and 5L3 of up to five devices in a row.

2.5 Layout of devices with I_e = 9 A

When using devices with a rated operational current I_e of 9 A, note that the permissible thermal continuous current I_L depends on the type of mounting and the ambient temperature. Refer to the diagram (→ figure 8) below. Moreover, the maximum permissible current of 56 A must not be exceeded, even in startup.

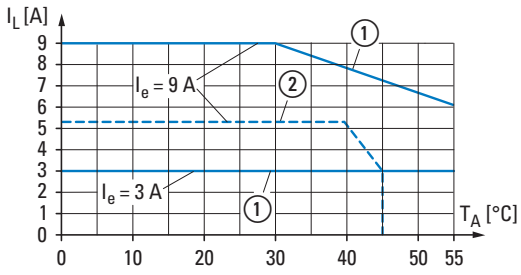


Figure 8: Thermal continuous current I_L according to the ambient temperature T_A

① When mounting the devices with a minimum distance of 20 mm

② With directly linked devices

The maximum current during start-up of the motor is derived by multiplying the motor rated current with the "startup factor", which with standard asynchronous motors is usually between 6 and 10.
Contact the motor manufacturer to establish the actual value.

Table 6: Thermalcontinuous current I_L with different mounting situations and I_e = 9 A

for EMS2-…-9-SWD devices	**Ambient temperature**			
Rated uninterrupted current I_U with mounting situation	**40 °C**	**45 °C**	**50 °C**	**55 °C**
Single device, top-hat rail horizontal, motor feeder on bottom	9 A	9 A	9 A	7.6 A
Linked devices with a device width distance (22.5 mm), Top-hat rail horizontal, motor feeder on bottom	9 A	9 A	6.8 A	6.1 A
Linked devices without spacing Top-hat rail horizontal, motor feeder on bottom	5.2 A	3 A	–	–

EMS2-…-SWD devices with a rated operational current I_e of 3 A can be operated at temperatures up to 55 °C without restriction.

Table 7: Thermal continuous current I_L with different mounting situations and I_e = 3 A

for devices EMS2-…-3-SWD	**Ambient temperature**			
Rated uninterrupted current I_U with mounting situation	**40 °C**	**45 °C**	**50 °C**	**55 °C**
Single device, top-hat rail horizontal, motor feeder on bottom	3 A	3 A	3 A	3 A
Linked devices with a device width distance (22.5 mm), Top-hat rail horizontal, motor feeder on bottom	3 A	3 A	3 A	3 A
Linked devices without distance between Top-hat rail horizontal, motor feeder on bottom	3 A	3 A	–	–

Example

A motor with the values shown below is to be operated with an EMS2-…-SWD electronic motor starter.

Motor:

Power:	P_{Mot} = 2.2 kW
Rated operational current I_e at 400 V:	I_{Mot} = 4.7 A
Startup factor I_{max} / I_{Mot}:	8.5

Control panel temperature: 55 °C

Questions:

- Is operation possible?
- How should the motor starter be mounted?

Reviews:

Step 1:

Check to see if the motor starter is suitable for the maximum current (56 A).

I_{max} = I_{Mot} x startup factor = 4.7 A x 8.5 = 39.95 A < 56 A

Step 2:

Which motor current is permissible for an ambient temperature of 55 °C?

- directly linked: not permissible
- at a 20 mm distance: 6.2 A > 4.7 A → permissible!

Conclusion:

The EMS2-…-SWD motor starter can be used for this application, but must be mounted with a distance of at least 20 mm between the devices.

3 Communication via SmartWire-DT (SWD)

3.1 Commissioning EMS2-…-SWD motor starters

EMS2-…-SWD motor starters are supplied with voltage via the SWD flat ribbon cable.

A distinction is made between two different supply voltages:

- The control voltage U_S (24 V) to supply the electronics in the devices
- The supply voltage U_{SWD} (15 V) for the communications

When the external control voltage is connected, all the LEDs on the front of the device light up for a short period of time. After this, the **PWR** (green) LED remains on.

When the supply voltage U_{SWD} is first connected, the **SWD** LED flashes every 1 -second-. The electronic motor starter is now ready for commissioning. The automatic addressing of all modules in the SmartWire-DT line is performed via the gateway (actuation of the configuration pushbutton on the gateway) during commissioning.

The **SWD** LED flashes during the addressing process.
The LED changes to a static green after the addressing process.

→ With types EMS2-…-24VDC, parameterizing the rated current must be completed by pressing the "Reset/Set" button in order for the set current to be applied.
With types EMS2-…-SWD, the current is set by the PLC program or the SWD Assist software.

3.2 Replacing EMS2-…-SWD motor starters

→ **REPLACING MOTOR STARTERS EMS2-…-SWD**

A motor starter must only be replaced after the entire SmartWire-DT system has been switched off.
In doing so, the order of the SWD modules must not be changed.
After replacing a motor starter and reconnecting the voltage, the configuration button on the gateway must be pressed.
This assigns the replaced motor starter with an address.

3.3 Special considerations when using the field bus system CANopen

When using data profile 2 or 5 in conjunction with SmartWire-DT gateway EU5C-SWD-CAN, the entries in the setting range for associated service data object (SDO) 2102subx need to be modified in the PLC configuration program.

For example, when using the CODESYS-3 programming system, you will need to change the default value from 0x00000030 to 0x00002093 if you want to use profile 3.

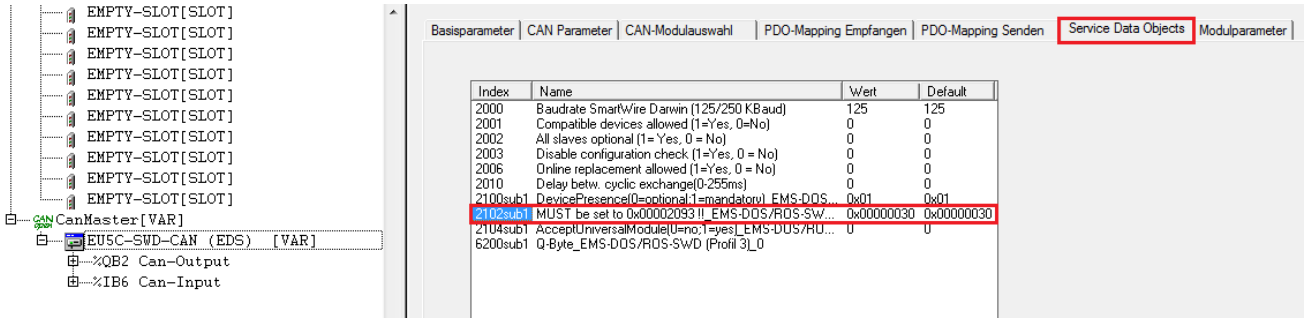


Figure 9: Service data object 2102subx

When using data profile 2, 3, 4, or 5 in conjunction with programming systems with a PLC configurator that does not feature automatic profile selection when configuring SDOs, the 2102subx SDO object needs to be added to the list of SDO objects and the required content must be passed.

3.4 Input and output data

The designation of the data (input and output data) is carried out in consideration of the superordinate controller:

- **Input data** are information which are provided by the motor starter EMS2-…-SWD, in order to be transferred via SmartWire-DT (SWD) (and maybe a gateway) to the master.
- **Output data** are information which the master transfers via SmartWire-DT (and maybe a gateway) to actuate the motor starter EMS2-…-SWD.

Available volume of data:

- 7 byte cyclical input data
- 1 byte cyclical output data
- 4 objects (6 byte) acyclical input data
- 2 objects (2 byte) acyclical output data

3.4.1 Cyclical data

A maximum of seven input bytes and one output byte on cyclical data are available.

The number of input bytes can be adjusted by preselecting the appropriate profile.

Table 8: Data profiles

Input data	Data profile				
	1	2	3	4	5
Status information 1	x	x	x	x	x
Set value of the motor protection, trip indication		x	x	x	x
Motor current – in percent			x	x	x
Thermal load – in percent			x	x	x
Device type, status information 2				x	x
Motor current – in amps					x

3.4.1.1 Cyclical input data

Byte 0: Status information 1

Bit	7	6	5	4	3	2	1	0
Configuration	SUBST	PRSNT	–	DIAG	EN	DIRL	DIRR/ DIRON	ERR

Bit	Designation	Meaning
0	ERR	**0**: no active error message present **1**: There is an active error present (motor protection has been triggered or there is an internal error)
1	DIRR/DIRON	**0**: Clockwise operating direction not active (EMS2-RO-…-SWD) or starter not active (EMS2-DO-…-SWD) **1**: Clockwise operating direction active (EMS2-RO-…-SWD) or starter active (EMS2-DO-…-SWD)
2	DIRL	**0**: Counterclockwise operating direction not active **1**: Counterclockwise operating direction active (EMS2-RO-…-SWD only)
3	EN	Safety-related release signal (EMS2-DOS-…-SWD and EMS2-ROS-…-SWD only) **0**: not present **1**: present
4	DIAG	**0**: no diagnostics active **1**: Diagnostics active Possible cause: internal device error or missing supply voltage U_S of the device with simultaneous voltage U_{SWD} present for the communication
5	–	Not used
6	PRSNT	**0**: module not present **1**: module present
7	SUBST	**0**: planned module present **1**: M22-SWD-NOP(C) universal module present

Byte 1: Set value of the motor protection, trip indication

Bit	7	6	5	4	3	2	1	0
Configuration	ACKR	TRIPP (MSB)	TRIPP	TRIPP (LSB)	Ir (MSB)	Ir	Ir	Ir (LSB)

Bit	Designation	Meaning
0, 1, 2, 3	Ir	Set value of the internal motor protection

Bit				Setting I_n in A	
Bit 3	Bit 2	Bit 1	Bit 0	I_e = 3 A	I_e = 9 A
0	0	0	0	0.18	1.5
0	0	0	1	0.3	1.0
0	0	1	0	0.44	2.5
0	0	1	1	0.6	3.0
0	1	0	0	0.68	3.5
0	1	0	1	0.88	4.0
0	1	1	0	1.0	4.5
0	1	1	1	1.1	5.0
1	0	0	0	1.2	5.5
1	0	0	1	1.5	6.0
1	0	1	0	1.6	6.5
1	0	1	1	1.9	7.0
1	1	0	0	2.1	7.5
1	1	0	1	2.4	8.0
1	1	1	0	2.7	8.5
1	1	1	1	3.0	9.0

4, 5, 6	TRIPP	Cause of a possible error

Bit 6	Bit 5	Bit 4	Ursache
0	0	0	not used
0	0	1	overload
0	1	0	instantaneous trip
0	1	1	phase imbalance
1	0	0	phase failure
1	0	1	obstruction
1	1	0	not used
1	1	1	not used

7	ACKR	0: There is no overload present. 1: There is overload present. The message must be acknowledged.

Byte 2: Motor current [%]

Bit	7	6	5	4	3	2	1	0
Configuration	I-REL (MSB)	I-REL	I-REL	I-REL	I-REL	I-REL	I-REL	I-REL (LSB)

Bit	Designation	Meaning
0, 1, ..., 7	I-REL	Motor current in percent (highest value of the three phase currents) Value range: 0 - 255 % I_e (100 % ≙ 3 A or 9 A, depending on type)

Byte 3: Thermal load [%]

Bit	7	6	5	4	3	2	1	0
Configuration	TH (MSB)	TH	TH	TH	TH	TH	TH	TH (LSB)

Bit	Designation	Meaning
0, 1, ..., 7	TH	Current calculated thermal load of the motor Value range: 0 - 255 % of the current that has been set with the motor protection function I_n Triggering occurs at 115 %.

Byte 4: Device type, status information 2

Bit	7	6	5	4	3	2	1	0
Configuration	OL-WARN	MAINS FAILURE	–	OK	TYPE (MSB)	TYPE	TYPE	TYPE (LSB)

Bit	Designation	Meaning
0, 1, 2, 3	TYPE	Type of motor starter EMS2-…-SWD
4	OK	1: The device is activated and current is flowing.
5	–	Not used
6	MAINS FAILURE	1: The device is activated; but there is no current.
7	OL-WARN	Current calculated thermal load of the motor 0: Load < 105 % of the set current I_n 1: Load > 105 % of the set current I_n

Bit 3	Bit 2	Bit 1	Bit 0	Type
0	0	0	0	not used
0	0	0	1	not used
0	0	1	0	not used
0	0	1	1	not used
0	1	0	0	EMS2-DO-T-3-SWD
0	1	0	1	EMS2-RO-T-3-SWD
0	1	1	0	EMS2-DOS-T-3-SWD
0	1	1	1	EMS2-ROS-T-3-SWD
1	0	0	0	EMS2-DO-T-9-SWD
1	0	0	1	EMS2-RO-T-9-SWD
1	0	1	0	EMS2-DOS-T-9-SWD
1	0	1	1	EMS2-ROS-T-9-SWD
1	1	0	0	not used
1	1	0	1	not used
1	1	1	0	not used
1	1	1	1	not used

Byte 5, 6: Motor current [A] (16-bit data word)

Byte 5 / Bit	7	6	5	4	3	2	1	0
Configuration	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS (LSB)

Byte 6 / Bit	7	6	5	4	3	2	1	0
Configuration	I-ABS (MSB)	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS (LSB)

Bit	Designation	Meaning
0, 1, ...,15	I-ABS	Motor current in amps (highest value of the three phase currents) Resolution: 10 mA Example: 357 ≙ 3.57 A

3.4.1.2 Cyclical output data

Byte 0: motor control

Bit	7	6	5	4	3	2	1	0
Configuration	PDIR/ PDIRR	PSTOP	PDIRL	–	RESA	RESM	SDIRL	SDIR/ SDIRR

Bit	Designation	Meaning
0 [1]	SDIR/SDIRR	**0**: EMS2-DO-…-SWD do not actuate or do not preselect clockwise rotation at EMS2-RO-…-SWD **1**: EMS2-DO-…-SWD actuate or preselect clockwise rotation at EMS2-RO-…-SWD
1 [1]	SDIRL	Only present for EMS2-RO-…-SWD **0**: Do not preselect counterclockwise rotation **1**: Select counterclockwise rotation
2 [2]	RESM	1: manual reset after overload shutdown by a rising edge
3 [2]	RESA	1: automatic reset after overload shutdown (continuous signal)
4 [2]	–	Not used
5 [3]	PDIRL	A rising edge starts the counterclockwise rotation with EMS2-RO-…-SWD.
6 [3]	PSTOP	A rising edge stops the motor.
7 [3]	PDIR/PDIRR	A rising edge starts EMS2-DO-…-SWD or the clockwise rotation with EMS2-RO-…-SWD.

1) Starting/stopping the electronic motor starter with a static signal:
the signal must prevail for the duration of operation. A removal indicates stopping the drive.
Alternatively, the motor starter can be actuated with impulses (see Bit 5, Bit 6 and Bit 7)
2) Reset (detailed functional description → section 4.2.6, “Trip and reset”, page 47)
3) Starting/stopping the drive with impulses:
the activation takes place in each case by the rising edge of the signal.
Alternatively, the actuation can be carried out via static signals (see Bit 0 and Bit 1)

3.4.2 Acyclical data

Alongside the cyclical input and output bytes, with electronic motor starter EMS2-…-SWD, the following acyclical objects can be read off or written.

The required object is addressed with parameters-ID and Index. The input address of the SWD module with which communication is to be established is set as parameter ID. The index addresses the object. The first object receives the number 1, the second the number 2 and so forth.
With device EMS2-…-SWD, the object 1 delivers, for example, the relative current I-REL.

3.4.2.1 Acyclical input data

Object 1 [Index 1]

Byte 0

Bit	7	6	5	4	3	2	1	0
Configuration	I-REL	I-REL	I-REL	I-REL	I-REL	I-REL	I-REL	I-REL

Bit	Designation	Meaning
0, 1, ..., 7	I-REL	Motor current in percent (highest value of the three phase currents) Value range: 0 - 255 % I_e (100 % ≙ 3 A or 9 A, depending on type)

Object 2 [Index 2]

Byte 0

Bit	7	6	5	4	3	2	1	0
Configuration	TH (MSB)	TH	TH	TH	TH	TH	TH	TH (LSB)

Bit	Designation	Meaning
0, 1, ..., 7	TH	Current calculated thermal load of the motor Value range: 0 - 255 % of the current that has been set with the motor protection function I_n Triggering occurs at 115 %.

Object 3 [Index 3]

Byte 0: Device type, status information 2

Bit	7	6	5	4	3	2	1	0
Configuration	OL-WARN	MAINS FAILURE	–	OK	TYPE (MSB)	TYPE	TYPE	TYPE (LSB)

Bit	Designation	Meaning
0, 1, 2, 3	TYPE	Type of motor starter EMS2-…-SWD
4	OK	**1**: The device is activated and current is flowing.
5	–	Not used
6	MAINS FAILURE	**1**: The device is activated; but there is no current.
7	OL-WARN	Current calculated thermal load of the motor **0**: Load < 105 % of the set current I_n **1**: Load > 105 % of the set current I_n

Bit 3	Bit 2	Bit 1	Bit 0	Type
0	0	0	0	not used
0	0	0	1	not used
0	0	1	0	not used
0	0	1	1	not used
0	1	0	0	EMS2-DO-T-3-SWD
0	1	0	1	EMS2-RO-T-3-SWD
0	1	1	0	EMS2-DOS-T-3-SWD
0	1	1	1	EMS2-ROS-T-3-SWD
1	0	0	0	EMS2-DO-T-9-SWD
1	0	0	1	EMS2-RO-T-9-SWD
1	0	1	0	EMS2-DOS-T-9-SWD
1	0	1	1	EMS2-ROS-T-9-SWD
1	1	0	0	not used
1	1	0	1	not used
1	1	1	0	not used
1	1	1	1	not used

Object 4 [Index 4]

Byte 0: Motor current – phase L1 in amps

Bit	7	6	5	4	3	2	1	0
Configuration	I-ABS (MSB)	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS (LSB)

Byte 1: Motor current – phase L2 in amps

Bit	7	6	5	4	3	2	1	0
Configuration	I-ABS (MSB)	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS (LSB)

Byte 2: Motor current – phase L3 in amps

Bit	7	6	5	4	3	2	1	0
Configuration	I-ABS (MSB)	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS	I-ABS (LSB)

Byte	Bit	Designation	Meaning
0, 1, 2	0, 1, ..., 7	I-ABS	Motor current in amps in the three phases: Byte 0: Phase L1 Byte 1: Phase L2 Byte 2: Phase L3 Value range: 0 - 255 % I_e (100 % ≙ 3 A or 9 A, depending on type)

3.4.2.2 Acyclical output data

Object 5 [Index 5]

Byte 0: Setting of the motor protection 2

Bit	7	6	5	4	3	2	1	0
Configuration	–	–	–	–	Ir (MSB)	Ir	Ir	Ir (LSB)

Object 6 [Index 6]

Byte 0: Setting of the motor protection 1

Bit	7	6	5	4	3	2	1	0
Configuration	–	–	–	–	Ir (MSB)	Ir	Ir	Ir (LSB)

<table>
<tr><th>Bit</th><th>Designation</th><th>Meaning</th></tr>
<tr><td>0, 1, 2, 3</td><td>Ir</td><td>Set value of the internal motor protection
<table>
<tr><th colspan="4">Bit</th><th colspan="2">Setting I_n in A</th></tr>
<tr><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th><th>I_e = 3 A</th><th>I_e = 9 A</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0.18</td><td>1.5</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0.3</td><td>1.0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>0.44</td><td>2.5</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0.6</td><td>3.0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0.68</td><td>3.5</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td><td>0.88</td><td>4.0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1.0</td><td>4.5</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1.1</td><td>5.0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>1.2</td><td>5.5</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1.5</td><td>6.0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1.6</td><td>6.5</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1.9</td><td>7.0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>2.1</td><td>7.5</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>2.4</td><td>8.0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>2.7</td><td>8.5</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>3.0</td><td>9.0</td></tr>
</table></td></tr>
<tr><td>4, 5, 6, 7</td><td>–</td><td>Not used</td></tr>
</table>

→ Motor protection 1 is the safety-oriented rated current.
A change must be confirmed on the device.
Motor protection 2 can be set without confirmation on the device with a value smaller than motor protection 1.

4 Short-circuit and motor protection

4.1 Short-circuit protection

For short-circuit protection, on the line side of the EMS2-…-SWD electronic motor starter, the protective elements according to table 9 below are permissible. The local standards with regard to the cable protection must also be taken into consideration.

4.1.1 Use in IEC environment

EMS2-…-SWD electronic motor starters can be used in an IEC environment according to table 9 below.

Table 9: Fuse protection in IEC environment

Device type	Maximum short-circuit current I_q at the installation location	Max. permissible line side voltage	Type of coordination
16A gG	50 kA	500 V	1
30A CCMR30	50 kA	500 V	1
FAZ-B16/3	2.5 kA	400 V	1
PKM0-4	50 kA	415 V	1
PKM0-6.3	15 kA	415 V	1
Fuse 16 A FF/gR (10 x 38 mm)	10 kA	500 V	2
Fuse 20 A FF/gR (10 x 38 mm)	5 kA	400 V	2
Fuse 30 A CC (10 x 38 mm)	30 kA	480 V	1

4.1.2 Use in UL environment

EMS2-…-SWD electronic motor starters are suitable for use

- in an electrical circuit with a maximum of 480 V and a symmetrical short-circuit current of maximum 5 kA;
- in an electrical circuit with a maximum of 480 V and a symmetrical shor-circuit current of maximum 100 kA, providing they are protected with a 30-A fuse, type J or CC or equivalent;
- in a “group installation” in a circuit with maximum 480 V and a symmetrical short-circuit current of maximum 5 kA;
- in a “group installation”, suitable for use in an electrical circuit with a maximum of 480 V and a symmetrical short-circuit current of maximum 100 kA, providing they are protected with a 30-A fuse, type J or CC or equivalent;

Table 10: Fuse protection in UL environment (“group installation”)

Device type	SCCR	Max. permissible line side voltage	Type of coordination
20A RK5	5 kA	480 V	1
30A CC	100 kA	480 V	1

WARNING

Use copper wire approved for at least 75 °C!
The device is designed for use with a low voltage, limited energy, isolated power supply.

	EMS2-...-T-3-SWD	EMS2-...-T-9-SWD
FLA Motor starter	3 A (480 V AC)	7,6 A (480 V AC)
FLA General Use	3 A (480 V AC)	9 A (480 V AC)

4.2 Motor protection

Themotor protection prevents the connected motor from heating up too much if the actual motor current is greater than the specified rated current (i. e. $I > I_n$). The time up until tripping depends on the current and the trip class.

Devices with a rated operational current I_e of 3 A have trip class 10.

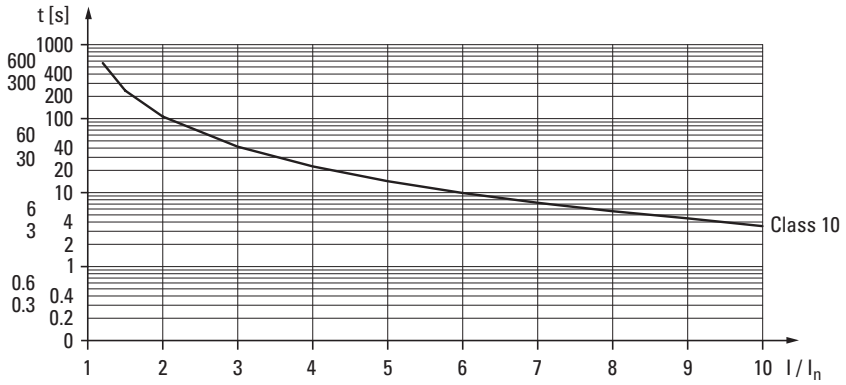


Figure 10: Tripping characteristics class 10

t = tripping time

I = actual motor current

I_n = setting of the motor protection on the EMS2-…-SWD device

Devices with a rated operational current I_e of 9 A have trip class 10A.

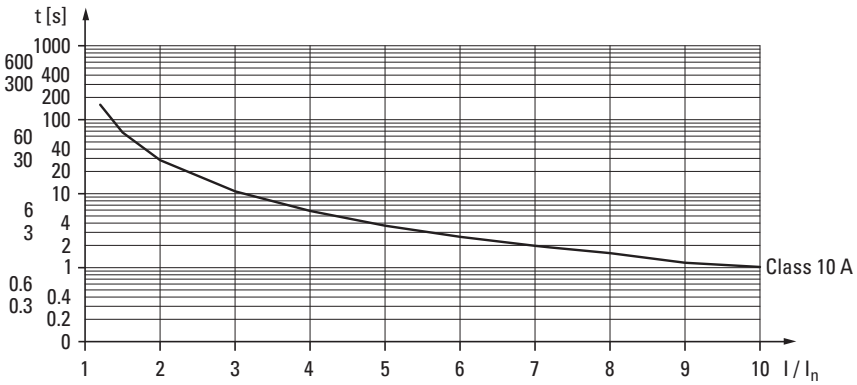


Figure 11: Tripping characteristics class 10A

t = tripping time

I = actual motor current

I_n = setting of the motor protection on the EMS2-…-SWD device

WARNING

Below the minimum device current, the motor protection on the EMS2-…-SWD motor starter is ineffective.

→ In the delivery state, the motor protection is set to the lowest value (see also the following Section).

4.2.1 Symmetry detection

The motor currents are measured at phases L1 and L3 and their symmetry is monitored.

If the motor currents deviate by ≥ 33 %, the motor switches off within two minutes.

If the motor currents deviate by ≥ 67 % (e.g. phase failure), the motor switches off within two seconds.

You may calculate the deviation using the following formulas.

$|I_{max}| > I_{nom} \rightarrow$ deviation = $(I_{max} - I_{min})/I_{max}$

$|I_{max}| < I_{nom} \rightarrow$ deviation = $(I_{max} - I_{min})/I_{nom}$

→ At high cycle rates, the motor protection function may be triggered by the higher inrush currents.

4.2.2 Motor with brake

If you connect a motor with brake (connection in motor terminal board), you must connect the 400-V AC brake to the 2/T1 and 6/T3 connections.

A 230-V AC brake is connected to connection 4/T2 and the star point of the motor.

WARNING

Increase the motor current monitoring by the nominal current of the brake. Adjust this accordingly on a hybrid motor starter.

4.2.3 Conditions when setting the motor protection

The following conditions must be met when setting the motor protection and displaying the set value:

- The device has a voltage supply (voltage via SWD or voltage to the terminals 1/L1, 3/L2, 5/L3).
- There is no start signal on the terminals ON, L or R.
- There are no errors.

The setting of the motor protection is part of the acyclical data (→ section 3.4.2.2, "Acyclical output data", page 32) and takes place from the PLC software or using the SWD Assist software.

A distinction is made between motor protection 1 and motor protection 2.

Motor protection 1 (motor nominal current)

- Motor protection 1 is the safety-oriented value.
- Motor protection 1 always takes precedence over motor protection 2 – even if both values are written by the PLC.
- Motor protection 1 **must always** be confirmed (with software or by pressing the **RESET** button).

To ensure the set value of motor protection 1 is applied, the **RESET** button must then be pressed or bit 2 (RESM) must be activated within byte 0 of the cyclical output data (→ section 3.4.1.2, "Cyclical output data", page 28).

Motor protection 2 (motor nominal current)

- The value of motor protection 2 must always be less than or equal to the value of motor protection 1.
- Motor protection 2 **must not** be confirmed.
  The value can be set and applied without activation on the device and without software.

Display of the set value for the motor nominal current

Having sent the set value for the motor current to the motor starter, the LED **PWR** flashes. After this, the **PWR** LED lights up permanently.

The four remaining LEDs (see below) display the set value in accordance with → table 11, page 46.

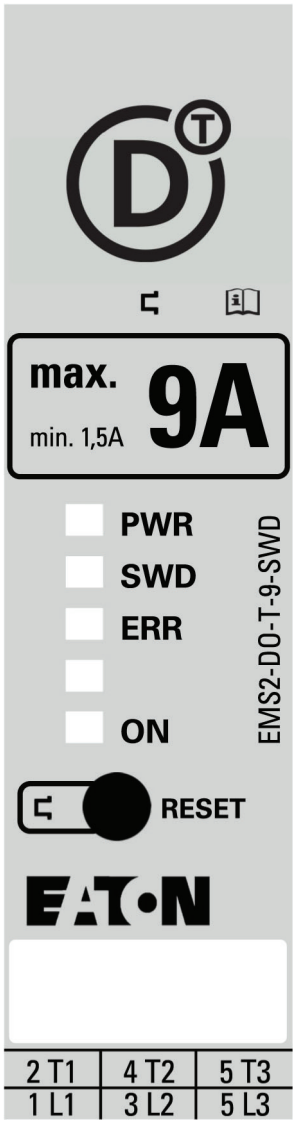


Figure 12: Front of EMS2-…-SWD motor starter

4.2.4 Setting options for the motor nominal current

The setting options for the motor nominal current are explained below. They are dependent on the bus system or communication system.

4.2.4.1 Setting with SWD Assist software

If you are using one of the following two SWD gateways, the motor protection is set via the **SWD Assist** software.

- EU5C-SWD-EIP-MODTCP (in the case of EtherNet/IP or Modbus)
- EU5C-SWD-POWERLINK (in the case of Powerlink)

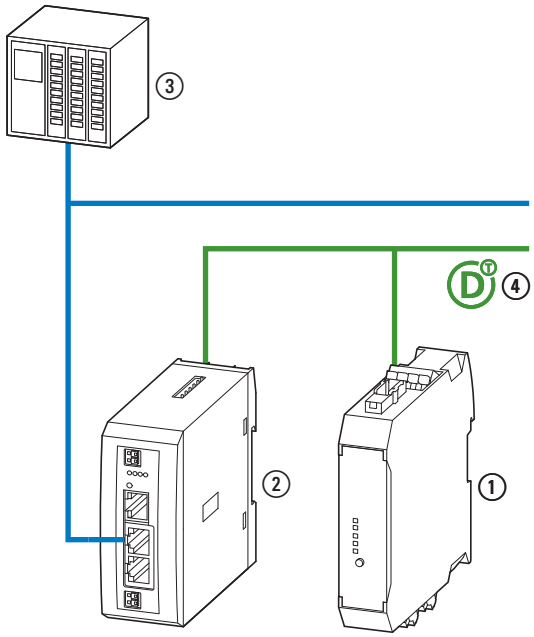


Figure 13: Configuration – with SWD gateway

① EMS2-…-SWD motor starter
② SWD gateway (EU5C-SWD-…)
③ PLC
④ SmartWireDT

Procedure

- ▶ Create an SWD configuration in offline mode.
- ▶ Select the EMS2-…-SWD module.
- ▶ Set the value for the motor protection in the **Device parameters** tab.

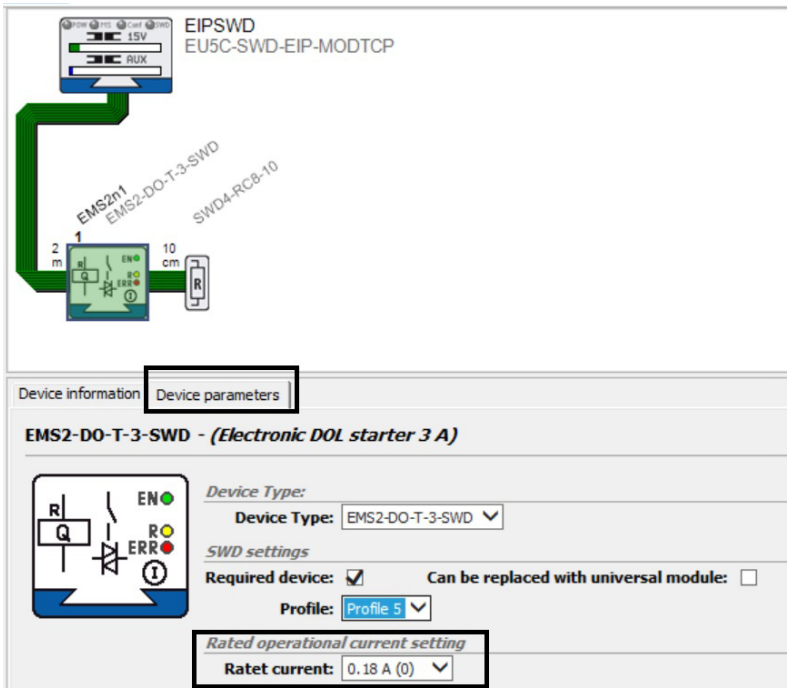


Figure 14: Select the motor protection in the "Device parameters" tab

- ▶ Select a communications view.
- ▶ Select an interface of the PC for the communication.
- ▶ Press the "Online" button.
- ▶ Download the configuration by pressing the "PC => Device" button.
  The **PWR** LED on the EMS2-…-SWD motor starter flashes.
  The remaining LEDs display the set value for motor protection.
- ▶ Press the **RESET** button (on the front of the motor starter).
  This applies the set value in the device (only for motor protection 1).
  After this, the **PWR** LED lights up permanently.

Checking the set value

To check whether the value you have set for motor protection has been correctly applied in the EMS2-…-SWD motor starter, proceed as follows:

- ▶ Press the **RESET** button for longer than two seconds.
  The **PWR** LED flashes.
  After 20 % of the time in which the **PWR** LED is flashing, the set value of motor protection 1 is displayed. After half of the flashing time, the set value of motor protection 2 is displayed. The remaining LEDs display the set value. The encoding of the LEDs (0 = off, 1 = on) can be found in → table 11, page 46.
- ▶ Release the **RESET** button.
  After this, the **PWR** LED lights up permanently.

4.2.4.2 Setting via TIA portal

If you are using the TIA software, proceed as follows:

- Import the GSD file (in the case of Profibus DP – e.g. for Eaton Gateway EU5C-SWD-PROFIBUS) or the GSDML file (in the case of Profinet – e.g. for Eaton Gateway EU5C-SWD-PROFINET) into the TIA portal. Note: The above files can be exported from the SWD-Assist or downloaded from the Eaton download center.
- Insert a gateway from the hardware catalog into the network configuration.

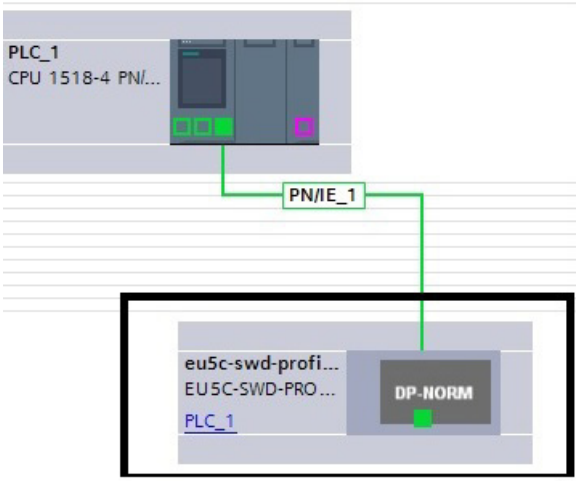


Figure 15: Selecting a gateway

- Switch to the **device view** and insert "EMS2."
- Select an EMS2-…-SWD motor starter.
- In the **General** tab, select "Module parameters."
- Enter the motor nominal current in the "Module parameters."

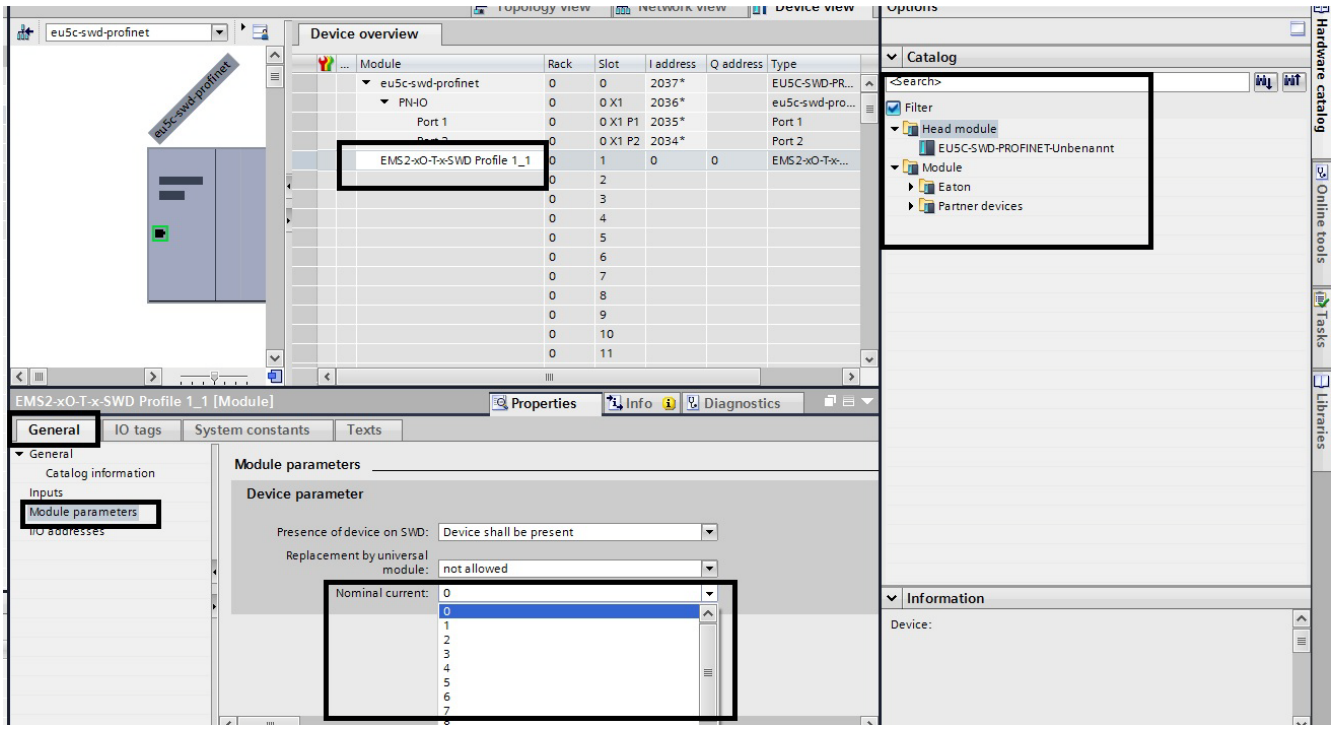


Figure 16: Selecting the motor starter (right) – setting the motor nominal current (below)

→ Entries 0 to 15 for the motor nominal current are encoded values.
The assigned current values can be found in → table 11, page 46.

- Save the configuration and download it to your PLC.
  The **PWR** LED on the EMS2 motor starter flashes. The remaining LEDs display the set value for motor protection.
- Press the **RESET** button.
  This applies the set value in the device (only for motor protection 1).
  After this, the **PWR** LED lights up permanently.

4.2.4.3 Setting via CODESYS

For configuration with gateway

The example of gateway EU5C-SWD-PROFIBUS below shows how to proceed if your configuration provides for an SWD gateway.

▶ In the **Devices** window under **EMS2**, select an EMS2-…-SWD motor starter (double click an entry).

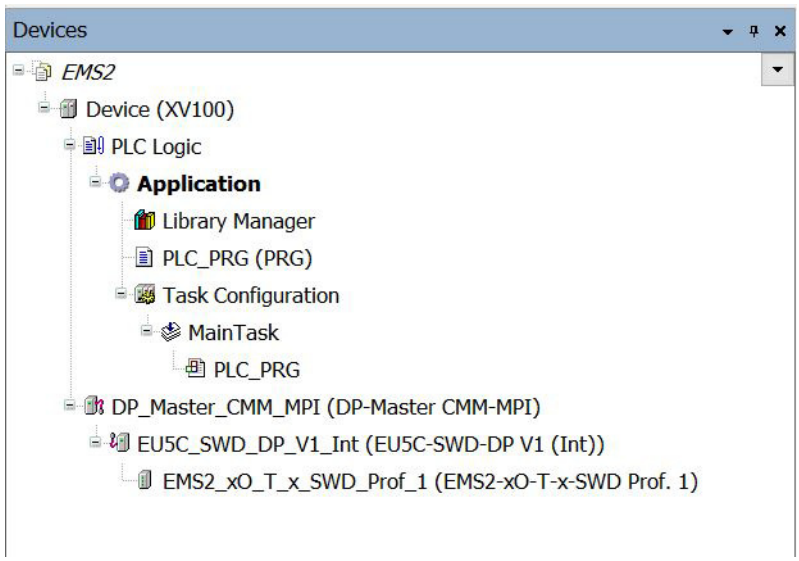


Figure 17: Selecting an EMS2-…-SWD motor starter

▶ In the **General** area under "Nominal current," select a value for the motor nominal current.

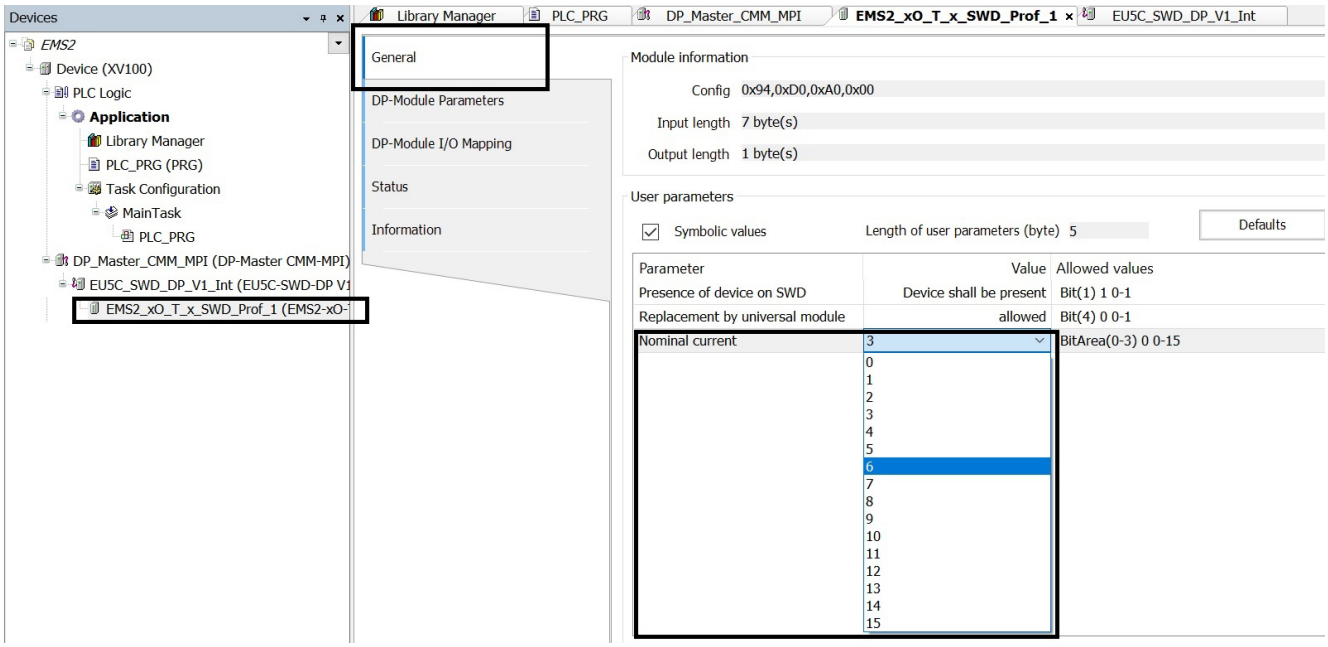


Figure 18: Selecting the motor starter (left) – setting the motor nominal current (below)

Entries 0 to 15 for the motor nominal current are encoded values.
The assigned current values can be found in → table 11, page 46.

- Save the configuration.
  The **PWR** LED on the EMS2 motor starter flashes.
  The remaining LEDs display the set value for motor protection.
- Press the **RESET** button.
  This applies the set value in the device (only for motor protection 1).
  After this, the **PWR** LED lights up permanently.

For configuration without gateway

The example of gateway XV100 Master below shows how to proceed if your configuration does not provide for an SWD gateway.

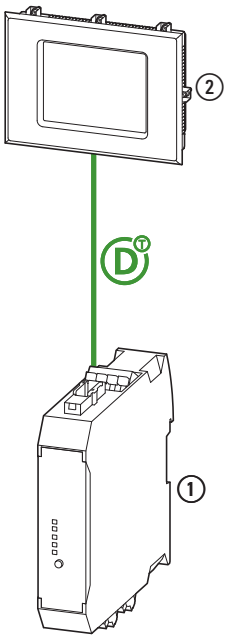


Figure 19: Configuration – without gateway
① EMS2-…-SWD motor starter
② XV100 Master

If you are using the XV100 Master device, proceed as follows:

▶ In the **Devices** window under the **SWD Master** entry, select an EMS2-…-SWD motor starter.

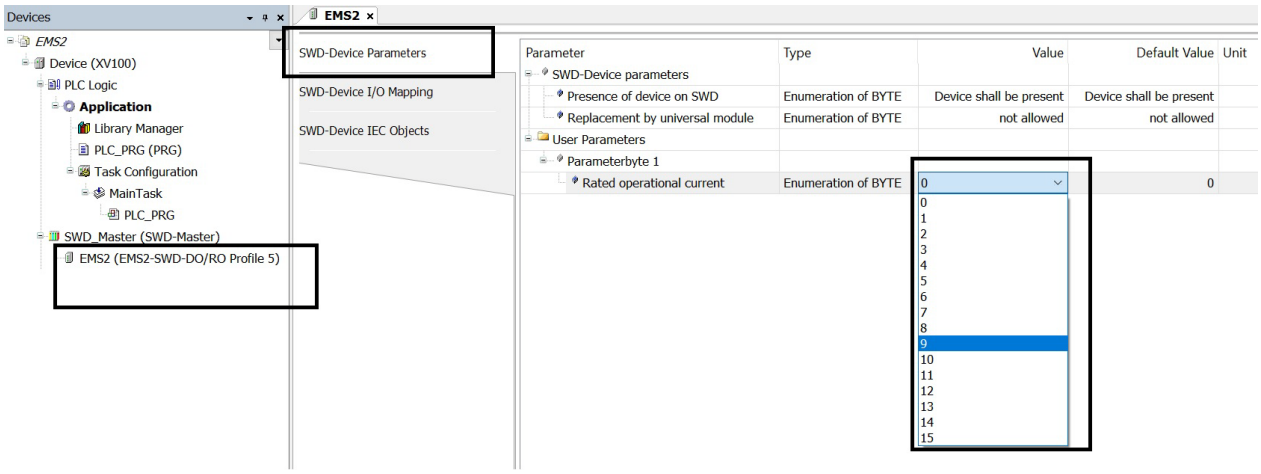


Figure 20: Selecting an EMS2-…-SWD motor starter

▶ In the tab **SWD Device Parameters,** select the parameter "Nominal current."
▶ Select a value for the motor nominal current from the list (values 0 to 15).

Entries 0 to 15 for the motor nominal current are encoded values.
The assigned current values can be found in → table 11, page 46.

- Save the configuration.
  The **PWR** LED on the EMS2 motor starter flashes.
  The remaining LEDs display the set value for motor protection.
- Press the **RESET** button of the EMS2-…-SWD motor starter.
  This applies the set value in the device (only for motor protection 1).
  After this, the **PWR** LED lights up permanently.

4.2.5 Setting values for the motor nominal current

The following table provides the values for the motor nominal current that you must set in the software specified above.

Table 11: Setting values for motor protection (motor nominal current I_n)

Code[2]					**Setting value for motor nominal current I_n**	
Encoded value for I_n[1]	**SWD**	**ERR**	**L**	**R / ON**	**I_e = 3 A (EMS2-…-3-SWD)**	**I_e = 9 A (EMS2-…-9-SWD)**
					A	**A**
0	0	0	0	0	0.18	1.5
1	0	0	0	1	0.3	2.0
2	0	0	1	0	0.44	2.5
3	0	0	1	1	0.6	3.0
4	0	1	0	0	0.68	3.5
5	0	1	0	1	0.88	4.0
6	0	1	1	0	1.0	4.5
7	0	1	1	1	1.1	5.0
8	1	0	0	0	1.2	5.5
9	1	0	0	1	1.5	6.0
10	1	0	1	0	1.6	6.5
11	1	0	1	1	1.9	7.0
12	1	1	0	0	2.1	7.5
13	1	1	0	1	2.4	8.0
14	1	1	1	0	2.7	8.5
15	1	1	1	1	3.0	9.0

1) Values 0 to 15 in the "Encoded value for I_n" column are the entries in the selection lists, as shown in → figure 16, → figure 18 and → figure 20 for the motor nominal current.
2) 0: LED off; 1: LED on

4.2.6 Trip and reset

Trip

In the case of tripping,

- the motor starter switches off,
- the **ERR** LED flashes,
- one of the **L**, **R** or **ON LEDs lights up** (depending on the direction of rotation previously traveled).

Reset

EMS2-…-SWD series motor starters have a “thermal memory”, which means that a reset after the motor protection has tripped is possible only once a waiting period (cooling-down time) has passed.
After the waiting period has passed, the **L**, **R** or **ON** LED which had previously lit up permanently prior to the error flashes (see also → section 6.2, “Resetting after an error message”, page 58).§

5 Application examples

One of the reasons why EMS2-…-SWD electronic motor starters achieve such a high lifespan is that the power to the contacts that are located in the device can be disconnected. This is done by the triggering of semiconductors and relays by the internal electronics.
For this function to be active, the motor starter needs to constantly be supplied with control voltage. This supply is provided via the 24-V-voltage of the SWD flat ribbon cable.

There are, however, application examples where in the case of a controlled stop the supply voltage is switched off via the SmartWire-DT in order to achieve a safe state,

CAUTION

Since the control supply voltage or the control voltage of the hybrid motor starter is disconnected via a single channel, this type of installation according to SIL 3 (Cat. 3, Cat. 4) is permitted, only if error prevention for cross circuits according to EN ISO 13849 is permitted.
This is the case, for example, if the hybrid motor starter and the safety relay are installed in the same switch cabinet.
If such error prevention is not permitted, the control supply voltage must be disconnected via two channels or two positions (→ section 5.1, "Application without controlled stop", page 50, → section 5.2, "Single-channel controlled stop application (cat. 3, SIL 3, PL e)", page 51).

5.1 Application without controlled stop

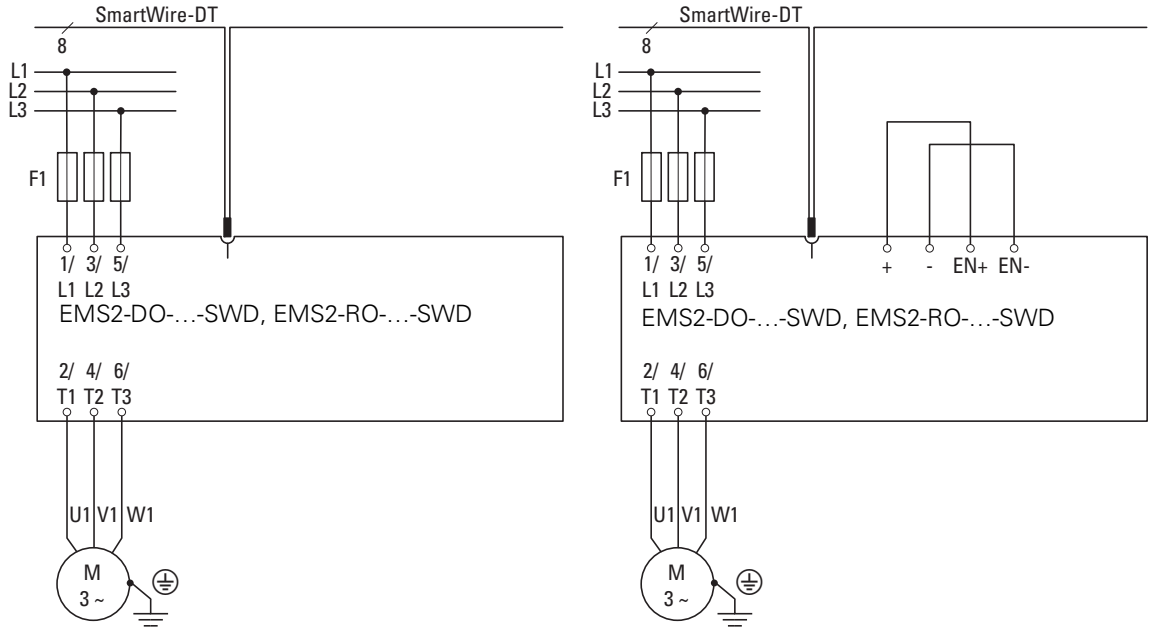


Figure 21:Application without controlled stop with error prevention

In this application, the EMS2-…-SWD series devices are **not** included in a controlled stop chain.

When using EMS2-**DOS**-…-SWD or EMS2-**ROS**-…-SWD, the terminals + must be bridged with EN+ and – with EN-, so that a start signal is accepted via SWD.

5.2 Single-channel controlled stop application (cat. 3, SIL 3, PL e)

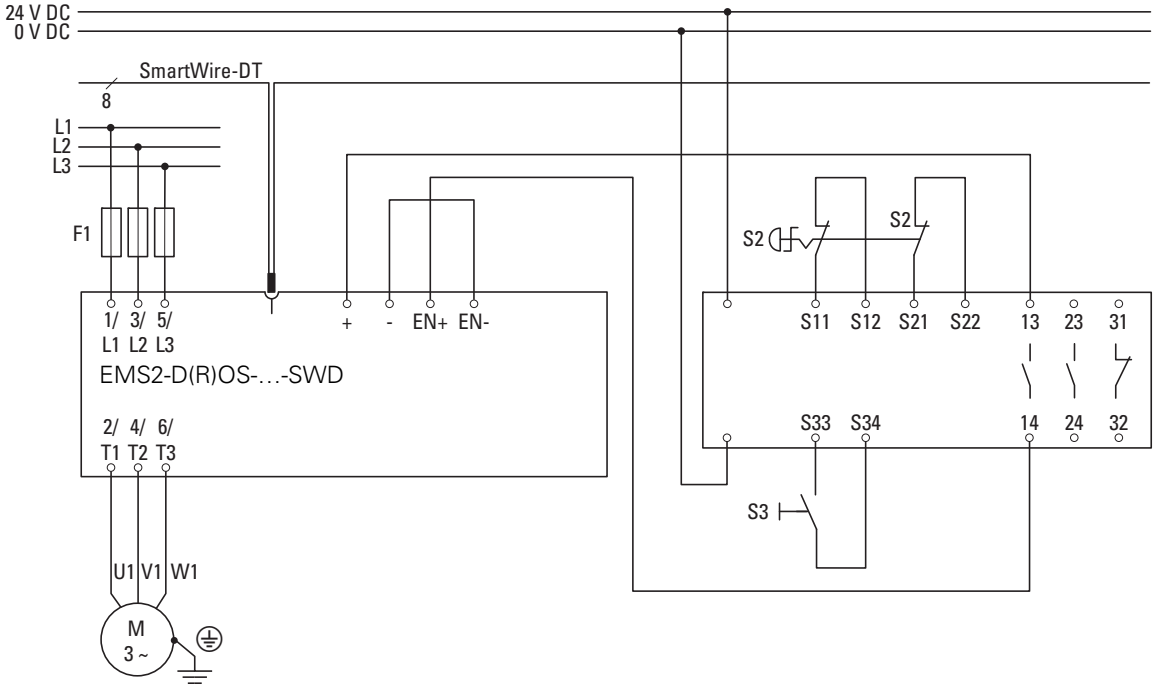


Figure 22:Single-channel controlled stop application with error prevention

The EMS2-D(R)OS-…-SWD motor starter is used in combination with an ESR5-series safety relay.

A cable for the safety-oriented enable (EN+) is connected via the safety relay. For the enable, the internal voltage on the terminals + and - is used. This type of wiring is then only accepted if the EMS2-…-SWD motor starter and the safety relay are located in the same control panel.
The background to this is a possible cross short-circuit which can lead to a bridging within the controlled stop circuit. This is more probable for cables which are located outside of the control panel than for a wiring within the same control panel.

5.3 Dual-channel controlled stop application (cat. 3, SIL 3, PL e)

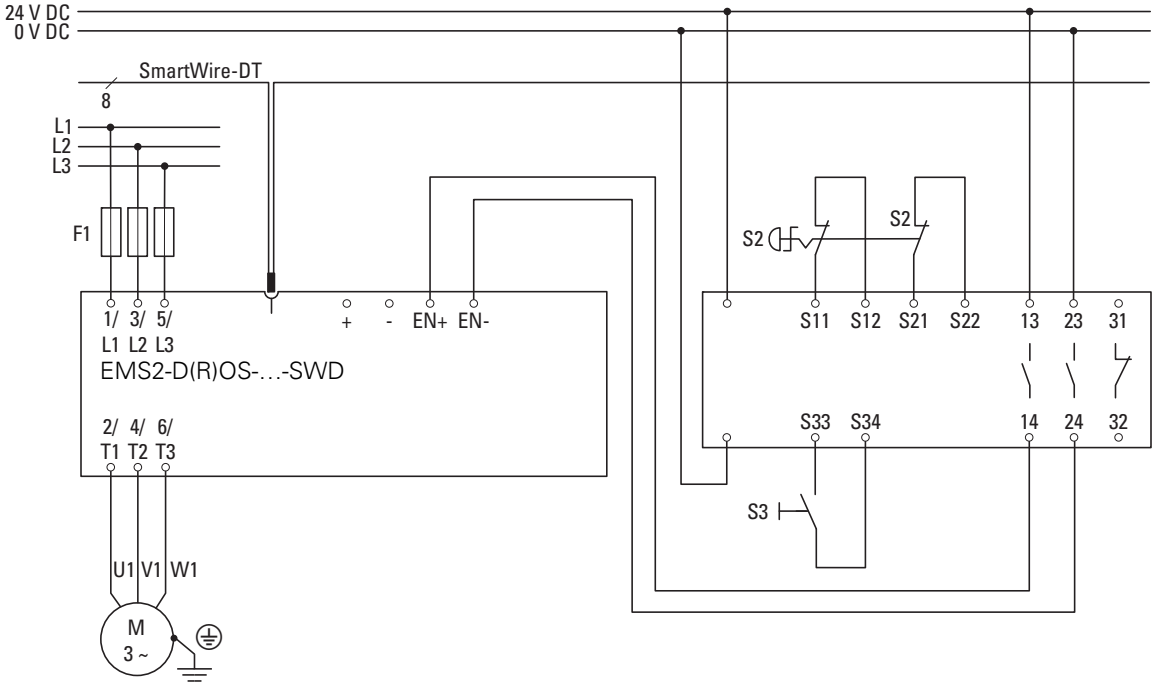


Figure 23:Dual-channel controlled stop application

The EMS2-D(R)OS-…-SWD motor starter is used in combination with an ESR5-series safety relay.

A cable for the safety-oriented enable (EN+ / EN-) is connected via the safety relay. For the enable, an external voltage of 24 V is used. This type of wiring is then only accepted if the motor starter EMS2-…-SWD and the safety relay are located in the same control panel.

6 Status messages

The status light emitting diodes (LEDs) (→ figure 1, page 11) indicate the operating states.

Internal and external device faults or process errors "ERR" (e.g.: overcurrent, imbalance, phase failure) are indicated by a red LED, while a yellow LED shows clockwise or counterclockwise operation.

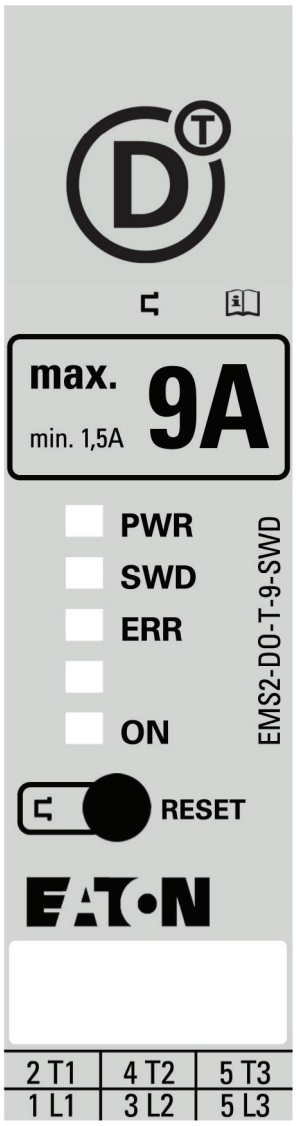
Internal faults cannot be acknowledged. They are stored in the device and will eventually prevent the equipment from being started at all. In case of external errors, an error acknowledgement is required to exit the safe shutdown state.

When the EMS2 detects a fault, the explosion-proof motor is switched off safely and the feedback relay is actuated. The fault can also be diagnosed using the status LEDs.

6.1 LEDs on the front of the device

The LEDs for displaying the device status have the following designations and colors.

Direct starter



PWR – green

SWD – green

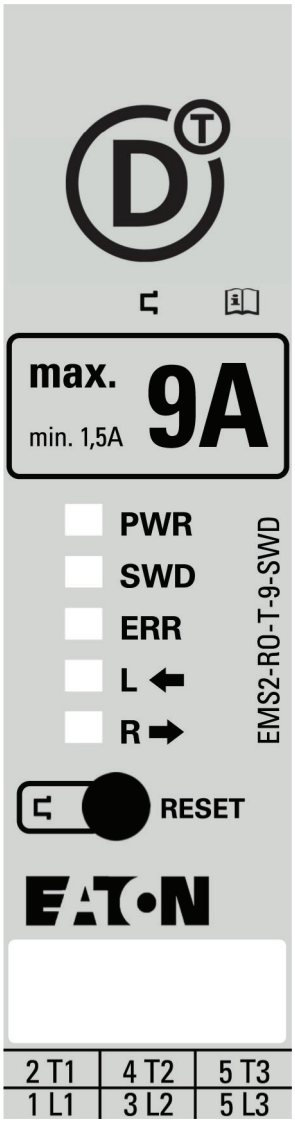
ERR – red (permanent light) / yellow (flashing)

no designation – yellow

ON – yellow

Figure 24: LEDs for direct starters

Reversing starters



PWR – green

SWD – green

ERR – red (permanent light) / yellow (flashing)

L – yellow

R – yellow

Figure 25: LEDs for reversing starters

The status LEDs in combination provide information about the device status.


LED does not light up


LED lights up


LED flashing

X
Any status

Table 12: Status messages – as a combination of the five LEDs

LED PWR	SWD	ERR	L (–)	R (ON)	Status	Description	Reset See also → section 6.2, "Resetting after an error message", page 58
○	○	○	○	○	Off	No supply voltage available	–
● / ☼	○	X	X	X	No SWD	Device not integrated into SWD	–
● / ☼	●	○	●	○	Data traffic	Device integrated into SWD. Cyclical or acyclical communication is taking place.	–
●	●	○	●	○	Drive switched on	Counterclockwise operation (L)	–
●	●	○	○	●	Drive switched on	Clockwise operation (R or ON)	–
☼	☼	●	☼	☼	Internal error	Device needs to be replaced	Not possible
●	X	☼	●	○	Motor protection tripped during counterclockwise operation → section 4.2, "Motor protection", page 35	Motor protection in cooling-down phase, Reset not possible.	Manually after a cooling-down time of approx. 2 min; automatically after approx. 20 min
●	X	☼	☼	○	Motor protection tripped during counterclockwise operation → section 4.2, "Motor protection", page 35	Cooling-down phase concluded, manual reset possible	Manually after a cooling-down time of approx. 2 min; automatically after approx. 20 min

LED					Status	Description	Reset
PWR	SWD	ERR	L (–)	R (ON)			See also → section 6.2, "Resetting after an error message", page 58
○	X	☼	○	●	Motor protection tripped during clockwise operation	Motor protection in cooling-down phase, Reset not possible.	Manually after a cooling-down time of approx. 2 min; automatically after approx. 20 min
○	X	☼	○	☼	Motor protection tripped during clockwise operation	Cooling-down phase concluded, manual reset possible	Manually after a cooling-down time of approx. 2 min; automatically after approx. 20 min
○	X	☼	○	○	Asymmetrical phase current	The currents in the phases deviate from one another by more than 33 %.	Manual
○	X	☼	●	○	Motor is stalled (Counterclockwise operation)	The maximum measurable motor current is exceeded for more than 2 s.	Manual
○	X	☼	○	●	Motor is stalled (Clockwise operation)	The maximum measurable motor current is exceeded for more than 2 s.	Manual
○	X	○	☼	○	With actuated output stage no current is measured.	Error has occurred during counterclockwise operation.	Automatic, as soon as the error has been remedied
○	X	○	○	☼	With actuated output stage no current is measured.	Error has occurred during clockwise operation.	Automatic, as soon as the error has been remedied
☼	●	X	X	X	Data traffic	**only with EMS2-DOS-… and EMS2-ROS-…:** Device integrated into SWD; EN not available	
Message via SWD					Bad checksum	Error when restoring the system. The thermal memory of the motor protection function is set to the maximum value. The error must be manually acknowledged even in automatic mode.	Manual

6.2 Resetting after an error message

WARNING

If an error is acknowledged and the bit SDIR/SDIRR or SDIRL is set to HIGH, this causes an automatic start-up of the motor starter, → section 3.4.1.2, "Cyclical output data", page 28.
In this case, use external measures
(e. g. by means of an interlock) to ensure that there is no hazardous situation.

The acknowledging (reset) of an error can be carried out in various ways. The options depend on the nature of the error (→ Table 12, page 56).

- **Automatic** reset
  - Setting via SWD required
    (→ section 3.4.1.2, "Cyclical output data", page 28)
- **Manual** reset
  - via the button on the front of the device,
  - via SWD
    (→ section 3.4.1.2, "Cyclical output data", page 28)

→ With a manual acknowledgment of the error, which can also take place via the bus, the motor starts up as long as the triggering signal is applied. With a manually monitored reset, edge monitoring is required.
According to the ATEX guideline, there must be no automatic start-up.

6.2.1 Automatic reset

When a phase or a motor that is not connected fail, or in the case of an operation beneath the minimum current I_{min}, the EMS2-…-SWD electronic motor starter is automatically reset as soon as the error has been remedied.

If an automatic reset is to take place after a message via the motor protection, this must be configured accordingly (see→ section 3.4.1.2, "Cyclical output data", page 28). The automatic reset takes place after approx. 20 minute scooling-down time.
It is possible to reset the device using a manual command during this period of time. The condition for this is that the cooling-down time for a manual reset (approx. 2 minutes) has expired. (One of the LEDs **L**, **R** or **ON** flashes).

→ An automatic reset with an operation of the EMS2-…-SWD electronic motor starter is **not** permissible in potentially explosive Ex e increased safety (ATEX) areas.

6.2.2 Manual reset

After remedying the error, the error message can be reset manually.

In the case of a message from the motor protection, note that the error message can be reset only after the cooling-down time has passed. During the cooling-down time, the LED **L**, **R** or **ON** lights up permanently. After the cooling-down time, the permanent light changes to flashing, meaning a reset is now possible.

The EMS2-…-SWD motor starter requires a signal with a rising edge with a duration of less than 2 seconds. If the signal is longer, the device remains in error mode.

The error is **not** reset when the reset signal is applied, it is reset when it is withdrawn (falling edge).

7 Technical data

Size/feature	EMS2-…-3-SWD	EMS2-…-9-SWD
Standards	**For EMS2-D(R)O-…-SWD devices without safety function:** IEC/EN 60947-1 IEC/EN 60947-4-2 **For EMS2-D(R)OS-…-SWD devices with safety function:** IEC/EN 60947-1 IEC/EN 60947-4-2 IEC 61508 ISO 13849	**For EMS2-D(R)O-…-SWD devices without safety function:** IEC/EN 60947-1 IEC/EN 60947-4-2 **For EMS2-D(R)OS-…-SWD devices with safety function:** IEC/EN 60947-1 IEC/EN 60947-4-2 IEC 61508 ISO 13849
Ambient conditions and mounting		
Ambient temperature during operation	-5 °C - +55 °C Condensation not permissible – prevent with suitable measures! Observe derating!	-5 °C - +55 °C Condensation not permissible – prevent with suitable measures! Observe derating!
Storage temperature, permissible	-40 °C - + 80 °C	-40 °C - + 80 °C
Degree of protection	IP20	IP20
Degree of pollution	2	2
Dimensions	→ section 8, “Dimensions”, page 65	→ section 8, “Dimensions”, page 65
Mounting	on 35-mm top-hat rail according to IEC/EN 60715	on 35-mm top-hat rail according to IEC/EN 60715
Mounting position	Vertical, motor feeder on bottom	Vertical, motor feeder on bottom
EMC	Emitted interference is cable related: EN 55011, class A Emitted interference is radiated: EN 61000-6-3, class A This is a product for environment A. In a domestic environment, this device may cause radio interference, in which case the user may be required to take adequate measures.	Emitted interference is cable related: EN 55011, class A Emitted interference is radiated: EN 61000-6-3, class A This is a product for environment A. In a domestic environment, this device may cause radio interference, in which case the user may be required to take adequate measures.
Connections		
Cross-section - control cables	0.2 mm² - 2.5 mm² AWG 24 - 14	0.2 mm² - 2.5 mm² AWG 24 - 14
Cross-section - power cables	0.2 mm² - 2.5 mm² AWG 24 - 14	0.2 mm² - 2.5 mm² AWG 24 - 14
Stripping length	10 mm (0.39")	10 mm (0.39")
Supply of the device / the control inputs		
Overvoltage category	III	III
Rated control voltage U_{AUX} (from SWD)	24 V DC	24 V DC
Range of the control supply voltage	19.2 V DC - 30 V DC	19.2 V DC - 30 V DC
Rated control current I_S	60 mA	60 mA
Rated actuating voltage U_C (EN+/EN-)	24 V DC	24 V DC
Rated actuating current I_C	7 mA	7 mA
Switching threshold	LOW < 9.6 V DC HIGH > 19.2 V DC	LOW < 9.6 V DC HIGH > 19.2 V DC

Size/feature	EMS2-…-3-SWD	EMS2-…-9-SWD
Protection against polarity reversal	Yes	Yes
Typical break time	< 30 ms	< 30 ms
Power circuit		
Rated operational voltage U_e	500 V AC, 50/60 Hz	500 V AC, 50/60 Hz
Operational voltage	42 V AC - 550 V AC	42 V AC - 550 V AC
Rated operational current AC51	3 A	9 A
Rated operational current AC53a	3 A	7 A
Permissible load current range	0.18 A - 3 A	1.5 A - 9 A
Motor protection tripping characteristics (IEC 60947-4-2)	Class 10	Class 10A
Heat dissipation	1.5 W - 3 W	1.5 W - 13 W
Cooling-off time with auto reset after triggering	20 min	20 min
Protection against overvoltage	Yes	Yes
Allocated protective element on the network side	→ section 4.1, “Short-circuit protection”, page 33	→ section 4.1, “Short-circuit protection”, page 33
Use in UL environment	→ section 4.1.2, “Use in UL environment”, page 34	→ section 4.1.2, “Use in UL environment”, page 34
Insulation properties		
Rated insulation voltage	500 V	500 V
Rated impulse voltage U_{imp}	6 kV	6 kV
Insulation properties between the actuating voltage, control supply voltage and auxiliary circuit to the main circuit	Operational voltage ≤ 300 V AC (e. g. 230 / 400V AC, 277 / 480 V AC): Safe isolation according to IEC/EN 60947-1 and EN 50178 checks for devices with safety Operational voltage 300 V AC - 500 V AC: Basic isolation according to IEC/EN 60947-1 Safe isolation according to EN 50178	Operational voltage ≤ 300 V AC (e. g. 230 / 400V AC, 277 / 480 V AC): Safe isolation according to IEC/EN 60947-1 and EN 50178 checks for devices with safety Operational voltage 300 V AC - 500 V AC: Basic isolation according to IEC/EN 60947-1 Safe isolation according to EN 50178
Insulation properties between actuating voltage and control supply voltage to auxiliary circuits	Safe isolation according to IEC/EN 60947-1 and EN 50178	Safe isolation according to IEC/EN 60947-1 and EN 50178
Additional information for devices with safety function, i.e. EMS2-D(R)OS-…-SWD		
System conditions		
Database for failure rates	SN 29500	SN 29500
System type (made up of subsystems)	Type B	Type B
Applied standard	IEC 61508	IEC 61508
Beta factor	2 %	2 %

Size/feature	EMS2-…-3-SWD	EMS2-…-9-SWD
Safe switch off		
Ambient temperature range	40 °C - 60 °C	40 °C - 60 °C
HFT (hardware fault tolerance)	1	1
MTTF (Mean Time to Failure)	34 years at 40 °C ambient temperature	34 years at 40 °C ambient temperature
$MTTF_D$ (Mean Time to Failure Dangerous)	164 years at 40 °C ambient temperature	164 years at 40 °C ambient temperature
Shutdown time	200 ms	200 ms
λ_{sd} – failure rate of detectable safe failures (sd = safe, detectable)	0 FIT	0 FIT
λ_{su} – failure rate of undetectable safe failures (su = safe, undetectable)	1311 FIT at 40 °C ambient temperature	1311 FIT at 40 °C ambient temperature
λ_{dd} – failure rate of detectable dangerous failures (dd = dangerous, detectable)	694 FIT at 40 °C ambient temperature	694 FIT at 40 °C ambient temperature
λ_{du} – failure rate of undetectable dangerous failures (du = dangerous, undetectable)	0.1 FIT at 40 °C ambient temperature	0.1 FIT at 40 °C ambient temperature
SFF (Safe Failure Fraction)	99 %	99 %
DC (Diagnostic Coverage)	99 %	99 %
PFH_D: (Probability of dangerous failure per hour)	0.1 FIT at 40 °C ambient temperature	0.1 FIT at 40 °C ambient temperature
PFD_{avg} (6 months / 36 months) (Average Probability of Failure on Demand)	0.5×10^{-6} / 2.9×10^{-6}	0.5×10^{-6} / 2.9×10^{-6}
Safety level according to	IEC/CEI 61508-1: to SIL3 ISO 13849-1: to category 3 PL e	IEC/CEI 61508-1: to SIL3 ISO 13849-1: to category 3 PL e
Motor protection		
HFT (hardware fault tolerance)	0	0
Ambient temperature	40 °C - 60 °C	40 °C - 60 °C
$MTTF_D$ (Mean Time to Failure Dangerous)	201 years	201 years
Shutdown time	according to class 10, IEC 60947	according to class 10A, IEC 60947
λ_{sd} – failure rate of detectable safe failures (sd = safe, detectable)	0 FIT	0 FIT
λ_{su} – failure rate of undetectable safe failures (su = safe, undetectable)	1044 FIT at 40 °C ambient temperature	1044 FIT at 40 °C ambient temperature
λ_{dd} – failure rate of detectable dangerous failures (dd = dangerous, detectable)	558 FIT at 40 °C ambient temperature	558 FIT at 40 °C ambient temperature
λ_{du} – failure rate of undetectable dangerous failures (du = dangerous, undetectable)	9 FIT at 40 °C ambient temperature	9 FIT at 40 °C ambient temperature
SFF (Safe Failure Fraction)	99 %	99 %
DC (Diagnostic Coverage)	98 %	98 %
PFD_{avg} (6 months / 36 months) (Average Probability of Failure on Demand)	0.04×10^{-3} / 0.24×10^{-3}	0.04×10^{-3} / 0.24×10^{-3}
Safety level according to	IEC 61508-1: SIL 2	IEC 61508-1: SIL 2

8 Dimensions

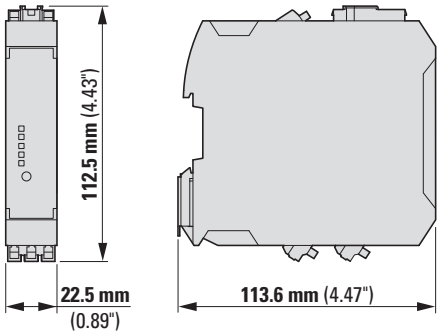


Figure 26: EMS2-…-SWD

8 Dimensions

9 Accessories

9.1 Three-phase current connector

The EMS2-XBR-T-… three-phase current connectors bridge the supply terminals (1L1 / 3L2 / 5L3) of multiple EMS2-…-SWD electronic motor starters. They are available in different versions, which differ in the number of motor starters to be connected (→ table 13).

The distance of the individual terminal blocks from one another is designed so that they can also be used if the motor starters are fitted at a distance of 22.5 mm from one another. The length l of the connection cable is 3 m.

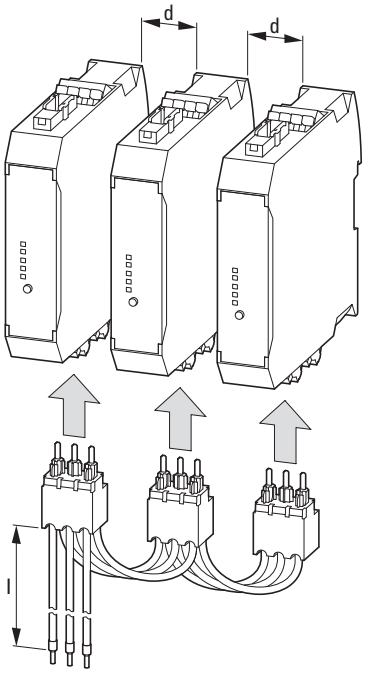


Figure 27: EMS2-XBR-T-… three-phase current connector and EMS2-…-SWD motor starters

Table 13: Three-phase current connector EMS2-XBR-T-…

Type	Length l of the connection cable	Maximum number of EMS2-…-SWD motor starters to be supplied	Maximum distance d between two starters
EMS2-XBR-T-2	3 m	2	22.5 mm
EMS2-XBR-T-3	3 m	3	22.5 mm
EMS2-XBR-T-4	3 m	4	22.5 mm
EMS2-XBR-T-5	3 m	5	22.5 mm

9 Accessories

9.1 Three-phase current connector

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T

U

Eaton is an intelligent power management company dedicated to improving the quality of life and protecting the environment for people everywhere. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power – today and well into the future.
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