Overcurrent Protection Relay MRS13R

The MRS13R overcurrent protection relay is designed for rapid detection and response to overcurrent conditions in railway applications. It prevents damage to electrical devices and systems by detecting short circuits or overloads and activating a fast switching response. Unlike conventional fuse solutions, the relay provides a reversible switching state, allowing reset once the fault condition is cleared.

Functionality Overview

- **Overcurrent Protection**: Responds to overcurrent conditions in within 20 ms.
- **Reliable Feedback**: Forcibly guided contacts guarantee accurate feedback about the switching state to a control system.
- **Diagnostic Input**: Includes a dedicated input for externally triggering the relay to verify mechanical switching integrity, independent of any overcurrent condition.
- **Status Indication**: Displays real-time operational status and parameter settings. An LED indicator signals overcurrent conditions.
- **Menu-Based Configuration**: Features a three-button interface for navigating menus and adjusting parameters, removing the need for potentiometers.
- **Compliance**:
    - IEC 61810-3 (Type A) for forcibly guided contacts
    - EN 50155 and EN 45545-2 for railroad vehicles
    - EN 61373 for shock and vibration protection

The MRS13R was designed for being used in combination with an AC current transformer and circuit-breaker, but direct loads may be connected as well. The applications may range from low current to kiloAmpere (kA) applications.

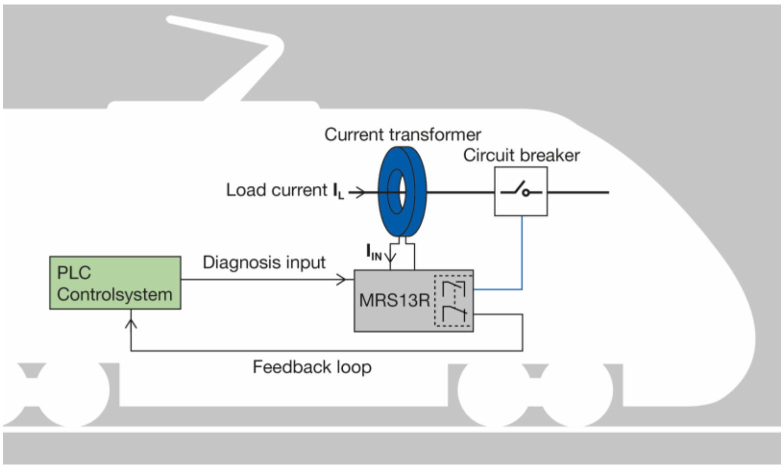

Figure 1: Function overview of the MRS13R

1 Safety

Read the enclosed instructions carefully before use! Disregarding the instructions may result in damage to equipment and/or serious personal injury.

This symbol indicates a risk of electrical hazards that could endanger personnel and infrastructure.
Ignoring this warning may result in **serious injury, death, equipment damage, or fire**.

This symbol indicates a required action to prevent damage to the device and surrounding equipment.
Failure to comply may result in **malfunctions, system failures, or equipment damage**.

CAUTION: The device may only be installed by qualified personnel familiar with the national and international laws, directives and standards that apply to the region.

CAUTION: This device is not suitable for use in wet areas, explosive atmospheres (e.g. in areas where the air contains high concentrations of flammable chemicals, vapours or particles such as grain, dust or metal powder).

CAUTION: Only mount and unmount the device when it is disconnected from any power source. This applies to the power supply as well as to all inputs and outputs.

CAUTION: During operation, the electrical connection points of the device carry hazardous voltages! These connection points must not be touched.

WARNING: For safe operation, be aware of detection limits of the device. See section 6.1 for details.

WARNING: Ensure that current pulses do not exceed the maximum permissible duration to prevent damage to the device; especially when using direct loads. See section 6.2 for details.

WARNING: Keep sufficient clearance between the MRS13R and components which create magnetic fields. External magnetic fields may affect the current measurement. See section 6.5 for details.

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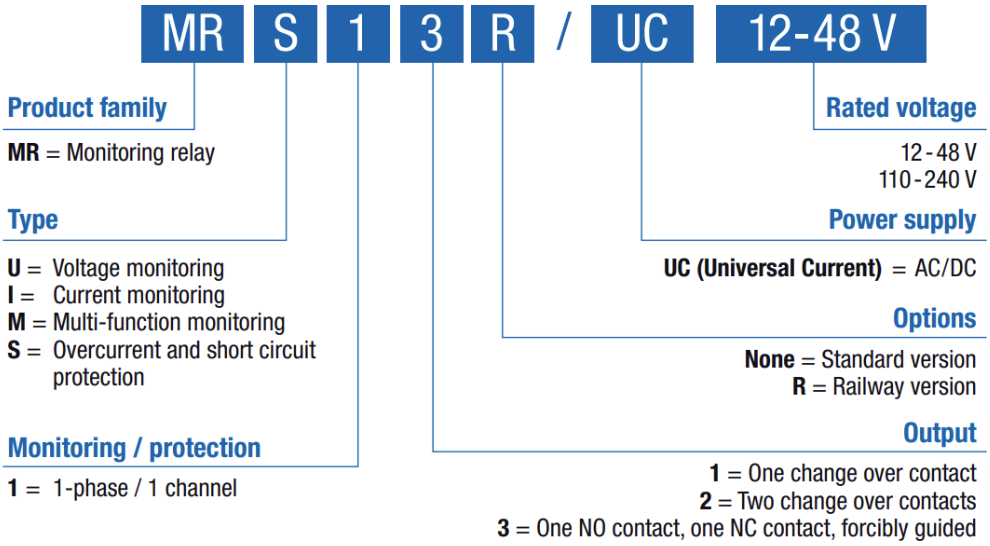
3 Type Designation



Please consult the MRS brochure for other variants or contact us for new configurations.

4 Operating Principle

The MRS13R continuously measures load current (I_L) via a current transformer or directly and compares it with two threshold values:

- **Overcurrent threshold (I_{Th}):** The configurable threshold level for detecting overcurrent conditions that may lead to damage due to overheating.
- **Saturation current threshold (I_{Sat}):** This threshold allows fastest detection of particularly critical overcurrent conditions including electrical shorts. This threshold is given by the internal current sensors' saturation level and therefore not configurable.

If the measured current exceeds any of the threshold values, the relay with its forcibly guided contacts (1 NO, 1 NC) is triggered. These contacts can be used to activate a circuit breaker and send an alarm signal to a higher-level control system as shown in Figure 1.

When the external fault is resolved, i.e. the measured current falls below the hysteresis threshold, the relay returns to its normal position. In turn, the actuated system, e.g. a circuit breaker, returns to its normal state of operation, and feedback is sent to the control system accordingly.

The diagnostic input allows functional testing of the relay from a higher-level control system or manually without an overcurrent condition.

Detection Timings

- Overcurrent detection occurs within **4.5 ms**.
- Saturation detection occurring within **3.1 ms**.
- The device scans for overcurrent incidents every **1.5 ms**, requiring at least three out of five samples to confirm an overcurrent event as depicted in Figure 2.

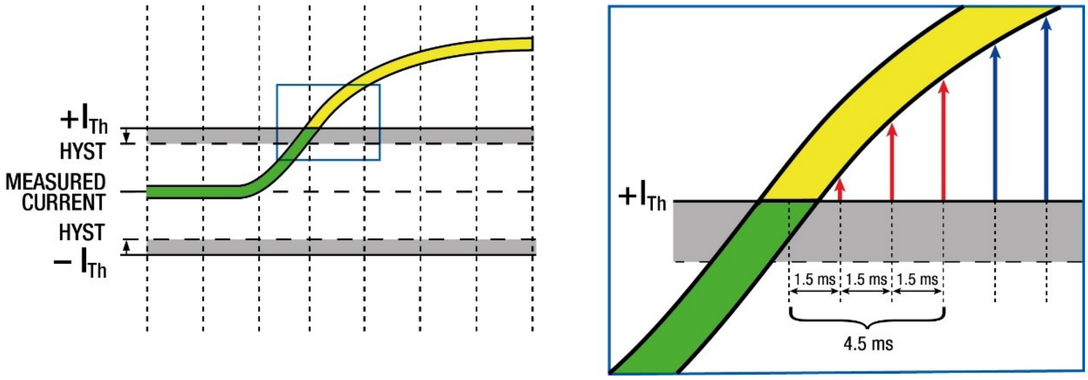


Figure 2: Overcurrent Detection

Hysteresis

Hysteresis (HYST) ensures stable recovery from an overcurrent condition. Once the current drops below a set threshold, it must fall below $|I_{Th} - (I_{Th} \times HYST)|$ before defaulting back to normal operation. This prevents unintended rapid switching between normal and fault states due to small variations in current near the threshold.

5 Operational Response and Status Indication

The detailed operational response of the MRS13R is displayed in Figure 3 for three exemplary events. The behaviour for the overcurrent detection is polarity independent.

Start: The measured load current starts within the set control limits. The relay is in its normal position and there is no alarm.

Event 1: Standard overcurrent detection

The load current declines and drops below the lower current threshold limit. Within t_{D1} the (negative polarity) overcurrent is detected and processed ($t_{\mu C}$). The devices' LED flashes to indicate the detection of the event and then remains on as the NC contact is opened (t_{Op}) and the NO contact is closed (t_B). The LED indication remains on until the current returns to the normal range, flashes during the configured switch-off delay (t_{Doff}) and turns off as the relay is released to its normal state (t_{Rel}, t_B).

Event 2: Saturation overcurrent detection

As a second event, a (positive polarity) saturation event is shown; the behaviour of the MRS13R is the same as for the first event, but with a faster detection time (t_{D2}).

Event 3: Relay test using the diagnostic input

As a third event, the diagnostic input is used to trigger the relay manually, emulating the response to a negative polarity overcurrent event (without involving an actual overcurrent condition). The DI input signal is processed ($t_{\mu C}$), the relay is immediately activated (t_{Op}, t_B) and the event is indicated by the LED. When the switch-off of the diagnostic signal is processed, the relay is released to its normal state (t_{Rel}, t_B) without (configurable) delay.

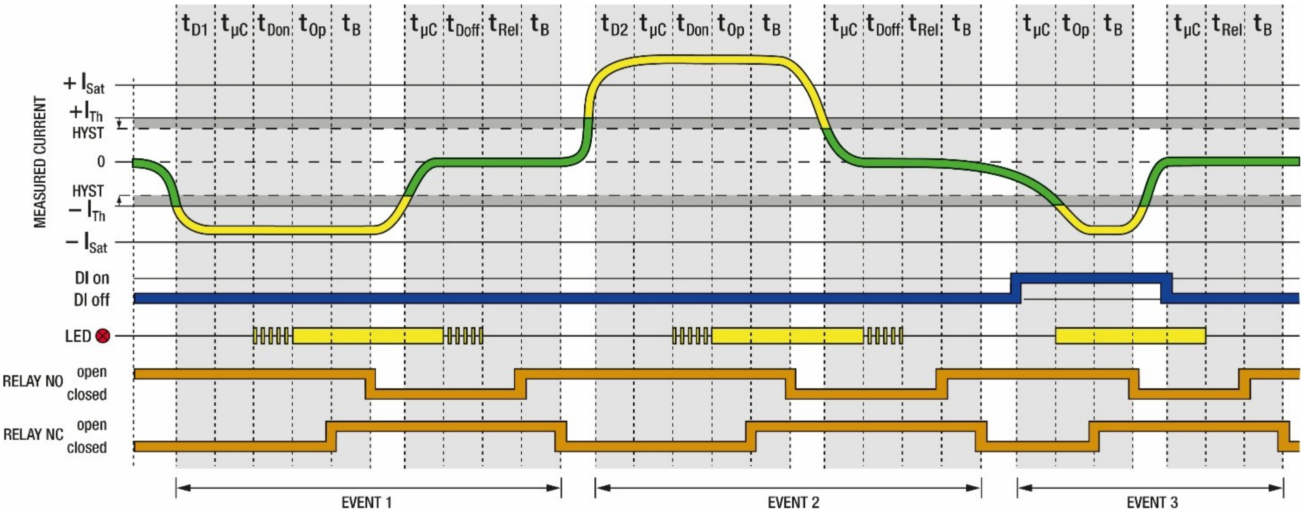


Figure 3: Detailed response of the MRS13R for overcurrent events

5.1 Response Times

The full response time for activating respectively deactivating the actuated system (e.g. circuit breaker) and returning feedback to the control system may consist of:

Detection time (Overcurrent)	t_{D1}	≤ 4.5 ms
Detection time (Saturation)	t_{D2}	≤ 3.1 ms
Intrinsic response time of the firmware	$t_{\mu C}$	≤ 1.3 ms
Response time NO to close	t_{OpNO}	~ 10 ms
Bounce time of the NO contact	t_{BNO}	~ 2 ms
Response time NC to open	t_{OpNC}	~ 3 ms
Bounce time of the NC contact	t_{BNC}	~ 15 ms
Release time of the closed NO / opened NC contact	t_{Rel}	~ 3 ms
On delay	t_{Don}	Configurable 0.0 – 999.9 s Default: 0.0 s
Off delay	t_{Doff}	Configurable 0.1 – 999.9 s Default: 3.0 s

Depending on whether the actuated system is connected to the NO or NC contact, the total response time varies.

The following table summarizes the total response times for the normally open and normally closed contact with default on delay t_{Don} = 0 s:

Detection event	**Total response time for the NO contact**	**Total response time for the NC contact**
Overcurrent	$t_{D1} + t_{\mu C} + t_{OpNO} + t_{BNO} + t_{Don} \approx$ 17.8 ms	$t_{D1} + t_{\mu C} + t_{OpNC} + t_{BNC} + t_{Don} \approx$ 23.8 ms
Saturation	$t_{D2} + t_{\mu C} + t_{OpNO} + t_{BNO} + t_{Don} \approx$ 16.4 ms	$t_{D2} + t_{\mu C} + t_{OpNC} + t_{BNC} + t_{Don} \approx$ 22.4 ms

Note: As for most relays, the NC contact opens quicker than the NO contact closes. Yet, the total response time of the NC is longer than for the NO contact. This is due to the significantly longer bounce time of the NC contact of 15 ms versus 2 ms for the NO contact. See Figure 4 for a graphic representation of the response times.

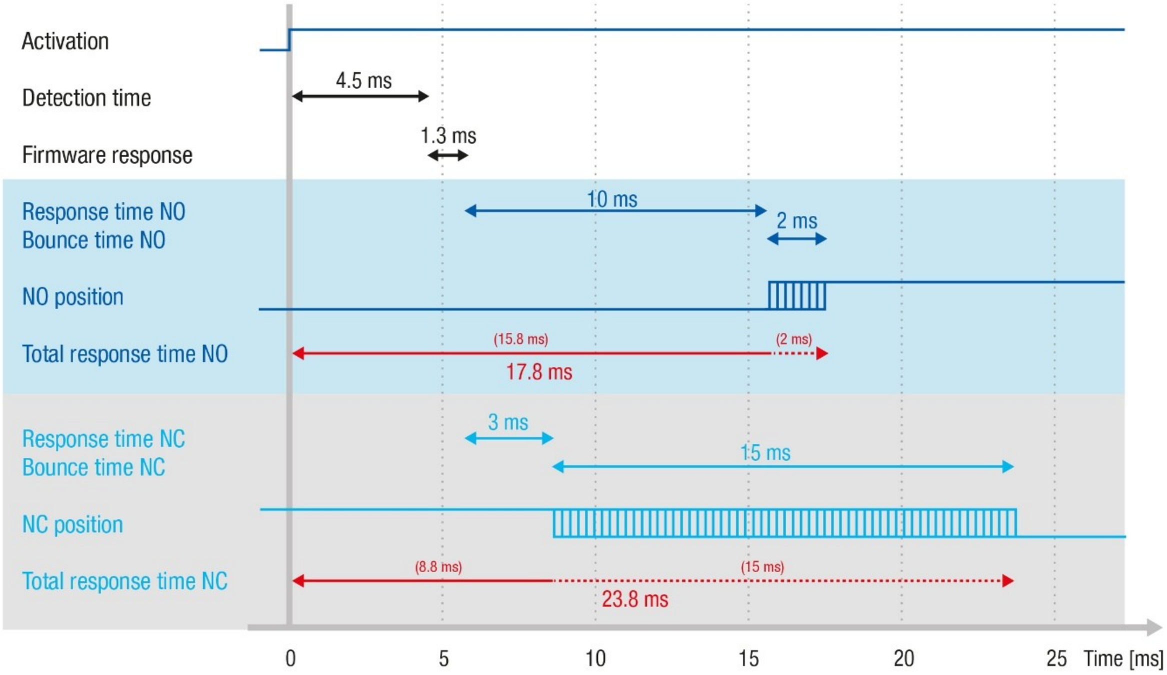


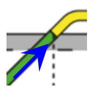
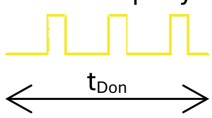
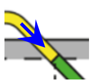
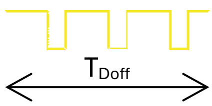
Figure 4: Break down of the total response time of the forcibly guided relay

5.2 Status Indication During Start-Up Delay

The following table lists the switching state during start-up delay for any load current and independently of the diagnostic input.

Start-up setting	LED	Relay	Switching state NC contact	Switching state NO contact
			forcibly guided contacts	
Default “Alarm off”	Off	Off	Closed	Open
Default “Alarm on”	Permanently On	On	Open	Closed

5.3 Status Indication During Operation

Power supply	Load current	Diagnostic input	LED	Relay	Switching state NC contact	Switching state NO contact
					forcibly guided contacts	
Off	Any	Any	Off	Off	Closed	Open
On	$I_L \leq I_{th}$	0	Off	Off	Closed	Open
On	$I_L > I_{th}$	0	Permanently on	On	Open	Closed
On	$I_L \leq I_{th}$	1	Permanently on	On	Open	Closed
On	$I_L > I_{th}$	1	Permanently on	On	Open	Closed
On	$I_L \leq I_{th} \rightarrow I_L > I_{th}$ 	0	Flashes rapidly 	Off ↓ On	Closed ↓ Open	Open ↓ Closed
On	$I_L > I_{th} \rightarrow I_L \leq I_{th}$ 	0	Flashes slowly 	On ↓ Off	Open ↓ Closed	Closed ↓ Open

5.4 Relay Test Using the Diagnostic Input

The diagnostic input DI is used to conduct a functional test of the relay, ensuring that the MRS13R operates correctly by verifying its switching function, load shutdown, and feedback to the controller.

- When the controller increases the voltage at the diagnostic input above 14 V, the normally open (NO) contact closes, and the normally closed (NC) contact opens. This simulates an overcurrent event, triggering the appropriate feedback to the controller.
- When the voltage at the diagnostic input drops below 5 V, the device returns to normal operation, where the NO contact remains open, and the NC contact is closed—indicating that the system is functioning below the overcurrent threshold.

5.5 Power Shutdown

To ensure a defined shutdown and avoid undefined device states, it is recommended to disconnect the power supply on the 24 V secondary side. If disconnection on the mains (230 V) side is required, the slow voltage decay caused by internal capacitors may lead the MRS13R into undefined states. In this case, a bleed-down resistor should be used to ensure controlled capacitor discharge as depicted in Figure 5.

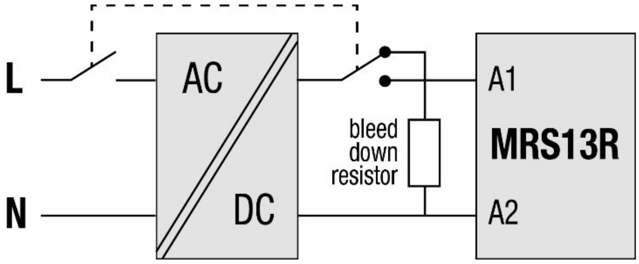


Figure 5: Power shutdown of the MRS13R via the mains.

6 Device Limitations

6.1 Current Detection Limits

The detection capabilities of the MRS13R are subject to specific time and current thresholds, which define its detection accuracy and reliability. As previously described, reliable overcurrent detection occurs within 4.5 ms for overcurrent events and within 3.1 ms for saturation events.

No detection is possible under 3.1 ms (overcurrent event) respectively 1.5 ms (saturation event).

For overcurrent events, detection is possible, but not guaranteed, in the period between 3.1 ms and 4.5 ms.

For saturation events, detection is possible, but not guaranteed, in the period between 1.5 ms and 3.1 ms.

This behaviour shown in Figure 6. It is polarity independent.

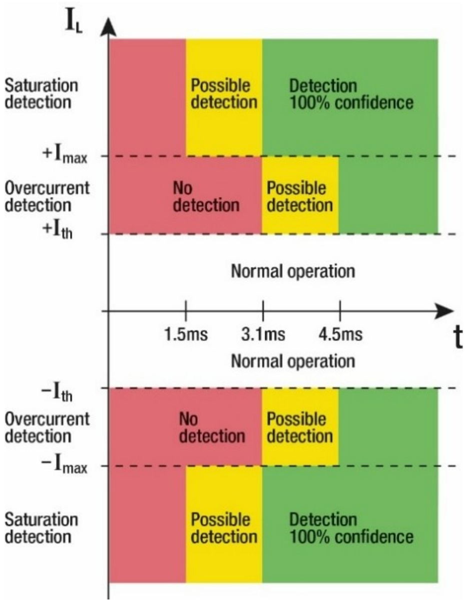


Figure 6: Minimum detection times

6.2 Temperature dependence of the overcurrent trigger

The effective triggering of the overcurrent threshold depends on temperature and overcurrent levels. The device is optimized for elevated temperatures under high current loads. Figure 7 illustrates the relative deviation in triggering across threshold currents from 400 A to 1.6 kA and temperatures ranging from -40 °C to 70 °C. Notably, within the 0°C to 70°C range, the deviation remains below 5%, ensuring stable performance.

Note: The values presented do not account for potential current sensor aging effects.

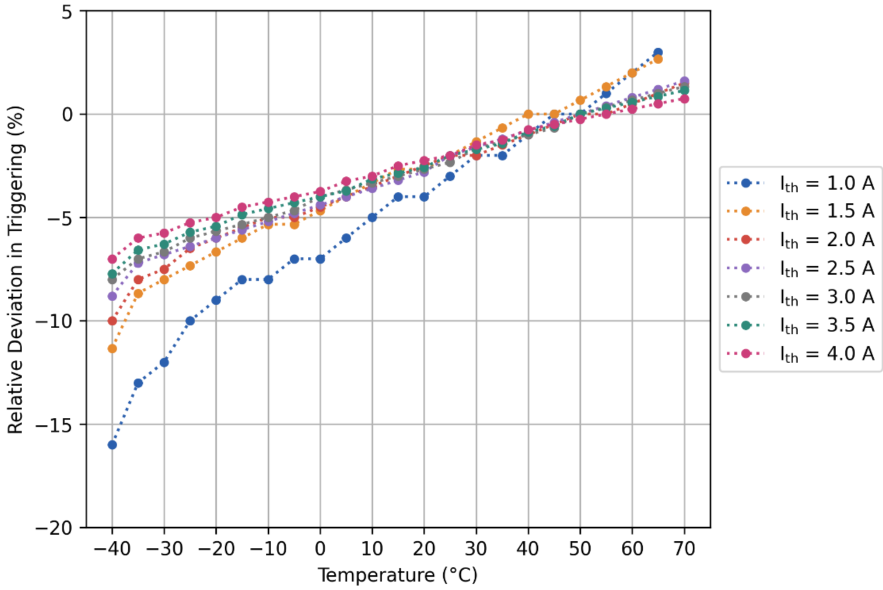


Figure 7: Temperature dependence of the overcurrent trigger

6.3 Derating for Transient Currents and Pulses

The MRS13R is equipped with a sensor rated for a continuous maximum current of 5 A. While the sensor can tolerate transient currents above this limit, such conditions are only permissible if the duration of the transient remains within specified limits.

To ensure proper operation and avoid damage, users must adhere to the derating curve shown in Figure 8. This curve defines the maximum allowable duration of a rectangular current pulse as a function of the applied current ranging from 20 s at 50 A to 1.8 ms at 400 A.

It is critical to obey the derating curve for all transient current events. Any deviation from the specified limits may compromise the sensor's integrity and overall performance of the MRS13R.

When the MRS13R is used in combination with a current transformer (CT), transient currents are typically attenuated due to the CTs saturation, providing effective protection for the internal current sensor. However, in direct load applications—especially under direct current (DC)—this protective effect is absent, and the sensor is directly exposed to inrush or transient pulses. In such cases, it is the responsibility of the user to ensure that all transient currents remain within the specified limits of the derating curve.

Note: The integrity of the current sensor cannot be verified with the diagnostic input.

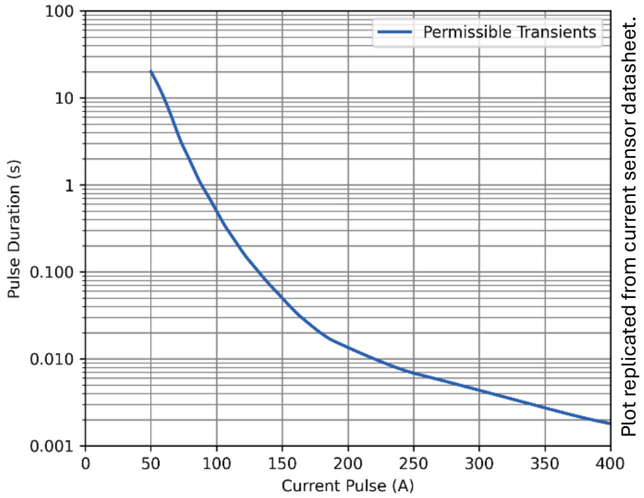


Figure 8: Derating for current pulses

6.4 Aging drift of the overcurrent trigger

The relative ageing drift of triggering the effective overcurrent threshold is dominated by the aging of the current sensor.

Typical	Min/Max. (3σ)
± 1%	±3%

This drift occurs gradually over the device's lifetime.

6.5 Magnetic Interference

The current measurement is based on the Hall effect. Such a Hall sensor measures current by sensing the induced magnetic field around a conductor and converts it into a proportional electrical signal, ensuring galvanic isolation and minimal power loss.

To ensure accurate current measurements, maintaining adequate clearance from other magnetic components is essential. External magnetic fields from nearby components, such as transformers, circuit breakers, or contactors can introduce measurement errors by distorting the local magnetic environment. For optimal performance, current-carrying components should be placed at a safe distance:

Nearby Component	Minimal Clearance to MRS13R
Current-carrying wires & contactors 5 A / 50 A / 1000 A	10 mm / 50 mm / 200 mm
Current transformer 400:1, ~kA primary current	300 mm
Circuit breaker	500 mm

In case of space constraints magnetic shielding can help mitigate interference.

6.6 Insulation

The MRS13R overcurrent protection relay measures the current by means of a Hall sensor whose input is galvanically isolated. See Figure 9 for the full insulation diagram and the table below for the test voltages for each insulation path.

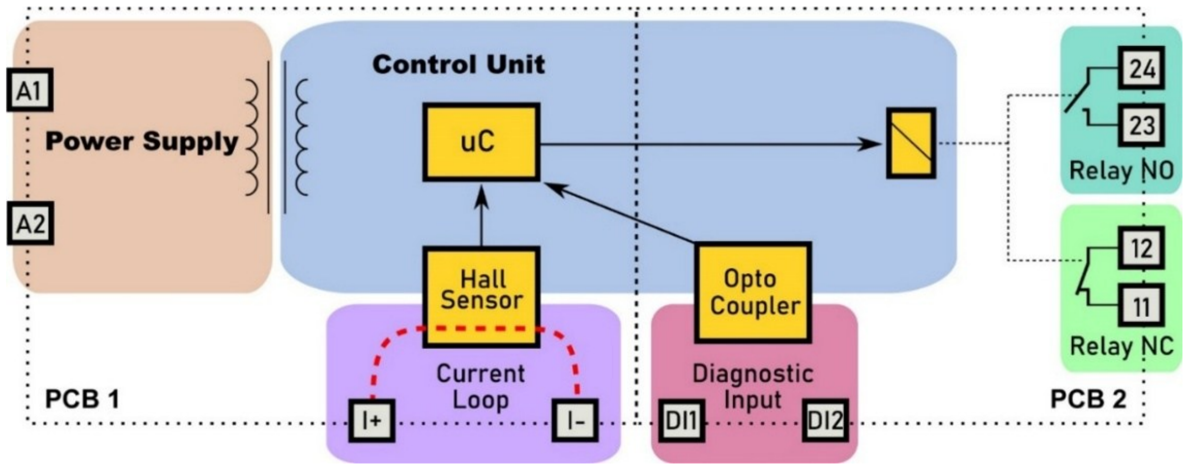


Figure 9: Insulation diagram

Insulation Path	Test voltage (1 Min)
Power supply – Current loop	3.0 kV
Power supply – DI input	3.0 kV
Power supply – Relais NO	3.0 kV
Power supply – Relais NC	3.0 kV
Relais NO – Relais NC	2.5 kV

Insulation Path	Test voltage (1 Min)
Current loop – DI Input	3.0 kV
Current loop – Relais NO	3.0 kV
Current loop – Relais NC	3.0 kV
DI Input – Relais NO	2.0 kV
DI Input – Relais NC	2.0 kV

7 Configuring the MRS13R

The MRS13R can be configured with the following parameters:

The **overcurrent threshold (I_{Th})** should be set high enough to prevent unintentional shutdowns caused by current or voltage transients at the measurement input. To avoid false trips, configure the overcurrent threshold at least 150 mA above the expected current amplitude. This buffer ensures that normal current fluctuations do not trigger the protection mechanism.

Note: If scaling is enabled, the overcurrent threshold adjusts to the load current level. For example, with a scaling factor of 100, the threshold (I_{Th}) is set to 1 kA, and overcurrent protection is triggered when the measured input current exceeds 10 A which represents 1 kA of load current.

The **hysteresis** stabilizes the detection process by preventing rapid on/off switching when the current fluctuates near the threshold level. To ensure reliable operation, set the hysteresis to at least 5%. This setting reduces the risk of unnecessary interruptions caused by minor current variations.

See Figure 10 for good practice recommendation for setting I_{th} and hysteresis.

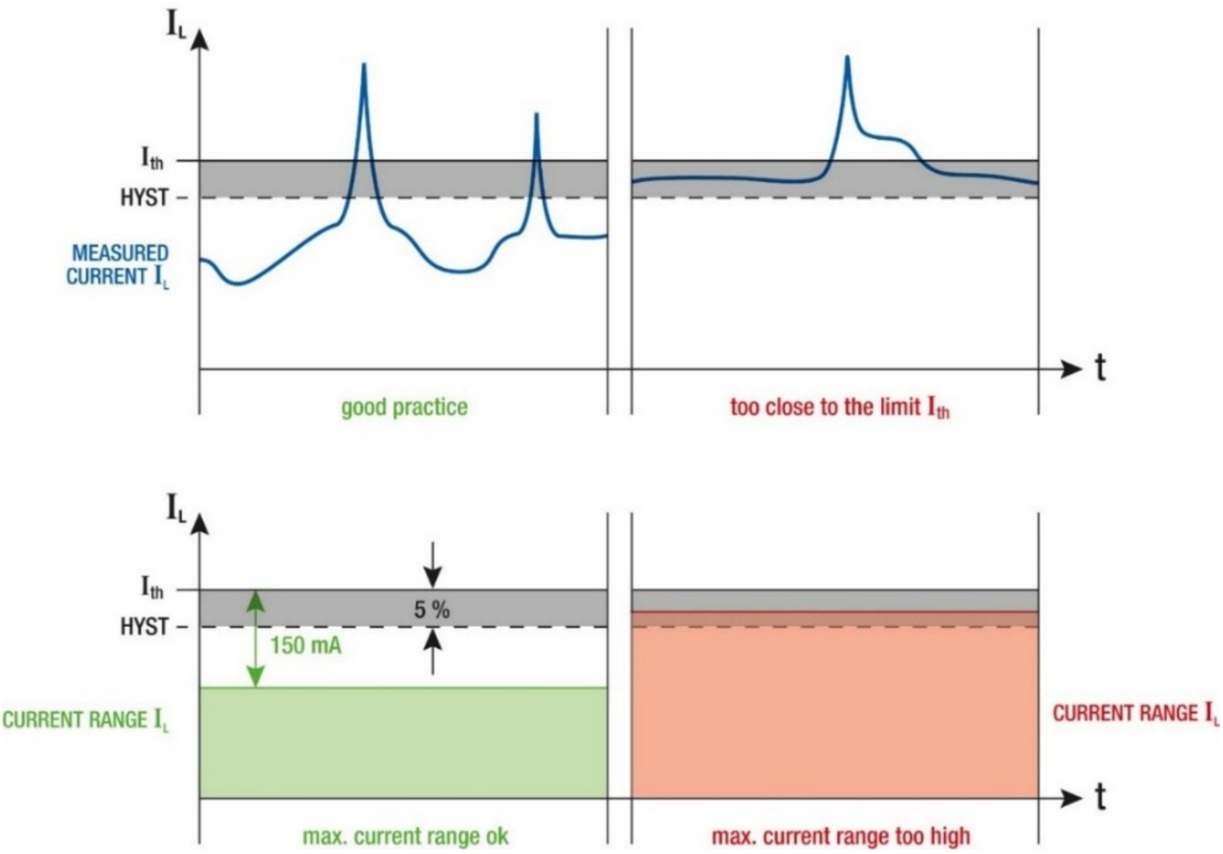


Figure 10: Configuring overcurrent threshold and hysteresis

The **scaling factor (I_L/I_{Th})** is based on the ratio between the current transformer and the measured current. Accurate scaling ensures that the MRS13R correctly interprets measurement signals, aligning protection thresholds with the actual load current. For proper overcurrent detection, the current transformer must operate within its linear working range, ensuring the measured current remains proportional to the load current. Therefore, the converter's operating range must be appropriately dimensioned.

If a load is connected directly to the measurement input, scaling may be deactivated.

Note: If the current threshold is > 5 A while scaling is enabled, it will revert to 5 A once scaling is turned off. Manual adjustment of the current threshold is then necessary.

The **on delay (t_{Don})** and **off delay (t_{Doff})** control the timing of the protection mechanism's activation and reset. The on delay specifies how long the current must exceed the threshold before triggering the protection function, filtering out short-term transients that do not pose a real risk. The off delay determines how long the system waits after the current returns to normal before resetting the protection function. This prevents frequent resets caused by momentary current dips. Properly configuring these delays ensures stable operation and reduces false trips.

The **startup state** determines the initial position of the relays when the device powers up. If set to "Alarm off", the device starts with the relays in their normal position (closed NC and open NO). If set to "Alarm on", the device starts with the relays in their switched position (open NC and closed NO).

The **startup delay** defines the time interval between powering up the device and triggering the configured startup state. This delay allows the system to stabilize before the relays assume their specified positions, preventing false alarms or unintended switching due to transient conditions during startup.

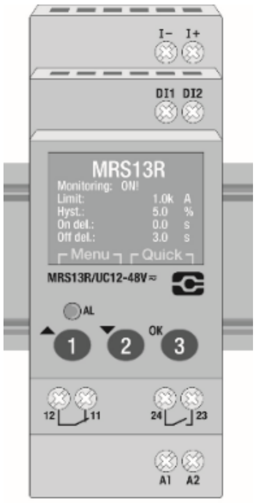
7.1 Considerations for New Current Transformer Design

Selecting the right current transformer is key to accurate system performance. When designing a new system, consider the maximum load current and the necessary threshold for circuit breaker activation. To ensure reliability, apply a proper margin based on the good practice recommendation outlined within this chapter. For the highest accuracy, choose a current transformer ratio that provides a current detection between 2 and 4 A at the MRS13R input. This will help achieve precise and consistent measurements.

7.2 Factory settings

The MRS13R comes out of the box with the following default factory settings:

Monitoring	**ON**
Limit (current threshold)	**1.2 kA** Value is scaled to the load current level if scaling is enabled
Hysteresis	**5.0 %**
On delay (t_{Don})	**0.0 s**
Off delay (t_{Doff})	**3.0 s**
Scaling factor (I_L/ I_{th})	**400**
Startup delay	**2.5 s**
Startup state Output 1	**Alarm on** Overcurrent alarm is on during start up delay



Other factory settings are available on request.

7.3 Operating instructions

▲ Increases the numeric value or moves to the next parameter.

▼ Decreases the numeric value or moves to the next parameter.

OK Confirms the selected value and advances to the next menu item.
Press and Hold: Returns to the previous menu or exits menu without saving changes.

▲ ▼ Enters full menu

▼ OK Enters quick menu to only set the current threshold (Limit)

Menu Structure

- **Settings** contains all settings to configure the MRS13R according to Chapter 7.
- **Output test** allows switching the relay manually. The LED indicates the current state.
- **Device test** shows the internal temperature of the device, a reference voltage (for internal use only).
- **Factory reset** allows resetting all parameters to the factory settings.
- **Setup** configures the startup state and delay according to Chapter 7.
- **Infos** shows the firmware version of the device.

The **Quick Menu** allows to directly change the overcurrent threshold. All other settings are accessible through the full menu (under settings).

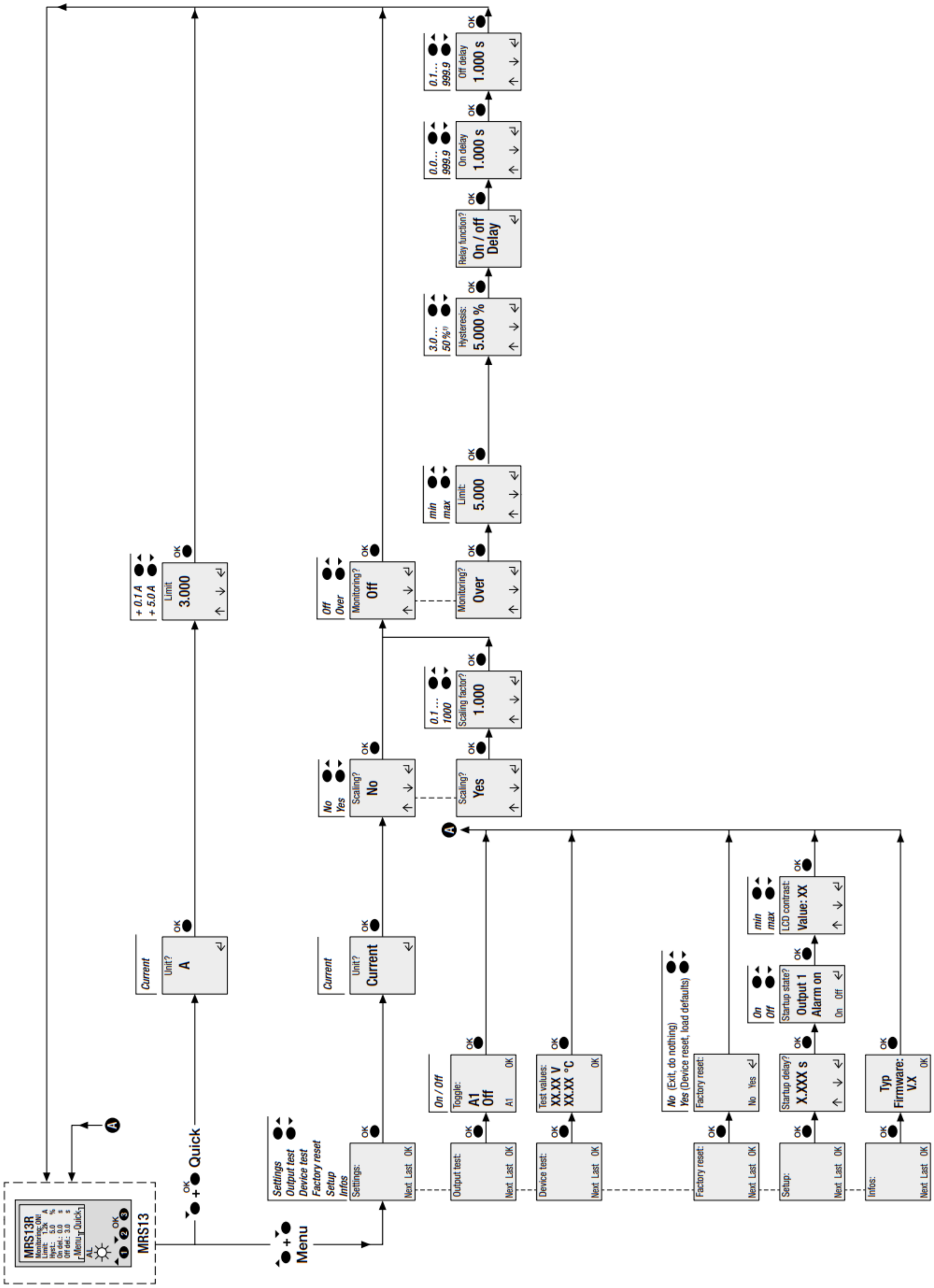
Menu Behaviour

- **Menu Timeout (60 s)**: If no button is pressed for 60 seconds, the device returns to measurement mode without saving the last parameter.
- **Display Reset (5 s)**: The display refreshes every 5 seconds, causing a slight flicker.
- **Display Refresh (0.5 s)**: The display updates every 0.5 seconds in metering mode.
- **Startup Behaviour**: After booting and self-test, the display menu automatically switches to show the currently set parameters.
- **Monitoring Behaviour**: If the monitoring function is turned ON, it automatically switches to the OVER function.
- **Saving Parameters**: After exiting the menu, parameters are saved. During this process (about 1 s), monitoring is paused, and the relay state remains unchanged. The device flashes while saving.
- **Self-Diagnosis**: The device continuously performs self-diagnosis. If a malfunction or error occurs, an alarm is triggered, and an error code appears on the display.
- **Value Display Format**:
    - Values above 1000 are displayed with a 'k' (e.g., 999k for 999000).
    - The smallest representable value is 0.001.

Error Handling

The MRS13R processor is monitored by a watchdog circuit, which automatically reboots the system if needed. If the boot process fails, the forcibly guided relay is activated, and an error message appears on the display. In case of an error, users should record the error code and contact our support team for assistance.

7.4 Menu Navigation



8 Electrical Connection Diagram

The MRS13 can be connected to a current transformer or directly to an AC or DC load. See Figure 11 and description below for the wiring diagrams and terminal designation.

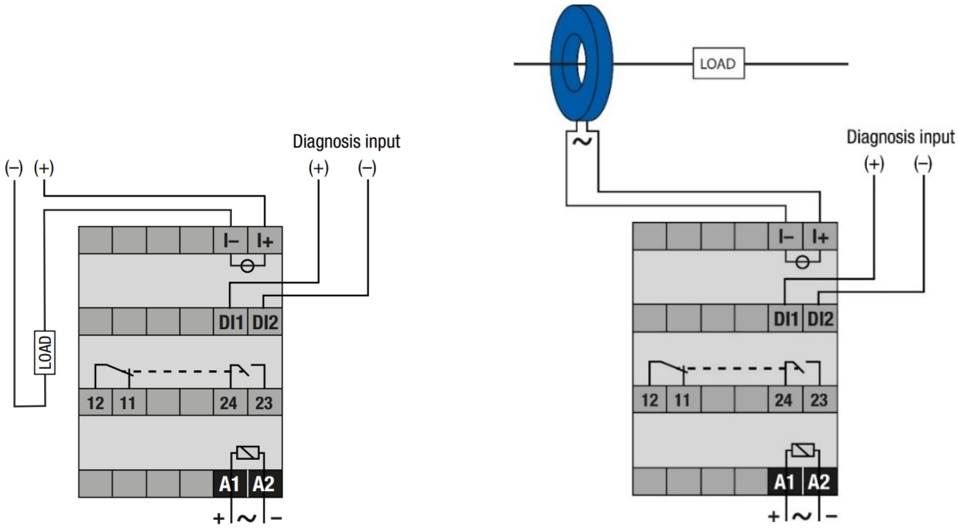
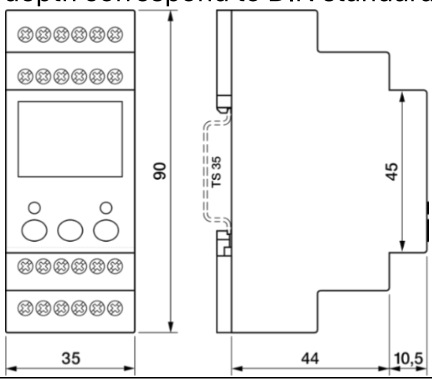


Figure 11: Electrical connection diagram without (left) and with (right) current transformer

Terminal Designation

- **A1/A2: Appliance power** for powering the MRS13R. Supports both DC (+/-) and AC (~) power input.
- **DI1/DI2: Diagnostic input** used for functional testing, as described in Section 5.4. Polarity independent.
- **I+/I-: Input** for the load **current measurement**. Terminals function as a pass-through connection.
- **11/12:** Normally closed (**NC**) **relay terminals**. Supports both DC and AC loads.
- **23/24:** Normally open (**NO**) **relay terminals**. Supports both DC and AC loads.

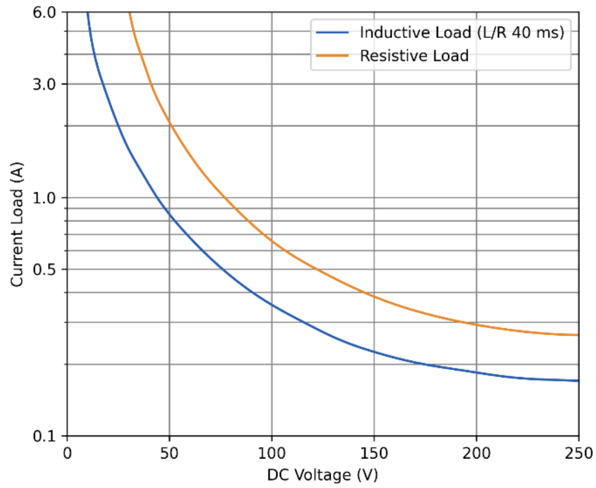
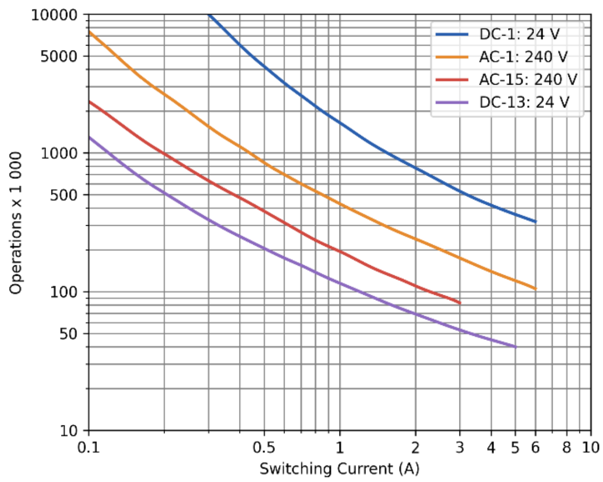
9 Specifications

Mechanical data	
Outside dimensions	Housing system DIN, W x H x D: 35 x 90 x 57 mm Height and depth correspond to DIN standard 43880 
Clamp	Screw terminal, M3, PZ2
Conductor cross-section	2.5 mm2, AWG14 (stranded) / 4mm2, AWG12 (Wire) Only copper conductors must be used
Stripping length	6 ... 7.5 mm / 0.24 ... 0.3"
Screw tightening torque min.	0.5 Nm
Screw tightening torque max.	0.6 Nm
Protection	IP 20
Case material	PA
Weight	107 g
Fastening	DIN Rail EN 60715
Shock resistance (16 ms) (min.)	NO: 17g / NC: 10g
Vibration resistance (10-200 Hz) (min.)	NO: 7g / NC: 3g
Mounting position	any

Ambient conditions	
Ambient temperature storage	-40 °C ... +85 °C
Ambient temperature operation	-40 °C ... +70 °C; (Display -20 °C ... +70 °C)
Relative humidity	10 % ... +95 % (not condensing)
Betting height	Max. 2'000 m over sea level (without derating)
Pollution degree	2
Overvoltage category	III

MTBF	
MTBF (IEC TR 62380) Ambient temperature 40 °C relative humidity ≤ 65 % duty cycle 100%	> 1'080'000 hrs (calculated)

Power supply	
Nominal voltage	12 … 48 V AC / DC
Operating voltage range	10 … 60 V AC / DC
Power consumption	AC / DC 3.2 VA / 1.6 W
Inrush current (MRS13R)	6.8 A, 50 µs
Frequency range	0; 16 … 63 Hz

Relay Output	
Number of contacts	1 NO + 1 NC forcibly guided complies with IEC 61810-3 (Category A)
Response time	< 20 ms (see Chapter 3 for details)
Available contact materials	AgCuNi + 0.2 … 0.4 µm Au
Rated voltage	240 V AC
Rated current	6 A
Minimum load	3 mA, 15 V (40 mW)
Inrush current (relay only)	30 A, 20 ms
Nominal Load DC	
Nominal Load AC-1	1500 VA
Mechanical Life	10 000 000 cycles
Electrical Lifetime at nominal load	

Measuring circuit*	
Measured parameters (load current)	I_L in A or kA depending on scaling
Min. setting step, resolution	0.1 A
Monitoring function	Overcurrent | OFF
Measuring current range	-5 … 5 A
Saturation detection threshold I_{Sat}	|± 5| A
Maximum pulse current	50 to 400 A depending on pulse length see Section 6.2 for details
Overcurrent I_{Th} adjustment range	0.1 … 5 A, (see also Chapter 7)
Tolerance of effective tripping current I_{th} as a function of temperature	+5 % to -15 % across the full specification range see Section 6.3 for details
Internal resistance	1.2 mΩ
Alarm switch-on delay T_{Don}	0 … 999.9 s
Alarm switch-off delay T_{Doff}	0.1 … 999.9 s
Hysteresis	3% … 50%,
Scaling factor $I_{Th\ Load}$ / I_{Th}	0.1 … 1000, default = 400
Minimum overcurrent time for detection	4.5 ms
Minimum overcurrent time for detection if sensor saturation	3.1 ms
Response time in case of overcurrent event	< 20 ms, see Section 5.1
Ageing drift of the overcurrent threshold over the device's lifetime	Typically ±1 % see Section 6.4 for details

* Consult Chapter 7 on how to configure the MRS13 appropriately.

Test-/ Diagnosis Input (DI)	
Maximum voltage DI1 to DI2 or DI2 to DI1	160 V DC
Threshold voltage logic 0 (DI1 – DI2)	< 5 V
Threshold voltage logic 1 (DI1 – DI2)	> 14 V
Sampling rate	1 / 1.5 ms

10 Technical approvals, conformities

LVD, EMC conformities	EN 60255-1:2022	
Rolling stock - Electronic equipment	EN 50155:2021	
	EN 45545-2:2020	Fire Protection in Rail Vehicles
	EN 50121-3-2:2017	EMC surge testing has been conducted with 1.2/50 µs 4 kV pulse, 2Ω on sense input
	EN 50124-1:2017	Isolation coordination
	EN 50125-1:2014	Environmental conditions for rolling stock and on-board equipment
	EN 60068-2-1:2008	Test A: Cold
	EN 60068-2-2:2008	Test B: Dry heat
	EN 60068-2-30:2006	Test Db: Humid heat cyclic 12 + 12 hours
	EN 61373:2011	Shock and vibration tests for rolling stock equipment
Built-in installation devices	DIN 43880:1988	
Compliance marking	CE UK CA EAC	

11 Document History

This document is available in English, German, French and Italian. In the event of any discrepancies or ambiguities between translations, the English version serves as the authoritative reference.

Version	Details of changes	Release date
001-004	Internal versions only	n/a
005	First released version	19.06.2024
006	New layout and document structure Extended hazard warnings Reformatting of data plots Extended information on device limitations Extended information on device configuration Add navigation menu	26.03.2025
007	Refine explanation of total response time incl. Figure 4 Editorial changes	26.09.2025