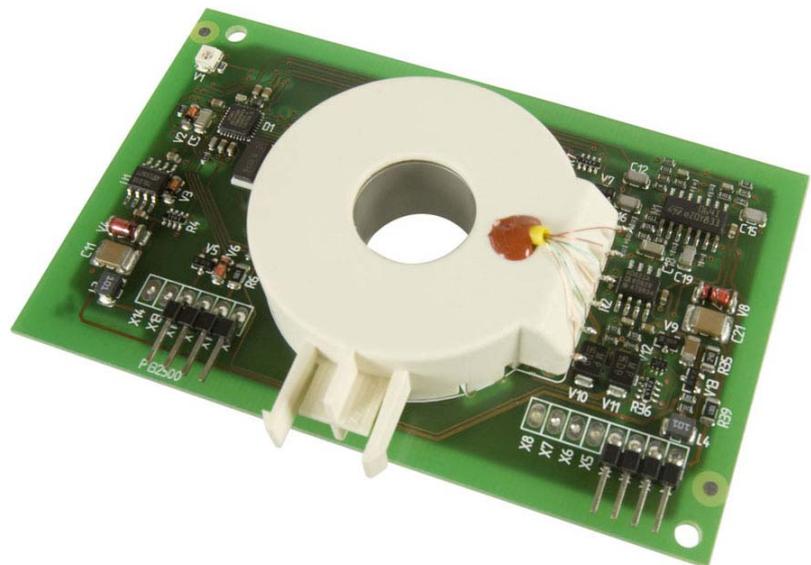


Operating Manual



RCMB101

CCID-20
AC/DC sensitive
residual current monitoring module
for installation into electric vehicle charging stations
Software version D359 V2



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1. Safety instructions

1.1 How to use this manual

This manual is intended for electrically skilled persons working in electrical engineering and electronics!

This operating manual describes the AC/DC sensitive residual current monitoring module RCMB101 with the software version indicated on the cover page. The functions and processes described may vary from those featured in other versions.

Please **read** this operating manual **before using the device**. This document must be kept in an easily accessible location near to the equipment.

1.2 Explanation of symbols

To make it easier for you to understand and revisit certain sections of text and instructions in the manual, we have used symbols to identify important instructions and information. The meaning of these symbols is explained below:



Information intended to assist the user to make optimum use of the product are marked with the Info symbol.



The warning symbol indicates a potential dangerous situation that may result in bodily injury and/or damage to property.

Observe the associated safety instructions!

1.3 Intended use

The AC/DC sensitive residual current monitoring module RCMB101 is used for monitoring residual currents in charging stations for electric vehicles where direct and/or alternating residual currents are likely to occur the value of which is constantly greater than zero. This also applies to the detection of leakage currents. The residual current monitoring module is to be mounted into the charging station as an open-type circuit board. The electrical connection is established by means of a plug-in connector suitable for PCBs.

1.4 Warranty and liability

Bender devices are designed and built in accordance with the state of the art and accepted rules in respect of technical safety. However, the use of such devices may introduce risks to the life and limb of the user or third parties and/or result in damage to Bender devices or other property.

Only use Bender equipment:

- As intended
- In perfect working order
- In compliance with the accident prevention regulations and guidelines applicable at the location of use

Eliminate all faults immediately which may endanger safety. Do not make any unauthorised changes and only use replacement parts and optional accessories purchased from or recommended by the manufacturer of the equipment. Failure to observe this requirement can result in fire, electric shock and injury.

Although great care has been taken in the drafting of this operating manual, it may nevertheless contain errors and mistakes. The Bender Group cannot accept any liability for injury to persons or damage to property resulting from errors or mistakes in this manual.

1.5 Personnel

Only appropriately qualified personnel may work on the Bender product. Qualified means familiar with the installation, commissioning and operation of the product and with training appropriate to the work. Personnel must have read and understood the safety section and warning information in this operating manual.

1.6 Work activities on electrical installations



Risk of electric shock!

*Failure to carry out work on electrical installations properly and correctly **can put life and limb at risk** and may damage the device!
Only **skilled persons** are permitted to carry out the work necessary to install, commission and run a device or system.*

- Compliance with applicable regulations governing work on electrical installations, and with the regulations derived from and associated with them, is mandatory. EN 50110 is of particular importance in this regard.
- If the device is being used in a location outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. European standard EN 50110 can be used as a guide.

2. Function

2.1 Device features

- Suitable for electric vehicle charging stations
- AC/DC sensitive measured value acquisition 0...500 Hz
- Internal measuring current transformer with test winding and screening for electrical interference field reduction, inside diameter 15 mm
- Measuring range 0...20 mA, with analogue output voltage
- Switching signal at the output according to the requirements of UL 2231-2, type CCID20
- Latch locks at the measuring current transformer allow easy installation of the module
- Monitoring of the connection to the measuring current transformer
- Reset via control input X10

2.2 Description of function

The residual current monitoring module detects the residual current caused by leakage and residual currents in the conductors passed through the measuring current transformer. The residual current monitoring module measures AC and DC currents. The r.m.s. value is determined by the DC components included in the residual current and by AC components which are below 500 Hz.

A signal in proportion to the r.m.s value is provided across the voltage output X1. The second output (X12) provides a switching signal when values are outside the permissible measuring range or in case of high or soaring residual currents.

The control input (X10) will also be queried. Depending on the sequence of the HIGH/LOW levels applied, the RCMB101 can be reset with or without a self test, calibration and activation of the test winding (test current supply).

2.3 Starting sequence

Once the residual current monitoring module is connected to the power supply, the automatic starting sequence begins.

The residual current monitoring module RCMB101 is supplied by an external power supply.



Note:

Users must ensure that the supply voltages $+U_s$ and $-U_s$ at X2 / X11 are strictly observed. Otherwise the signals at the outputs X1 and X12 may be outside the tolerance range!

Supply voltage fluctuations may influence the residual current measurement. To exclude this effect (particularly during calibration), the starting sequence is as follows:

Supply voltage measurement

1. Once a supply voltage $+U_s \geq 5 \text{ V}$ is applied, the starting sequence begins.
2. The residual current monitoring module disables the open collector switching output X12 (HIGH level).

Calibration

3. When a supply voltage of $+U_s \geq 11 \text{ V}$ is reached, calibration (offset measurement) is started by the module. It must be ensured that no residual current is flowing.
4. Once calibration is complete, the supply voltage measurement will be repeated. Where the condition $+U_s \geq 11 \text{ V}$ cannot be fulfilled, calibration will be repeated. After successful calibration, the residual current monitoring module enables the switching output X12 (LOW level).

Test current supply

5. The test winding is supplied with test current for 2 s (two-stage test current). The resulting measured value is available at X1 and the corresponding switching state is applied to output X12.

Test current supply	Test current	Duration	Output X1	Output X12
First sequence	11 mA, 400 Hz	1 s	1.2 V	does not switch
Second sequence	DC 22 mA	1 s	4.85 V	switches after max. 800 ms

When the current is supplied to the test winding, X1 drops to LOW level. X12 will only be enabled when a HIGH level is applied at X10.

Other features

6. When the test winding is supplied with current, the behaviour of the residual current module is determined by the control input X10:

Impulse duration at X10 (HIGH)	Behaviour of the RCMB
$\leq 50 \mu\text{s}$	The input is monitored until an impulse of $T \geq 50 \mu\text{s}$ is applied.
50...100 μs	Self test (supply voltage measurement, calibration and test current supply) will be repeated
$> 100 \mu\text{s} \dots < 5 \text{ ms}$	Control input X10 will be queried again
$> 5 \text{ ms}$	Residual current measurement starts after 10...11 ms

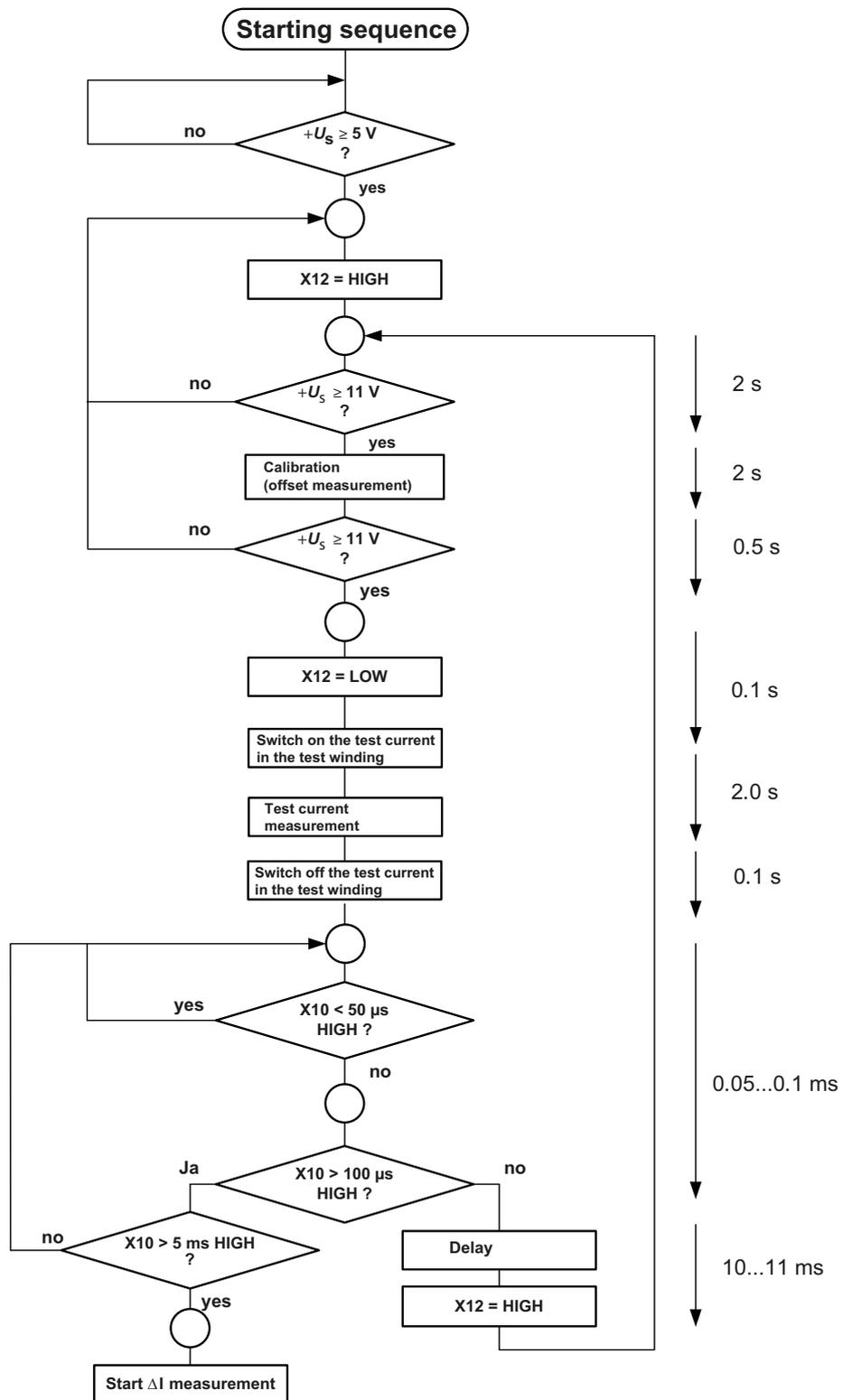


Fig. 2.1: Starting sequence

2.4 Analogue voltage output X1

The r.m.s. value of the currently measured residual current is available at X1 as a proportional output voltage.

If the residual current monitoring module detects values outside the measuring range, the analogue output X1 will be set to 4.85 V. As soon as the residual current drops below 10 mA, the output X1 will still remain at 4.85 V for approx. 1.2 s before the currently measured value will be displayed. Therefore, the shutdown can be reliably evaluated by the charging control electronics.

Output voltages < 150 mV or > 4.85 V signal a short-circuit, an interruption or a possible fault of the residual current module. For details about fault detection, refer to page 16.

2.5 Switching output X12

When values are outside the measuring range ($I_{\Delta n} \geq 20$ mA) or a fault is detected by the monitoring module, the switching output X12 will be disabled and signalled by the open collector output X12.

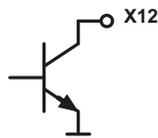


Fig. 2.2: Open collector

Only when the measured value of the residual current falls below 10 mA for a period of 1.2 s, the switching output X12 will be enabled again by activating the transistor (LOW level at X12).

In order to check the switching capacity of the open collector output X12, a functional test according to chapter 2.6.5 can be initiated via the control input X10.

2.6 Control input X10

2.6.1 Cyclical self test

Before each charging cycle, a self test has to be activated (reset with subsequent calibration) by the charging control electronics via the input X10. This requirement can only be met when sufficient supply voltage $+U_s / -U_s$ is available (> 11 V).

The sequence of the measurement is described in chapter 2.6.4. During the calibration process, also the digital output X12 switches. The cyclical self test is used to check the measuring function of the device. This is a measure to ensure that the protective function is guaranteed.

2.6.2 Reset function

A reset of the residual current monitoring module can be carried out at any time via the control input X10. For activating the reset function, a LOW level is to be applied across the control input X10 for at least $T1 > 530$ ms.

In this case, the residual current measurement process has to be interrupted.

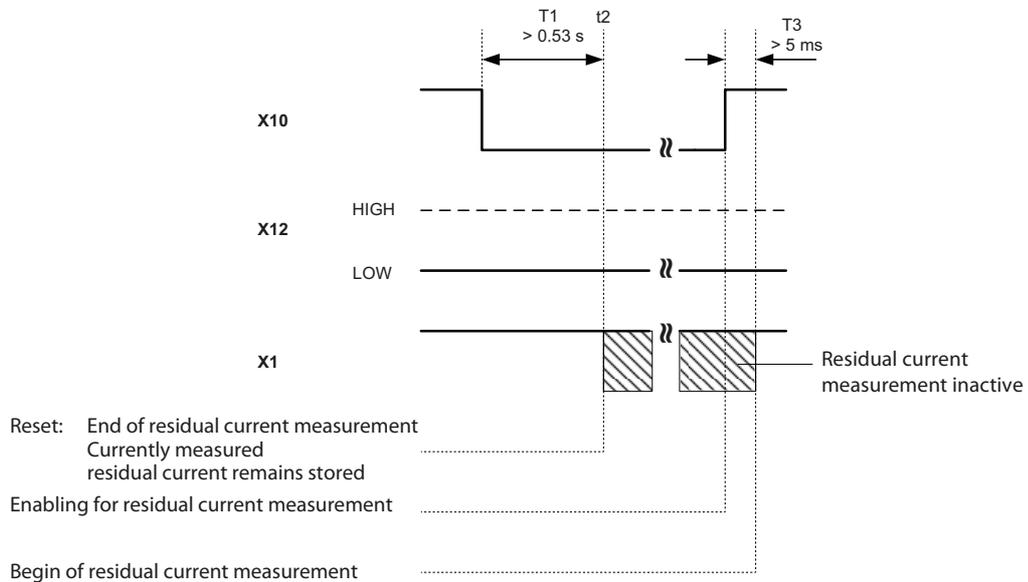


Fig. 2.3: Reset

The residual current measurement remains active during the period $T1$. The residual current measured at the point of time $t2$ remains stored until the residual current measurement is restarted after applying a HIGH level at X10 for the period $T3 > 5$ ms.

2.6.3 Impulse duration for activating a reset

When a LOW level is applied at the control input X10 of the residual current monitoring module for $T < 530$ ms, no reset will be carried out. The outputs X1 and X12 will remain unaffected. The residual current measurement will stay active.

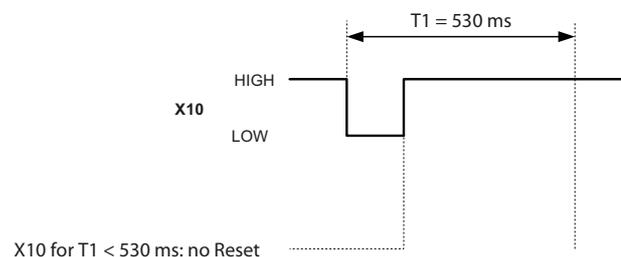
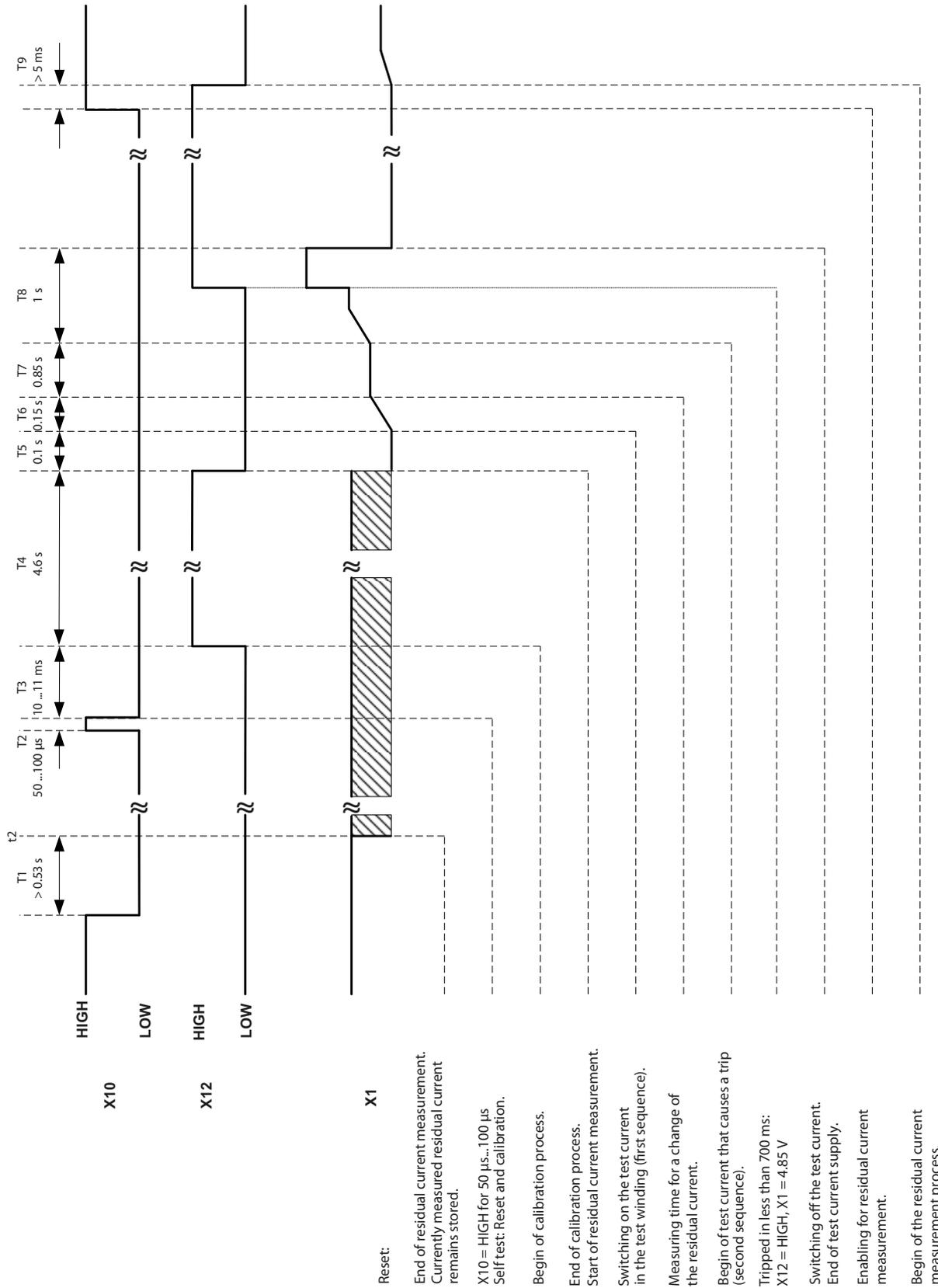


Fig. 2.4: Impulse duration for activating a reset

When the condition is met that a LOW level is applied at the control input X10 for at least $T1 = 530$ ms, disturbing pulses will not cause a reset of the residual current monitoring module.

2.6.4 Self test: Reset and subsequent calibration of the RCMB101



The signalling sequence at the control input X10, illustrated in the preceding diagram, results in a self test as a reset and subsequent calibration. The self test includes a test of the supply voltage before and after zero point measurement. If the supply voltage is outside the tolerance, calibration will be repeated.

Reset

For activating the reset function, a LOW level is to be applied across the control input X10 for at least 530 ms. The residual current measurement remains active during the time T1. After T1 has elapsed, the residual current value measured at the time t2 is stored by the residual current monitoring module. From the time T1 has elapsed until the time residual current measurement is restarted (when T9 has elapsed), residual current measurement is inactive.

Calibration

A calibration is carried out when T1 has elapsed and a control impulse (HIGH for 50...100 µs) is applied at the control input X10.

Calibration starts within 10...11 ms (T3). The RCMB disables the open collector switching output X12 (HIGH) and carries out an offset measurement. The DC component of a residual current, still flowing, results in an incorrect calibration.

The calibration process approx. takes 4.6 s (T4). Once the calibration process is complete, the switching output X12 (LOW) will be enabled.

Test current supply

After calibration the test winding is supplied with current for 2 s. The measured values resulting from the two test currents will be provided proportionally at X1 and the corresponding switching states are applied to X1 (details page 8).

Repeating calibration

Once the test winding is supplied with current (X12 = LOW), calibration can be repeated as often as required by applying a new control impulse at X10.

Starting residual current measurement

The residual current monitoring module starts residual current measurement when a HIGH level is applied at X10 for at least 5 ms (T9).

The residual current measured at the time t2 remains stored until the measurement is restarted.

2.6.5 Functional test switching output X12

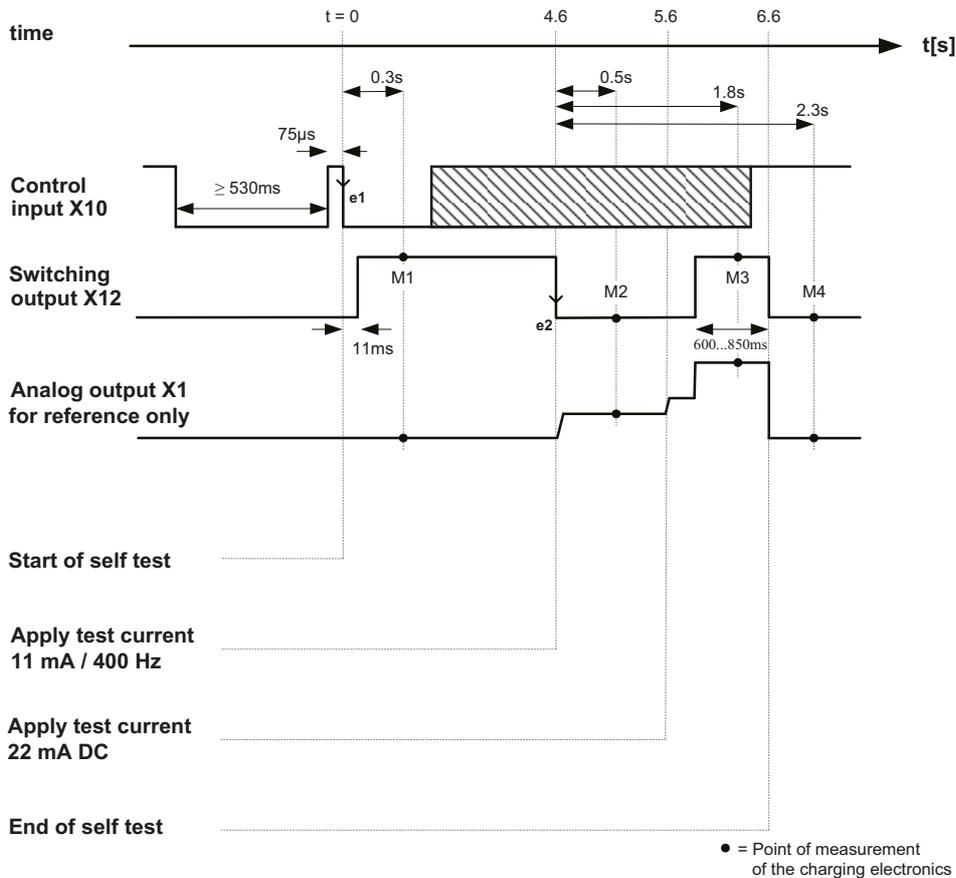


Fig. 2.5: Monitor points for the functional test

After starting the functional test via the control input X10 (control impulse HIGH for 50... 100 µs), the charging control electronics should monitor the correct functionality of the digital output X12 at the following points in time:

Monitor point related to falling edge e1 (X10)

M1 X12 disabled after 0.3 s

Monitor point related to falling edge e2 (X12)

M2 X12 enabled after 0.5 s

M3 X12 disabled after 1.8 s

M4 X12 enabled after 2.3 s



Note:

The falling edge „e2“ is used for the timing of the monitor points M2, M3 and M4. Therefore, the end of the internal self test at $t = 6.6$ s may vary if the supply voltage $+U_s = 12$ V is unstable at the time of e2.

If X10 is maintained at LOW level at the end of the self test, X12 remains disabled until X10 has reached HIGH level for at least 5 ms. Refer to the diagram in chapter 2.6.4 for more information.

2.7 Values outside the permissible measuring range

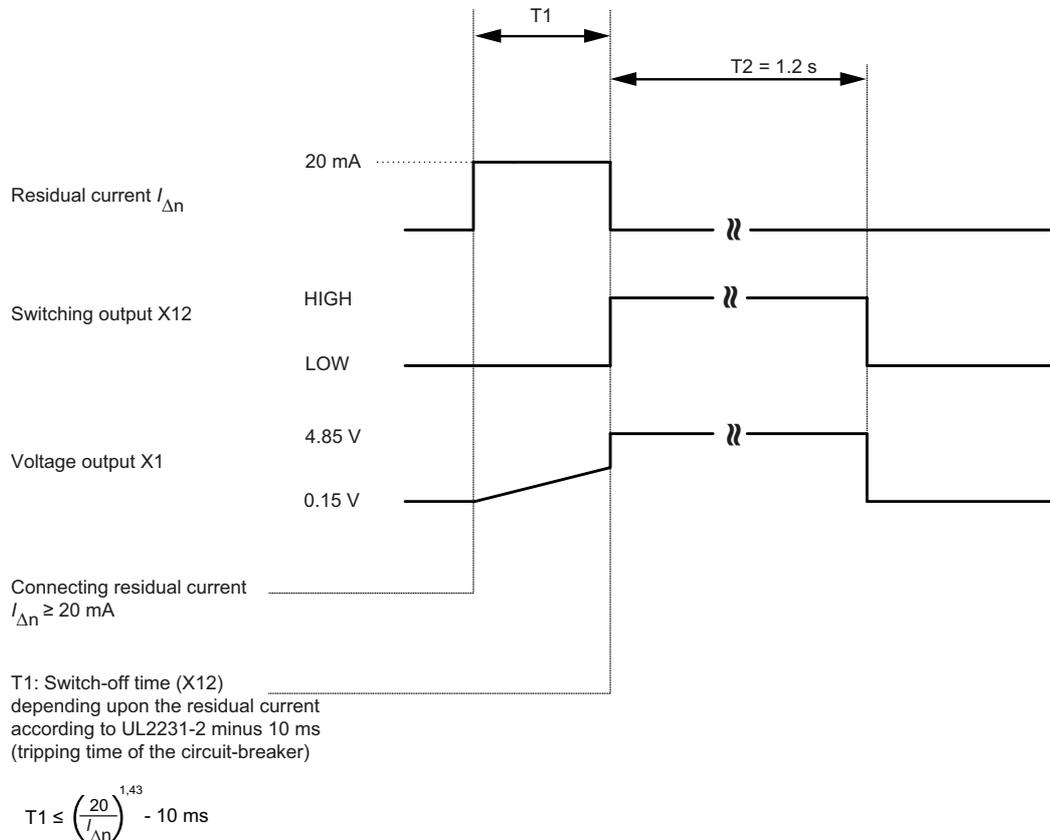


Fig. 2.6: Behaviour of the outputs when the values are outside the measuring range

If the residual current exceeds the measuring range (residual current $\geq 20 \text{ mA}$), the residual current monitoring module will disable the open collector output X12 (HIGH) after time T1 has elapsed. The disconnection time is dependent on the value of the residual current (see chapter 2.8).

If the residual current monitoring module detects values outside the measuring range, the analogue output X1 will be set to 4.85 V. As soon as the residual current falls below 10 mA, the output X1 will remain at 4.85 V for approx. 1.2 s before the currently measured value will be displayed. In this way, the shutdown can be reliably evaluated by the charging control electronics.

2.8 Measuring range and switching times

Measuring range

The measuring range of the residual current is 0...20 mA according to UL 2231 type CCID-20.

Switching time residual current monitoring module (without switching device)

The maximum switching times of the output X12 is dependent on the residual current.

For UL application:

Make sure that the maximum switching times are at least 10 ms below the maximum disconnection times required by UL 2231.

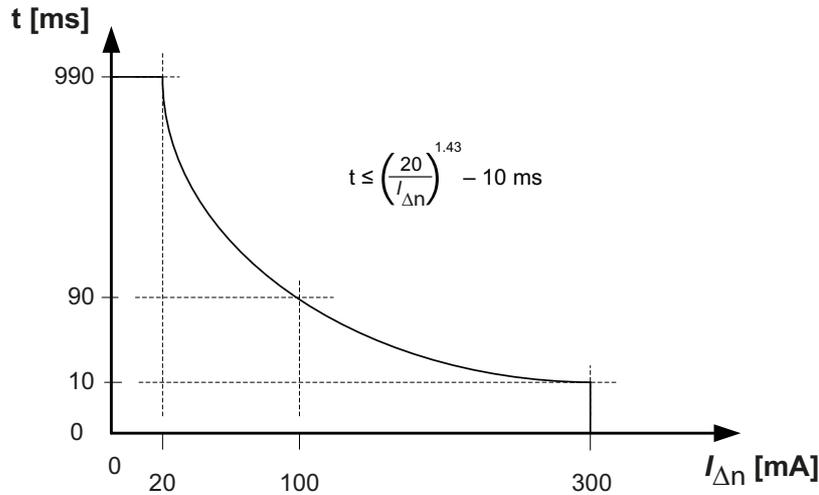


Fig. 2.7: Operating characteristics residual current monitoring module according to UL 2231-2



Note:

In order to comply with the switching times required by the standard (CCID20), the **switching time of the circuit-breaker** (incl. driver circuit) **must not exceed 10 ms!**

2.9 Fault detection and the resulting technical reactions

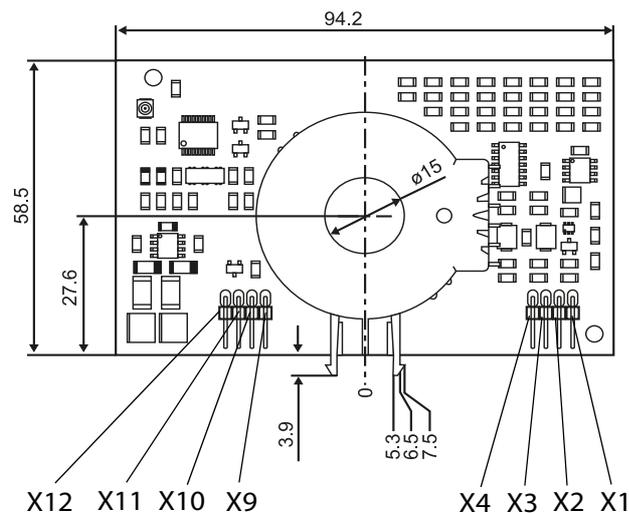
Type of fault	Detection	Response
Wire break in the residual current transformer	Frequency measurement of the measuring oscillator	X1 = 5.0 V X12 = HIGH
Short-circuit in the residual current transformer winding	Frequency measurement of the measuring oscillator	X1 = 5.0 V X12 = HIGH
Constant output voltage at the measuring oscillator	Frequency measurement of the measuring oscillator	X1 = 5.0 V X12 = HIGH
Failure main oscillator	Reset by internal watchdog	X1 = 5.0 V or X1 = 0 V X12 = HIGH
Supply voltage failure	Monitoring module connects and disconnects residual current monitoring	X1 = 5.0 V or X1 = 0 V X12 = HIGH
Open collector output constantly at LOW level	Self test to check whether output X12 switches to HIGH for 4.6 s when supply voltage is connected; for details about time T4 refer to page 12	Charging control electronics detects fault after connecting to the supply voltage
Analogue output X1 constantly at LOW level	Output voltage outside the permissible voltage range	Disconnection by charging control electronics
Storage cell of the computer system defective	Detection by memory self test	X1 = 5.0 V X12 = HIGH
Loss of return addresses from subprograms	Response of internal watchdog	X1 = 5.0 V X12 = HIGH

3. Installation and connection

3.1 Installation

Refer to dimension diagrams page 21.

3.2 Connection assignment



Plug designation	Description
X1	Analogue voltage output
X2	$-U_s$: Voltage supply -12 V via current limiting or 100 mA fuse recommended
X3	GND: ground
X4	not connected
X9	GND: ground
X10	Control input: 0...5 V
X11	$+U_s$: Voltage supply +12 V via current limiting or 100 mA fuse recommended
X12	Switching output/alarm output (transistor, open collector)



Note:

The user must ensure that the supply voltages $+U_s$ and $-U_s$ at X2 / X11 are strictly observed. Otherwise the signals at the outputs X1 and X12 may be outside the tolerance range!

Cable routing through the measuring current transformer

Only conductors insulated in conformance with the standards may be routed through the measuring current transformer.

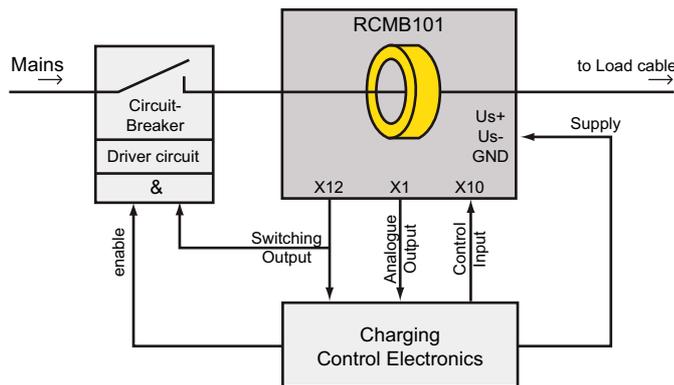
The conductors must be routed **centrally** through the measuring current transformer!

3.3 Example applications

3.3.1 The circuit-breaker is controlled by the charging control electronics and the switching output X12

The switching output X12 uses the circuit-breaker as a signalling device which is controlled by the charging control electronics software.

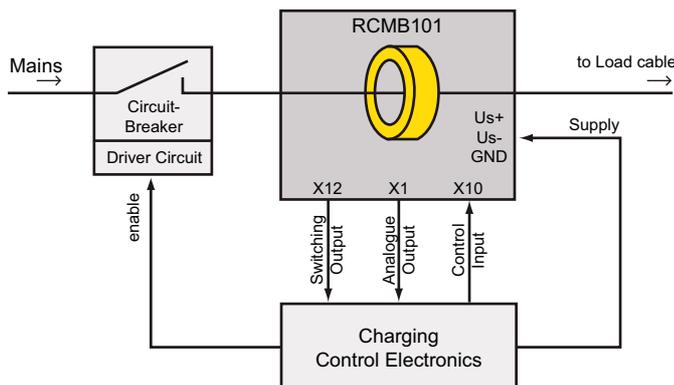
The switching output X12 and the analogue output X1 are monitored by the charging system to ensure that the outputs always provide consistent information. Furthermore, it is checked that the behaviour after a test triggered by control input X10 is correct.



3.3.2 The circuit-breaker is controlled by the charging control electronics

The circuit-breaker is controlled by the charging control electronics software.

The switching output X12 and the analogue output X1 are monitored by the charging system to ensure that the outputs always provide consistent information. Furthermore, it is checked that the behaviour after a test triggered by control input X10 is correct.



Note:

In order to comply with the switching times required by the standard (CCID20), the **switching time of the circuit-breaker** (incl. driver circuit) **must not exceed 10 ms!**

4. Technical data

4.1 Data in tabular form

Voltage supply

+ U_s (X11)	12 V (\pm 1 V)
- U_s (X2)	-12 V (\pm 1 V)
Ripple U_s	\leq 100 mV
Power consumption	\leq 1 W

Measuring circuit

Operating characteristic acc. to	UL 2231-2 (CCID20)
Frequency range	0 . . . 500 Hz
Measuring range	0 . . . 20 mA
Relative uncertainty	0 . . . -25 %
Max. nominal current	50 A / 45 . . . 65 Hz

Response value

Rated residual operating current $I_{\Delta n}$	20 mA
---	-------

Inputs

Control input X10:	
HIGH level	4.5 . . . 5.5 V
LOW level	0 . . . 0.5 V

Outputs

Output voltage range	DC 0.15 V . . . 4.85 V
Sensitivity analogue output	1 V / 10 mA
Tolerance at 1.5 . . . 10 mA	0 . . . -20 % / \pm 1 mA
Tolerance at 10 . . . 50 mA	0 . . . -20 %
Tolerance at 0.15 V	+50 mV / - 0 mV
Tolerance at 4.85 V	-150 mV / + 50 mV
Output resistance at the measurement output X1	1 k Ω (short-circuit proof)
Switching behaviour switching output X12 (Open Collector)	
LOW:	values within the permissible measuring range
HIGH:	values outside the permissible measuring range
Max. switching voltage X12	+ 24 V
Max. switching current X12	DC 10 mA

Test winding

Output voltage at X1 with a test current of 22.4 mA after 800 ms	4.85 V
Output voltage at X1 with a test current of 11 mA / 400 Hz	\geq 1.1 V

Time response

Operating time t_{ae} at X12 for $I_{\Delta n}$	$<$ 990 ms
Max. switching time of the selected circuit breaker under rated conditions	\leq 10 ms
Recovery time t_b	\leq 2s

Environmental conditions

Without solar radiation, precipitation, water, icing. Condensation possible temporarily:

Classification of climatic conditions acc. to IEC 60721:

Stationary use (IEC 60721-3-3).....	3K5
Transport (IEC 60721-3-2).....	2K3
Long-time storage (IEC 60721-3-1).....	1K4

Classification of mechanical conditions acc. to IEC 60721:

Stationary use (IEC 60721-3-3).....	3M6
Transport (IEC 60721-3-2).....	2M2
Storage (IEC 60721-3-1).....	1M3

Deviation from the classification of climatic conditions:

Ambient temperature, during operation.....	-25 °C ... +80 °C
Ambient temperature, during transport.....	-40 °C ... +80 °C
Ambient temperature, during long-time storage.....	-25 °C ... +80 °C
Relative humidity.....	10 ... 90 %
Air pressure.....	70 ... 106 kPa

Connection

Plug-in connectors for PCBs, single-row.....	0.65 mm x 0.65 mm
Possible counterpiece for plug-in connector.....	Samtec: BCS-104-L-S-TE
.....	3M: 960104-6202-AR
Modular dimensions.....	2.54 mm

Other

Operating mode.....	continuous operation
Position of normal use.....	any
Software version.....	D359 V2
Weight.....	≤ 65 g

4.2 Ordering information

Type	Measuring range	Frequency range	Art. No.
RCMB101	0...20 mA	0...500 Hz	B 9404 2098

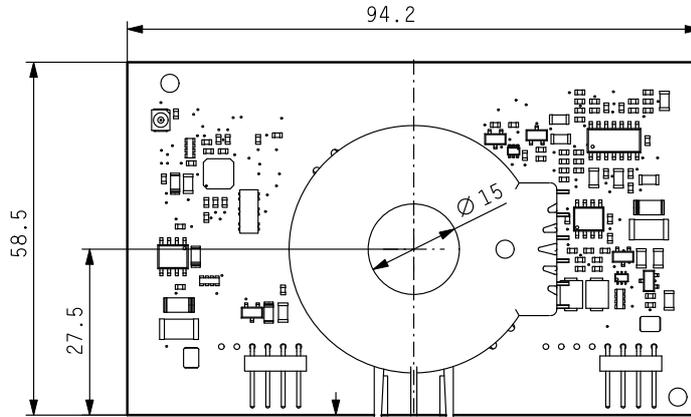
4.3 Approvals/certifications



File # E193871, UL 2231-2, "Standard for personnel protection systems for electric vehicle (EV) supply circuits:
Particular requirements for protection devices for use in charging systems"

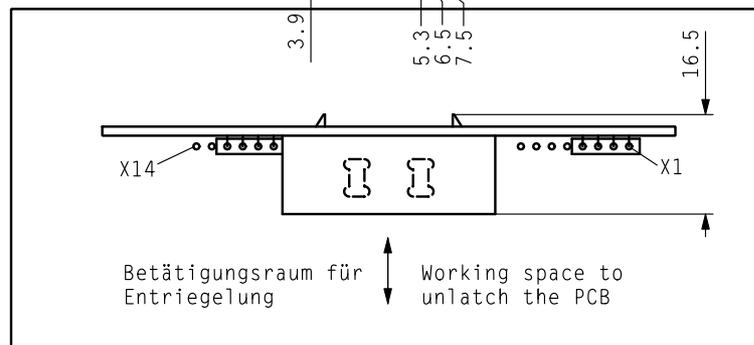
4.4 Dimension diagrams

Dimensions are given in mm



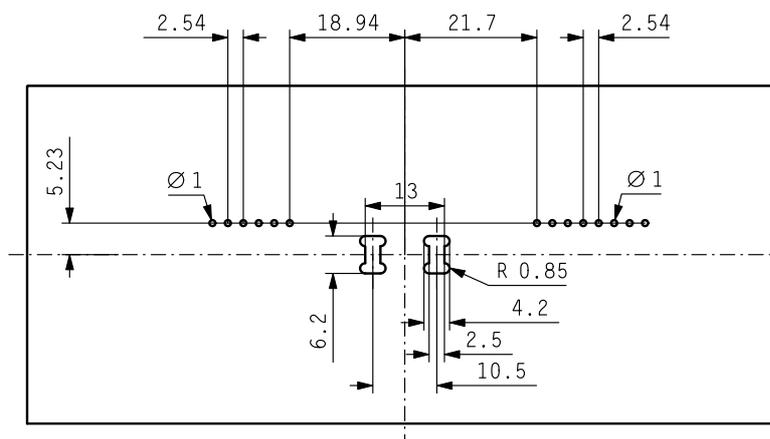
Bender-Leiterplatte
1,5mm dick

Bender
printed circuit board
thickness: 1.5mm



Bender-Leiterplatte
auf einer Grundplatte

Bender
printed circuit board
on a baseplate



Grundplatte (Maße)
Ausführung: 1,7mm dick
Toleranz: +0,1mm / -0mm

baseplate (dimensions)
Thickness: 1.7mm
Tolerance: +0.1mm/-0mm



D611008101



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