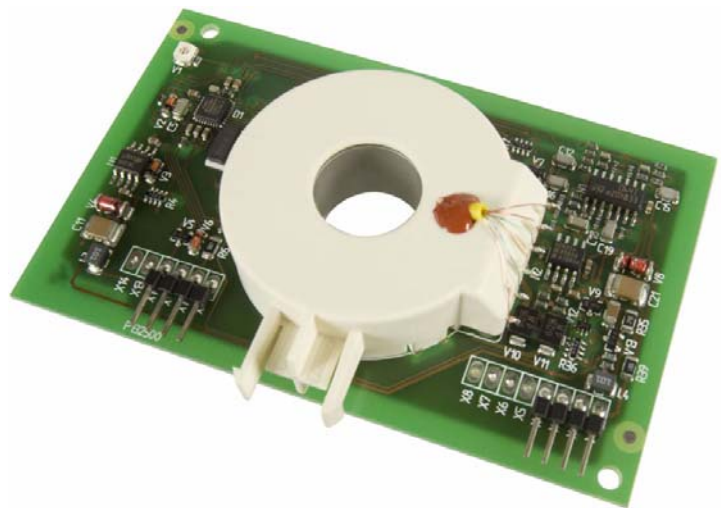
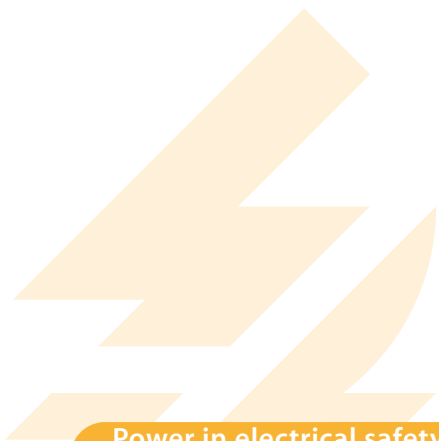


Product description



RCMA278P-S

AC/DC sensitive
residual current monitoring module
for installation into photovoltaic inverters
Software version D338 V2





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1. Effective use of this manual

1.1 Notes for the user

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

In order to make it easier for you to find specific text passages or references in this manual and for reasons of comprehensibility, important information is emphasised by symbols. The meaning of these symbols is explained below:



Information calling attention to hazards are marked with this warning symbol.



Information which is designed to help you make the best use of the product is highlighted with the information symbol.

1.2 General safety instructions

In addition to this data sheet, the documentation of the device includes a sheet entitled "Important safety instructions for Bender products".

1.3 Work activities on electrical installations

- All work necessary for the installation, commissioning and operation of the equipment or system must be carried out by electrically skilled persons.
- Observe the relevant regulations applying to work on electrical installations, in particular DIN EN 50110 or its subsequent regulations.
- Unprofessional work activities on electrical installations may result in a threat of danger to life and limb!
- If the equipment is used outside the Federal Republic of Germany, the standards and regulations which apply where the equipment is used must be followed. The European standard EN 50110 is recommended to be used as a directive.

2. Function

2.1 Device features

- Suitable for transformerless photovoltaic inverters
- 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...100mA, with analogue output voltage
- Switching signal at the output at currents ≥ 100 mA, e.g. for fast inverter disconnection
- 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 Product description

The AC/DC sensitive residual current monitoring module RCMA278P-S is suitable for fault current monitoring in transformerless photovoltaic inverters where direct and/or alternating fault 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 inverter as an open-type circuit board. The electrical connection is established by means of a plug-in connector suitable for PCBs.

2.3 Function

The module detects the residual current caused by leakage and fault 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 calculated 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 made available across the 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.

2.3.1 Self test after connection to the supply voltage

Once the supply voltage has been switched on, the module carries out a self test. For this purpose, the test winding is supplied with a current of 22,4 mA for 1 s. The resulting measured value of typical 1.26 V is available at the analogue output X1 (tolerance: 1.12...1.4 V). The automatic start of calibration also causes the digital output X12 to switch.

2.3.2 Cyclical self test

Every 24 h, at the latest, a reset with subsequent calibration has to be activated by the inverter control via the input X10. This requirement can only be met when sufficient supply voltage $+U_s$ /- U_s is available.

The ensuing sequence of measurement is described in "chapter 2.6.2". The automatic start of calibration also causes the digital output X12 to switch. 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.

2.4 Analogue voltage output X1

The currently measured residual current is available across X1 as a proportional output voltage.

Output voltages $< 150 \text{ mV}$ or $> 4.85 \text{ V}$ not only signal a short-circuit or an interruption, but also a possible fault of the residual current monitoring module.

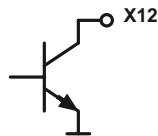
When a fault is recognised by the monitoring module, output X12 will simultaneously be switched to the high-impedance state.

For details about fault detection, refer to page 16.

Values outside the measuring range $>100 \text{ mA}$ are signalled via the switching output X12. In addition the analogue output signal is provided at X1 for approx. 1.2 s and can be evaluated by the inverter.

2.5 Switching output X12

Values outside the measuring range, a residual current $I_{\Delta} \geq 150 \text{ mA}$ or a fault detected by the monitoring module are signalled by the Open Collector output X12. The transistor blocks, as a result the switching output is in a high-impedance state.

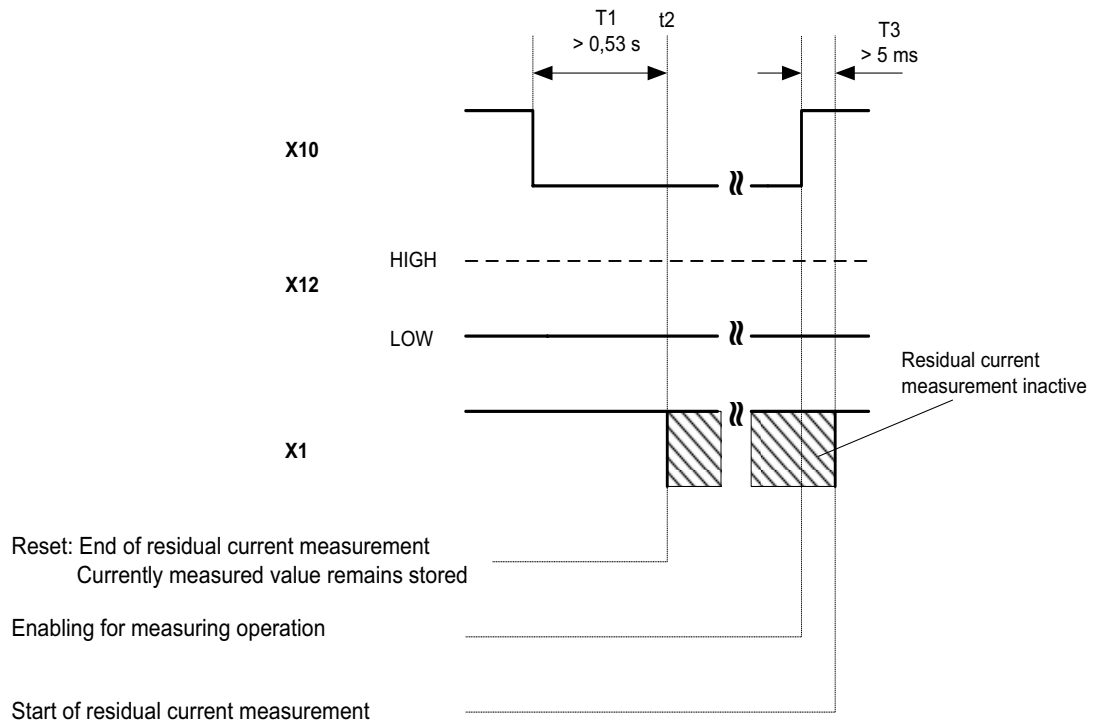


Only when the measured value of the residual current falls below 15 mA , the transistor will open and the switching output X12 will be in the low-impedance state after 1.2 s.

In order to check the switching capacity of the Open Collector output X12, a functional test according to "chapter 2.6.2" can be initiated via the control input X10.

2.6 Control input X10

2.6.1 Reset function

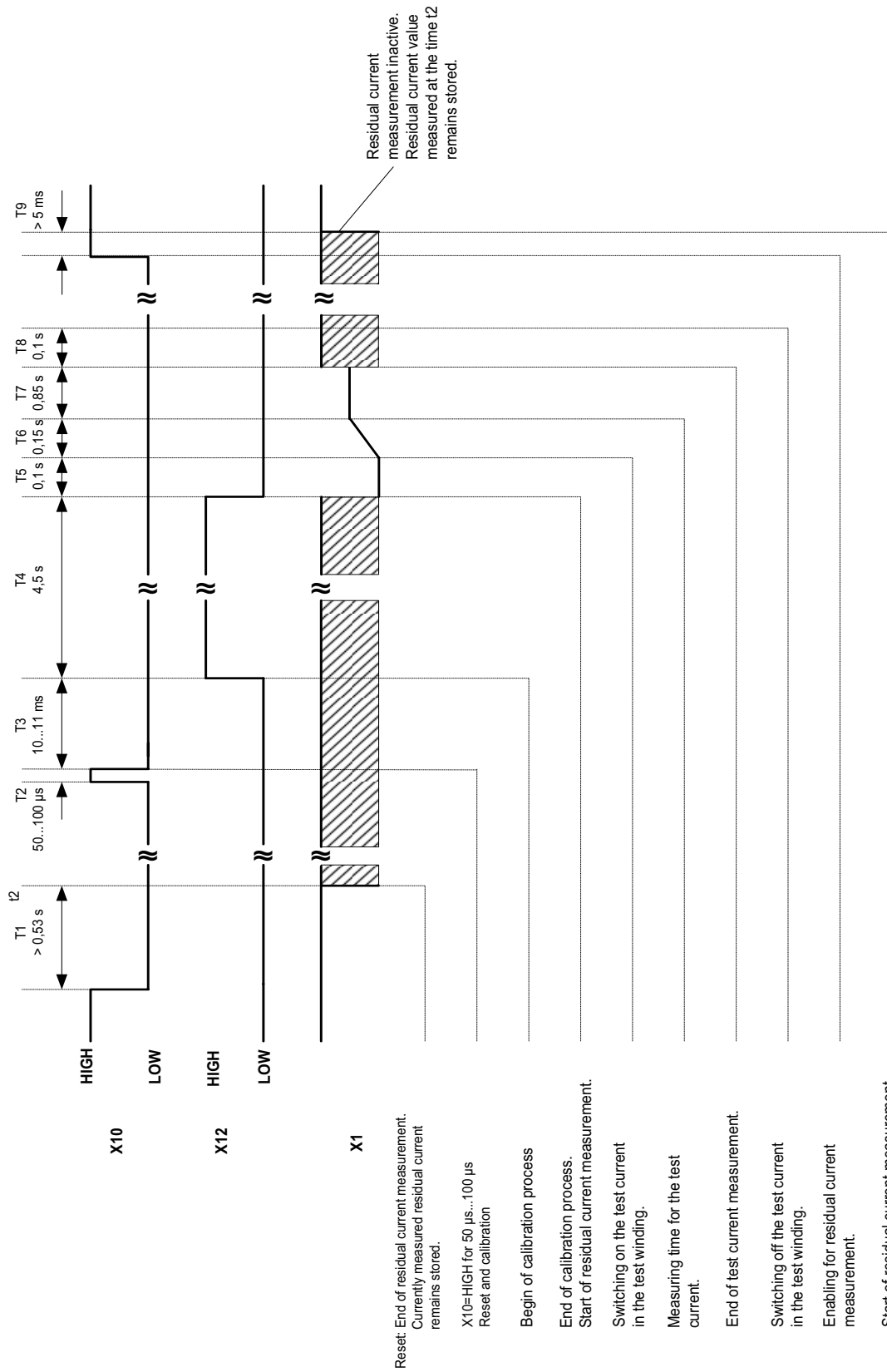


A RESET of the residual current monitoring module RCMA278P-S can be carried out at any time via the control input X10. In this case, the residual current measurement process has to be interrupted.

For activating the RESET function, a LOW level is to be applied across the control input X10 for at least $T1 > 530$ ms.

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.

2.6.2 Reset and subsequent calibration of the RCMA278P-S



The signalling sequence at the control input X10, illustrated in the preceding diagram, results in a RESET and subsequent recalibration.

For activating the RESET function, a LOW level is to be applied across the control input X10 for at least $T1 = 530$ ms. The residual current measurement remains active during the time $T1$. After $T1$ has elapsed, the residual current, which in normal condition falls to 0 mA during the period $T1$, is stored by the residual current monitoring module at the time $t2$.

A calibration is carried out when $T1$ has elapsed and a HIGH level is applied across X10 for the time $T2 = 50...100$ μ s. If that's the case, the calibration will start within $T3 = 10...11$ ms. For this purpose, the Open Collector switching output must be in the high impedance state so that a HIGH level is applied across X12 when a pull-up resistor is connected (switching transistor blocked). The calibration procedure approximately takes $T4 = 4.5$ s and is completed when the voltage across X12 drops to LOW (switching transistor conductive). Then the test winding is supplied with current for 1 s and the resulting measured value is output at X1. Once the calibration procedure is completed (X12 to LOW), calibration can be repeated as frequently as desired by applying a HIGH level across X10 for $T2 = 50...100$ μ s.

The RCMA278P-S starts the residual current measurement when a HIGH level is applied across X10 for at least $T5 = 5$ ms.

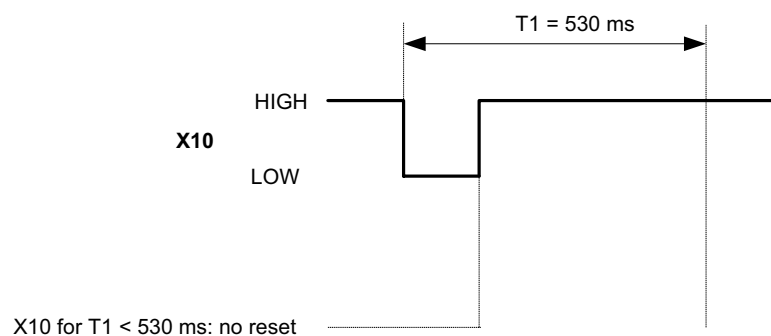
The residual current measured at the time $t2$ remains stored until the residual current measurement is restarted after applying a HIGH level across X10 for at least $T3 = 5$ ms. From the time $T1$ has elapsed until the time residual current measurement is restarted (when $T5$ has elapsed), residual current measurement is inactive.

A calibration includes the following functions:

zero point measurement and testing of the permissible voltage supply. Before and after zero point measurement, the supply voltage is checked. If the supply voltage is outside the tolerance, calibration will be repeated continuously, refer to "chapter 2.7". A residual current still flowing results in an incorrect calibration. Once calibration is completed, the test winding is supplied with current for 1 s and the resulting measured value is output at X1.

2.6.3 Measuring sequence without inverter reset

If a LOW level is applied across 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.



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

2.7 Starting sequence

The residual current monitoring module RCMA278P-S is supplied by an external power supply. The residual current measurement is subject to supply voltage fluctuations. To exclude this effect (*calibration is considerably affected!*), the following starting sequence is applied:

The starting sequence of the residual current monitoring module begins when a supply voltage of $U_{s+} \geq 5 \text{ V}$ is applied. The residual current monitoring module switches the switching output X12 (Open Collector) to HIGH level. Once $U_{s+} \geq 11 \text{ V}$ is reached, the module starts calibration. It must be ensured that no residual current is flowing.

Once calibration is complete, the supply voltage measurement will be repeated. If the condition $U_{s+} \geq 11 \text{ V}$ is not met, calibration will be repeated.

Then the residual current monitoring module switches the switching output X12 to LOW level. Then the test winding is supplied with current for 1 s and the resulting measured value is output at X1.

If the control impulse at the input X10 is shorter than $T = 50 \mu\text{s}$, the input will be monitored until an impulse $T \geq 50 \mu\text{s}$ is applied.

If the control impulse at the input X10 is at HIGH level for longer than $T = 100 \mu\text{s}$, residual current measurement will start when a HIGH level is applied across the control input X10 for $T5 > 5 \text{ ms}$.

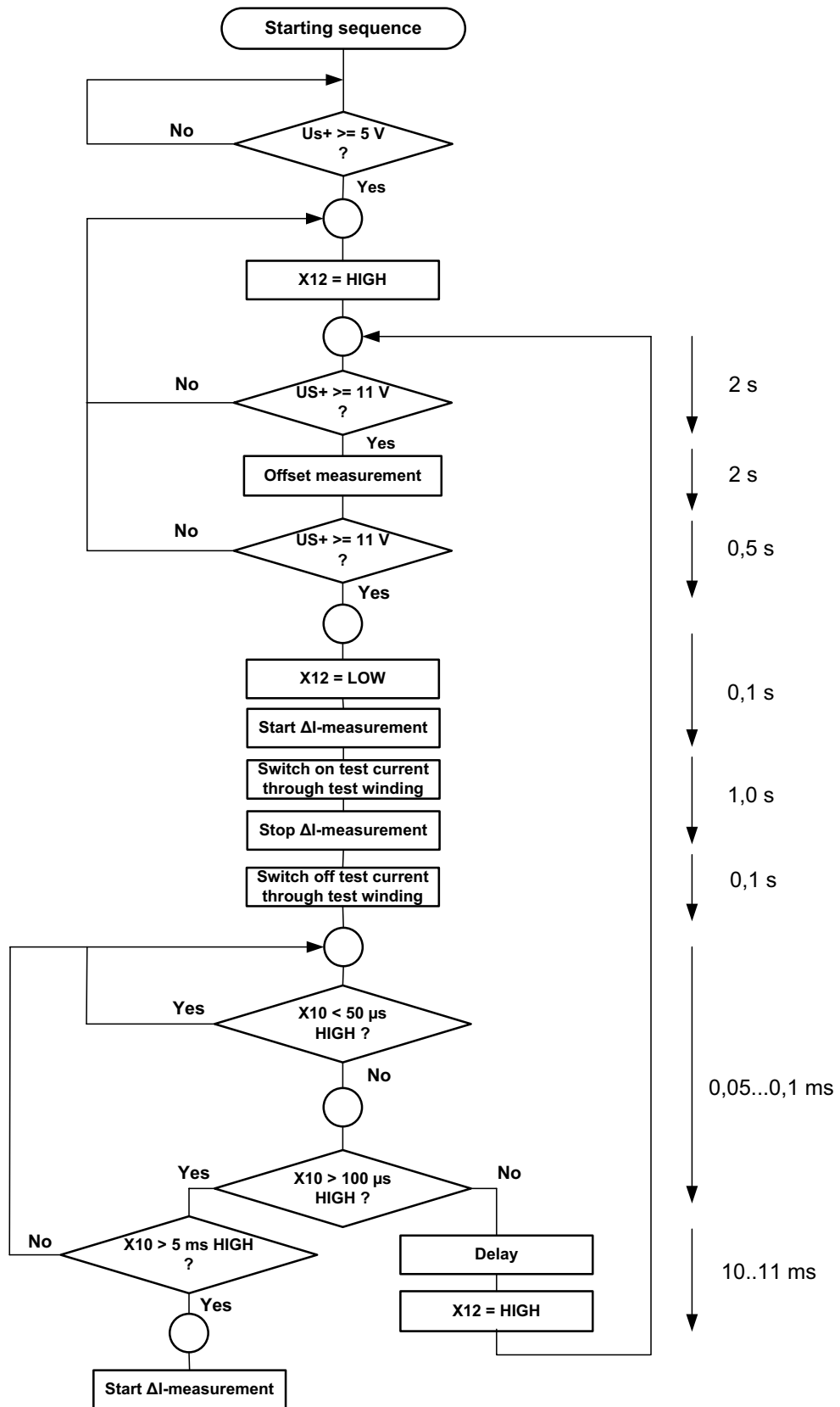
If the control impulse at the input X10 is at HIGH level for $T \leq 5 \text{ ms}$, the control input will be scanned again.

If the control impulse at the input X10 is at HIGH level for $T = 50 \dots 100 \mu\text{s}$, the residual current monitoring module will switch the switching output X12 to HIGH level after 10...11 ms. Both supply voltage measurement and calibration will be repeated.

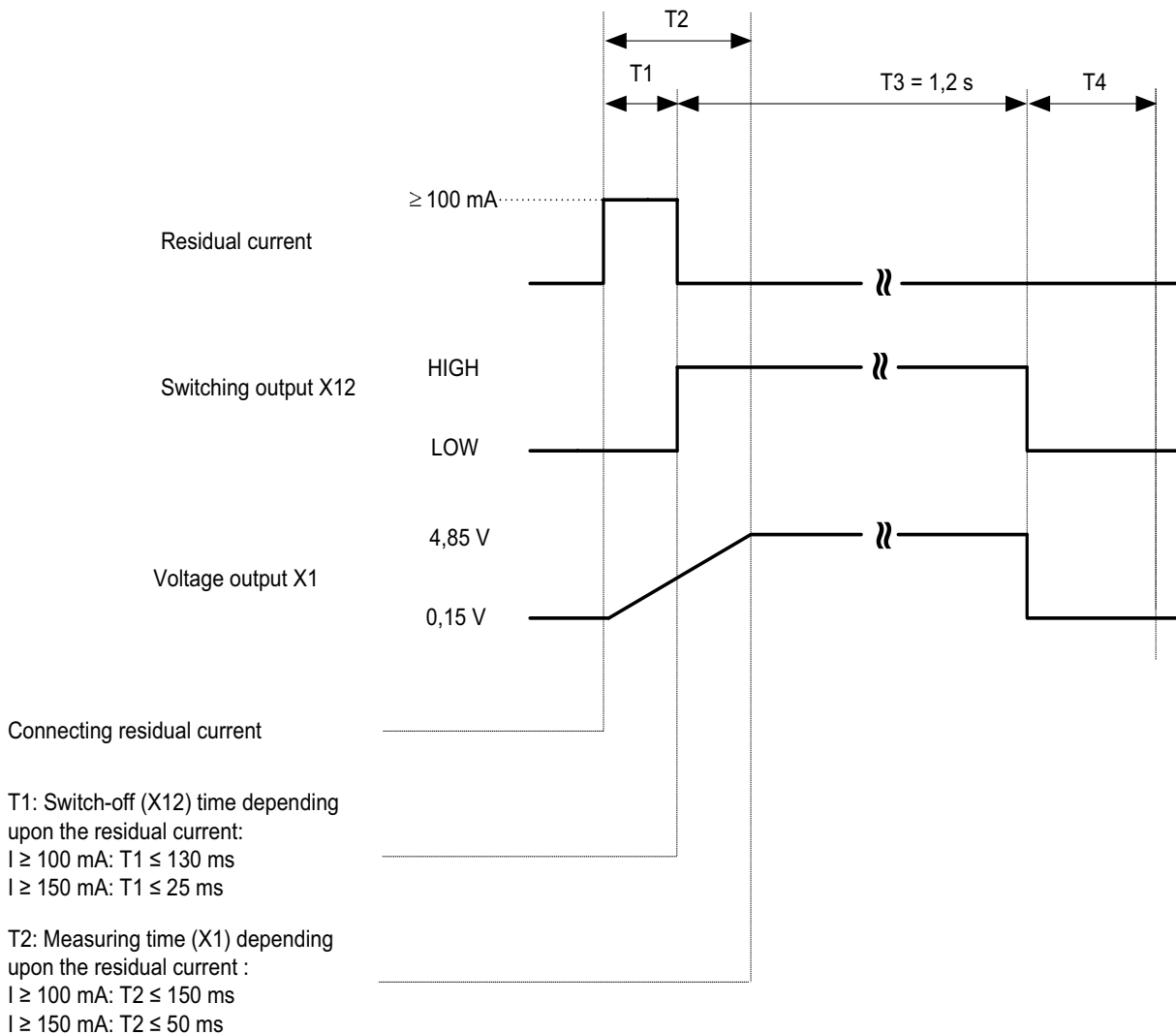
Calibration starts after applying a HIGH level with a pulse duration of $T2 = 50 \dots 100 \mu\text{s}$ at the control input X10. If the pulse duration is met, the residual current monitoring module will switch the switching output X12 to LOW level after 10...11 ms. Both the measurement of the supply voltage and calibration will be repeated.

In this way, the pulse T2 can be used to test the switching output X12.

If the input is not connected (continuous HIGH level), residual current measurement will take place 5 ms after testing the supply voltage.



2.8 Values outside the permissible measuring range



If the residual current exceeds the measuring range (residual current $\geq 100\text{mA}$), the residual current monitoring module RCMA278P-S will switch the Open-Collector output to HIGH once the measuring time $T1$ has elapsed.

In comparison to the switching output X12, the voltage at the analogue output X1 increases with a delay to $U_{x1} = 4.85 \text{ V}$ within the time $T2$. The switching time $T1$ of the switching output X12 and the rise time $T2$ of the voltage at the analogue output X1 are dependent on the value of the residual current. Refer to the legend of $T1$ and $T2$ of the diagram above.

After switching off the residual current $\geq 100 \text{ mA}$, the device stores the voltage value of the analogue output X1 and the status of the switching output X12 for the time $T3 = 1.2 \text{ s}$.

The level of the switching output X12 will only change to LOW when the residual current drops to values $\leq 15 \text{ mA}$.

2.9 Measuring range and measuring times

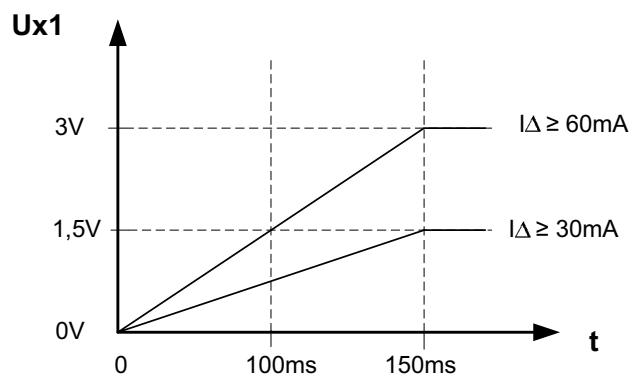
2.9.1 Measuring range

The measuring range of the residual current is 0...100 mA.

2.9.2 Measuring times

Change in residual current	Measuring time	ΔU_{X1}
$I_{\Delta} \geq 30 \text{ mA}$	< 150 ms	1.5 V
$I_{\Delta} \geq 60 \text{ mA}$	< 100 ms	$\geq 1.5 \text{ V}$

The measuring time starts when the residual current I_{Δ} changes and ends when the output voltage has changed in proportion to the residual current ΔU_{X1} of $\geq 1.5 \text{ V}$ at X1. The change in residual current is the amount of increase based on a static value within the measuring range. In this case, the measuring times can only be reached when the residual current I_{Δ} rises rapidly.



Switching times at the switching output X12:

Residual current	Measuring time
$I_{\Delta} \geq 100 \text{ mA}$	< 130 ms
$I_{\Delta} \geq 150 \text{ mA}$	< 25 ms

Residual currents higher than the measuring range result in a HIGH level at the switching output X12. This switching state will remain for 1.2 s after the value has dropped below the limit of the measuring range.

2.10 Fault detection and the resulting technical reactions

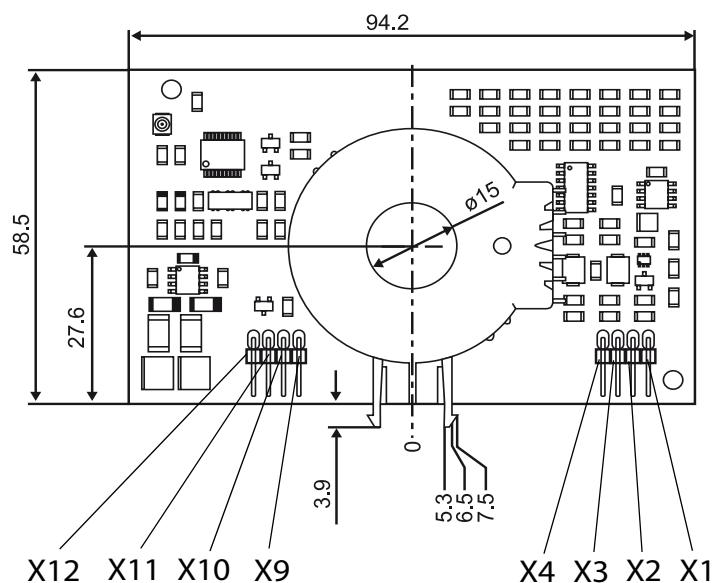
Type of fault	Detection	Reaction
Wire break in the residual current transformer	Frequency measurement via CT test input at the controller	X1 = 5.0 V X12 = HIGH
Short-circuit in the residual current transformer winding	Frequency measurement via CT test input at the controller	X1 = 5.0 V X12 = HIGH
Constant output voltage at the measuring oscillator	Frequency measurement via CT test input at the controller	X1 = 5.0 V X12 = HIGH
Failure of the controller clock (Main Clock)	The internal computer watchdog responds to the independent pulse	X1 = 5.0 V X12 = HIGH
Supply voltage failure	Monitoring module connects and disconnects residual current monitoring	X1 = 5.0 V X12 = HIGH
Open-Collector output constantly at LOW level	While connecting the supply voltage, when checking that the output switches to HIGH for 4 s; For details about time T4 refer to page 10	Detection by inverter operating control after connecting to supply voltage. Triggered via output X1
Analogue output constantly to LOW level	Output voltage outside the permissible voltage range	Disconnection of the inverter by operating control
Storage cell of the computer system defective	Detection by continuous self test	X1 = 5.0 V X12 = HIGH
Loss of return addresses from subprograms	Response of the internal watchdog	X1 = 5.0 V X12 = HIGH

3. Installation and connection

3.1 Installation

Refer to dimension diagrams on page 21.

3.2 Terminal assignment



Plug designation	Description
X1	Analogue voltage output
X2	$-U_s$: Voltage supply -12 V / -15 V
X3	GND: ground
X4	not connected
X9	GND: ground
X10	Control input: 0...5 V
X11	$+U_s$: Voltage supply +12 V / +15 V
X12	Switching output/alarm output (transistor, Open Collector)



The input supply voltages $+U_s$ and $-U_s$ at X2/X11 should be supplied by Limited Voltage/Limited Current source or a Class 2 power supply



If the supply voltages $+U_s$ and $-U_s$ at X2/X11 are outside the permissible voltage range, the signals at the outputs X1 and X12 may be outside the tolerance range!

3.2.1 Cable routing through the measuring current transformer

Only a UL listed jacket cord or a UL recognised component conductor (AWM Style 3271, AWG 10) with an additional UL recognised tubing suitable for the rated voltage around the conductor can be routed through the hole of the measuring current transformer.

Make sure to route the conductors centrally through the measuring current transformer!

4. Technical data

4.1 Data in tabular form

Voltage supply

$U_5 + (X11)$	12 V (± 1 V)
$U_5 - (X2)$	-12 V (± 1 V)
Alternative:	
$U_5 + (X11)$	15 V (± 1 V)
$U_5 - (X2)$	-15 V (± 1 V)
Power consumption	≤ 1 W

Measuring circuit

Operating characteristic acc. to IEC 60755	Type B
Frequency range	0 . . . 500 Hz
Measuring range	0 . . . 100 mA
Resolution	< 2 mA
Ripple max.	< 15 mV (effective)
Max. nominal current	50 A / 45 . . . 65 Hz

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/20 mA
Tolerance at 3...10 mA	0 . . . -20 % / ± 1 mA
Tolerance at 10...100 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	1.12..1.4 V
---	-------------

Specified time

Changes in residual current $I_{\Delta} \geq 30$ mA (output X1)	< 150 ms
Changes in residual current $I_{\Delta} \geq 60$ mA (output X1)	< 100 ms
Residual current $I_{\Delta} \geq 100$ mA (output X12)	< 130 ms
Residual current $I_{\Delta} \geq 150$ mA (output X12)	< 25 ms

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
Long-time 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... 100 %
Air pressure	70... 106 kPa

Connection

Plug-in connectors for PCBs, single-row	0.65 mm x 0.65 mm
Modular dimensions	2.54 mm

Other

Operating mode	continuous operation
Position of normal use	any
Weight	≤ 65 g

4.2 Ordering information

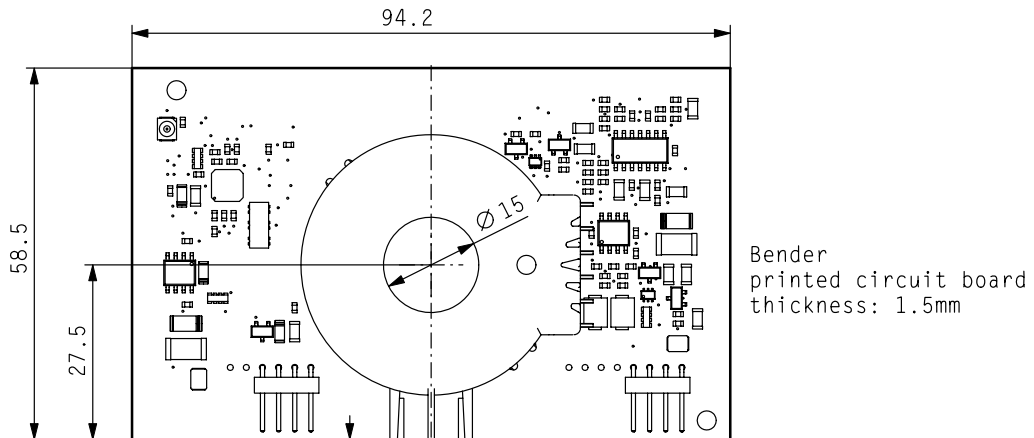
Type	Measuring range	Frequency range	Art. No.
RCMA278P-S	0...100 mA	0...500 Hz	B94042095

4.3 Approvals and Certifications

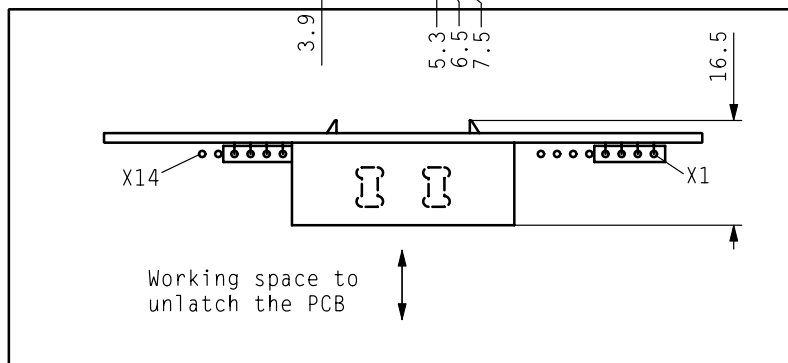


4.4 Dimension diagrams

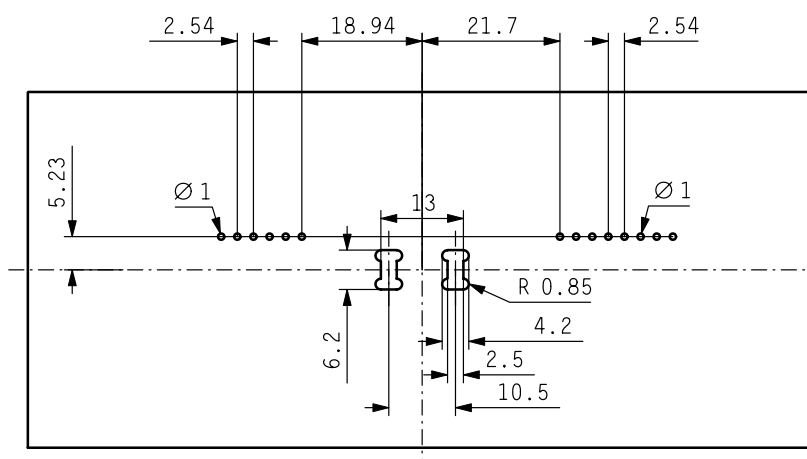
Dimensions are given in mm



Bender printed circuit board thickness: 1.5mm



Bender printed circuit board on a baseplate



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

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