MRCDB425-L

AC, DC and pulsed DC sensitive modular residual current device
for MRCD applications

Table of contents

1 General information

1.1 How to use the manual

ADVICE
This manual is intended for qualified personnel working in electrical engineering and electronics! Part of the device documentation in addition to this manual is the enclosed supplement "Safety instructions for Bender products".

ADVICE
Read the operating manual before mounting, connecting and commissioning the device. Keep the manual within easy reach for future reference.

1.2 Indication of important instructions and information

DANGER
Indicates a high risk of danger that will result in death or serious injury if not avoided.

WARNING
Indicates a medium risk of danger that can lead to death or serious injury if not avoided.

CAUTION
Indicates a low-level risk that can result in minor or moderate injury or damage to property if not avoided.

ADVICE
Indicates important facts that do not result in immediate injuries. They can lead to malfunctions if the device is handled incorrectly.

Information can help to optimise the use of the product.

1.3 Service and Support

Information and contact details about customer service, repair service or field service for Bender devices are available on the following website: https://www.bender.de/en/service-support.

1.4 Training courses and seminars

Regular face-to-face or online seminars for customers and other interested parties:

https://www.bender.de/en/know-how/seminars

1.5 Delivery conditions

The conditions of sale and delivery set out by Bender GmbH & Co. KG apply. These can be obtained in printed or electronic format.

1.6 Inspection, transport and storage

Check the shipping and device packaging for transport damage and scope of delivery. In the event of complaints, the company must be notified immediately. Please use the contact form at the following address: https://www.bender.de/en/service-support/take-back-of-old-devices/.

When storing the devices, observe the information under Environment / EMC in the technical data.

1.7 Warranty and liability

Warranty and liability claims for personal injury and property damage are excluded in the case of:

- improper use of the device
- incorrect mounting, commissioning, operation and maintenance of the device
- Failure to observe the instructions in this operating manual regarding transport, commissioning, operation and maintenance of the device
- unauthorised changes to the device made by parties other than the manufacturer
- non-observance of technical data
- Repairs carried out incorrectly
- the use of accessories or spare parts that are not provided, approved or recommended by the manufacturer
- Catastrophes caused by external influences and force majeure
- Mounting and installation with device combinations not approved or recommended by the manufacturer

This operating manual and the enclosed safety instructions must be observed by all persons working with the device. Furthermore, the rules and regulations that apply for accident prevention at the place of use must be observed.

1.8 Disposal of Bender devices

Abide by the national regulations and laws governing the disposal of this device.

Bender GmbH & Co. KG is registered in the waste from electrical and electronic equipment (WEEE) register under the WEEE number: DE 43 124 402. For more information on the disposal of Bender devices, refer to https://www.bender.de/en/service-support/take-back-of-old-devices/

1.9 Safety

If the device is used outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. In Europe, the European standard EN 50110 applies.

DANGER

Risk of fatal injury due to electric shock!

Touching live parts of the system carries the risk of:

- *Electrocution due to electric shock*
- *Damage to the electrical installation*
- *Destruction of the device*

Before installing the device and before working on its connections, make sure that the installation is de-energised.

Observe the rules for working on electrical systems.

2 Function

2.1 Intended Use

Modular residual current devices of type MRCDB425-L are designed for AC, pulsed DC, and smooth DC AC and pulsed DC residual and fault current measurement in earthed TN and TT networks. The devices can be used as an additional protective measure for the following protection goals, among others:

– Protection against indirect contact (DIN VDE 0100-410, IEC60364-4-41)
– Protection against thermal effects (DIN VDE 0100-420, IEC60364-4-42)
– System protection (DIN VDE 0100-430, IEC60364-4-43)
– Protection against fire risks (DIN VDE 0100-530, IEC60364-5-53)

According to IEC 60364-5-53 and DIN VDE 0100-530, it is intended for use in earthed power supplies (TN and TT systems).

Please note that the standards mentioned may contain further requirements for use.

A modular fault current device according to product standard IEC60947-2 Annex M is completed by a measuring current transformer designed for this purpose and a circuit breaker with undervoltage release (device combination).

ADVICE
According to the product standard IEC60947-2 Annex M.7.1, it must only be possible to adjust the response value by means of an intentional action. This requires a cover that can be sealed.

The supplied sealing cover must be installed!

Suitable measuring current transformers are listed in the technical data. The switching time of the circuit breaker with undervoltage release incl. tripping device under load must not exceed 20 ms.

The requirements of the system and operating conditions on site and the application must be taken into account by selecting a suitable device combination and individual parameterisation. Furthermore, the notes, instructions and specifications in this manual must be observed and implemented.

The devices are intended for operation in control cabinets or similarly protected environments.

For intended operation, observe the specifications in this manual. Any other use than that described in this manual is regarded as improper.

2.2 Device features

Besonderheiten

- 1 measuring channel for AC, pulsed DC, or AC/DC sensitive measuring
- Configurable frequency response
- Functionality can be expanded with unlockable software modules
- Simple configuration with Bender Connect App via NFC interface
- Customer-specific factory settings possible

Residual current measurement

- Modular residual current device (MRCD) in accordance with DIN EN IEC 60947-2 Annex M
- 1 channel for residual current measurement
- Either AC, pulsed DC, or AC/DC sensitive measuring

- Type A, type F, type B and type B+ characteristics can be set in accordance with IEC 60755 (or VDE 0664-400)
- Measurement of AC/DC (r.m.s. value) and AC and DC components
- Frequency range: DC, 15 Hz…20 kHz
- Frequency analysis up to the 400th harmonic, calculation of the THD value

Response value monitoring

- Main alarm with adjustable residual response value $I_{\Delta n}$
- Prewarning: 10…100 % of the residual response value $I_{\Delta n}$
- Separate evaluation of AC/DC (RMS) or AC and DC components
- Response value 30 mA…3 A
- Configurable frequency response
- Adjustable time delays
- Fault-memory behaviour selectable
- Start-up delay configurable
- Continuous CT-connection monitoring

Display and operation

- NFC interface for parameter setting with the Bender Connect App
- LED bargraph with
  - Device status LED
  - Percentage measurement indication
  - Alarm LEDs for prewarning and main alarm
- Integrated combined test/reset button, connection for external buttons
- Sealable transparent cover

Interfaces

- Digital input (I)
- Digital input/output (Q)
- Multifunctional digital/analogue output (M+)
- Alarm relays K1 and K2
- Modbus RTU (RS-485)
- NFC interface for device parameter setting via Bender Connect App with the device energised or de-energised

2.3 Functional description

2.3.1 Overview of device start-up and delay times

After the supply voltage U_S has been applied and the recovery time t_b has elapsed, the start-up delay t begins. During the start-up delay t, no alarms are signalled. The residual current is detected via an external measuring current transformer. If the measured value exceeds the response value of the pre-warning and/or the main alarm, the response delay t_{on} begins.

After t_{on} has elapsed, a prewarning or a main alarm is output via the respective outputs and interfaces and the corresponding alarm LED lights up. If the release value is reached before t_{on} has elapsed, no alarm is signalled: the LEDs do not light up and no prewarning or main alarm is output.

The set delay on release t_{off} starts when the measured value reaches the release value again after the alarm state has been triggered. When t_{off} has expired, the device returns to its initial state.

When fault storage is activated, the prewarning and main alarm are output via the interfaces and LEDs until a reset is carried out. A reset can be carried out via the interface or the combined test/reset button (T/R).

The T/R button can also be used to test the device, switch the NFC function on and off, set write protection and set the Modbus device address.

If the "Start with alarm" function (see Modbus register 32804) is selected , all alarms are set during device startup. The alarms are only reset when the device startup is complete and the device is ready to measure, no limit values are violated and no error messages are present.

2.3.2 Configure device start-up behaviour

Start-up delay

The device is operational and ready for measurement as soon as the supply voltage U_S has been created and the standby time t_b has elapsed. During start-up, the device does not report any prewarnings or main alarms.

With the adjustable start-up delay time *t*, the start-up can be delayed further in addition to the recovery time.

Start with alarm

The "Start with alarm" function controls the behaviour of an output during start-up.

When this function is enabled, the output behaves as if an alarm is present during start-up. The function is automatically terminated after the device has started up successfully and is reactivated the next time the device is started.

"Start with alarm" can be configured individually for each output.

Parameter		Adjustability	Modbus register	Range of values
Start-up delay *t*		yes	32900	0…900 s
Start with alarm for	K1	yes	32119	enabled | disabled
	K2	yes	32219	enabled | disabled
	Q	yes	32420	enabled | disabled
	M+	yes	32522	enabled | disabled

The function is enabled for all outputs in the factory settings.

2.3.3 Connection monitoring

The connection to the measuring current transformer is permanently monitored.

In the event of a fault, a message is output via the interfaces and the status LED flashes yellow.

After the fault has been fixed, the device automatically returns to the initial condition and the status LED lights up green. If the fault memory is activated, the alarm messages are only deleted by a reset.

The corresponding LEDs flash yellow for this period.

2.3.4 Manual self test

The device performs a manual self-test by pressing the T/R-button (3...6 s).

Users need to carry out the manual self test periodically (at least every 6 months).

2.3.5 Malfunction

In the event of an internal malfunction, the status LED changes its colour from green to red or yellow. The error code can be queried via the device interfaces.

2.3.6 Delay times t_b, t, t_{on} and t_{off}

The times t_b, t, t_{on} and t_{off} described below delay the output of alarms via LEDs, , relays and Modbus RTU.

Recovery time t_b
The recovery time is the time the device needs to be ready for measurement after the supply voltage U_S has been connected.

Start-up delay t
After the supply voltage U_S has been connected, the measuring function is delayed by the set time t plus the recovery time t_b.

Response delay t_{on}
If values exceed or fall below the defined residual-operating-current limits, the residual current monitor needs the response time t_{an} to output the alarm. A set response delay t_{on} is added to the device-specific operating time t_{ae} and delays signalling:
Response time $t_{an} = t_{ae} + t_{on}$
If the fault does not persist during the response delay, the alarm is not signalled.

ADVICE
A response delay can only be set if the response value $I_{\Delta n} > 30$ mA.
For response values $I_{\Delta n} \leq 30$ mA, the MRCDB425-L always triggers immediately ($t_{on} = 0$ s).

Delay on release t_{off}
If the alarm no longer exists and the storing of a fault in the memory has been disabled, the alarm LEDs go out and the alarm relays switch back to the initial status. By means of the delay on release, the alarm state is maintained for the selected period.

2.3.7 Alarm assignments

Messages relating to

- Test
- Device error
- Prewarning
- Main alarm $I_{\Delta n}$
- CT connection fault
- Start with alarm

can be assigned to the outputs via the device interface. Details can be found in the channel descriptions of the outputs and in the Modbus register overview.

Further information

"Modbus register overview", page 39

"Interfaces", page 23

2.3.8 Response value monitoring

The response value monitoring triggers a prewarning or a main alarm as soon as the measured value violates the response values for prewarning or main alarm and can be set individually. A violation of a response value occurs as soon as a measured value violates a response value at least for the response time t_{an}. The response time t_{an} results from the device related operating time t_{ae} and the adjustable response delay t_{on} ($_{an} = t_{ae} + t_{on}$).

ADVICE

A response delay t_{on} can only be set for response values $I_{\Delta n} > 30$ mA. For response values $I_{\Delta n} \leq 30$ mA, the MRCDB425-L always triggers immediately ($t_{on} = 0$ s).

The start-up delay time t_{on} is reset before it has elapsed as soon as the measured value no longer violates the response value.

An alarm (prewarning or main alarm) is automatically reset as soon as a measured value no longer violates the response value plus a hysteresis for the duration of the delay on release toff. An activated fault memory function prevents this automatic reset. The delay on release t_{off} is reset before its expiration as soon as the measured value violates the response value again.

Monitoring function

The **overcurrent mode** checks whether the measured value exceeds a response value.

Response values

Depending on the type of transformer connected, the following response values are available for the prewarning and the main alarm. The response value for the main alarm is set as an absolute value, while the response value for the prewarning is set as a percentage of the response value for the main alarm.

Measured value	Prewarning	Main alarm
RMS	Yes	Yes
AC	Yes	No
DC	Yes	No

ADVICE

Response values that are too far apart have a negative effect on the measuring accuracy and can trigger a device error ('invalid CT setting', error code 4.75...7.78).

Even if you only want to monitor the RMS value with a "Type B" measuring current transformer, **always set the AC and DC values to the same values as the RMS values** *for the prewarning and main alarm.*

Alarm signalling

The signalling of an alarm (prewarning, main alarm) is carried out

- via the alarm LED(s)
- via message assignment using an output (Q, M+, K1 and K2)
- via Modbus register for alarm and measured values (register 999…1044)

Settings

Parameter	Adjustable	Modbus register
Main alarm response values	Yes	32616
Prewarning response values	Yes	32624; 32628; 32632
Hysteresis	Yes	32704
Response delay t_{on}	$I_{\Delta n} \leq 30$ mA: No ($t_{on} = 0$) $I_{\Delta n} > 30$ mA: Yes	32902 [1)]

Parameter	Adjustable	Modbus register
Delay on release t_{off}	Yes	32910

1) If $I_{\Delta n} \leq 30$ mA, custom register entries are ignored.

2.3.9 Factory settings

There are two ways to carry out a reset:

Factory settings without interface
After restoring the factory settings, all previously changed settings are reset to the state upon delivery. The settings for the Modbus interface are not reset.

Factory settings with interface
After restoring the factory settings, all previously changed settings including the settings for the Modbus interface and the device address are reset to the state upon delivery.

These settings are configured in Modbus registers 60000…60003, function 4.

2.3.10 Combined function button (T/R button)

Reset = pressing the T/R button 1…3 s

Test = pressing the T/R button 3…6 s

NFC = pressing the T/R button 6…10 s

Addr. = pressing the T/R button 10…15 s

2.3.11 Fault memory

The storing of a fault in the memory can be enabled or disabled. When the fault memory is enabled, stored alarms can be reset by performing a reset. The storing of a fault in the memory is factory-set to disabled.

2.3.12 NFC interface

The NFC interface can be used to transmit a previously configured device parameter setting directly to the device.

This function is available only via the Bender Connect App. You can find this app in the Appstores for iOS and Android.

Download on the App Store

In the Bender Connect app the device first needs to be made known. Then the device-specific setting options are shown so that they can be configured. When the data is transferred, feedback is given whether the parameter configuration has been successful. Parameter settings can be transmitted to the device via the Bender Connect app by holding the mobile phone close to the device.
To a **de-energised** device, a parameter setting can be transferred via the Bender Connect app. This setting is then activated automatically when the device is connected to the current supply.

GET IT ON Google Play

When a device is **plugged in**, too, parameters can be configured via the Bender Connect App. To this end, the NFC interface first needs to be activated in the device.

The NFC interface is activated via the T/R button at the front of the device or via the Modbus interface.

The NFC antenna is located at the front on the righthand side of the MRCDB425-L.

2.3.13 Software update

After a software update, the device must first be reset to its factory setting. After that, all parameters can be adjusted again.

Further information

32006

Function 4: Reset to factory settings with/without interface parameters

2.3.14 Offset calibration

The combination of measuring current transformer and MRCDB425-L must be calibrated in the system to the same level to ensure the accuracy of the differential current measurement.

During device start-up (e.g. after a shutdown), an automatic offset calibration is performed. The offset calibration can be triggered manually at any time via register 59004.

The system is switched off during the offset calibration.

ADVICE
The supply voltage of the device must always be taken **before** *the circuit breaker.*

3 Dimensions, mounting and connection

Only skilled persons are permitted to carry out the work necessary to install, put into service and run a device or system.

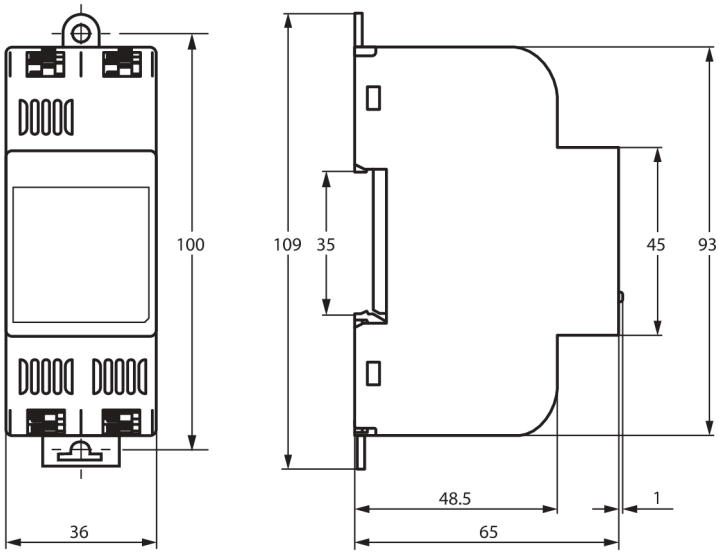
DANGER
Risk of fatal injury due to electric shock!
Touching live parts of the system carries the risk of:

- *Risk of electrocution due to electric shock*
- *Damage to the electrical installation*
- *Destruction of the device*

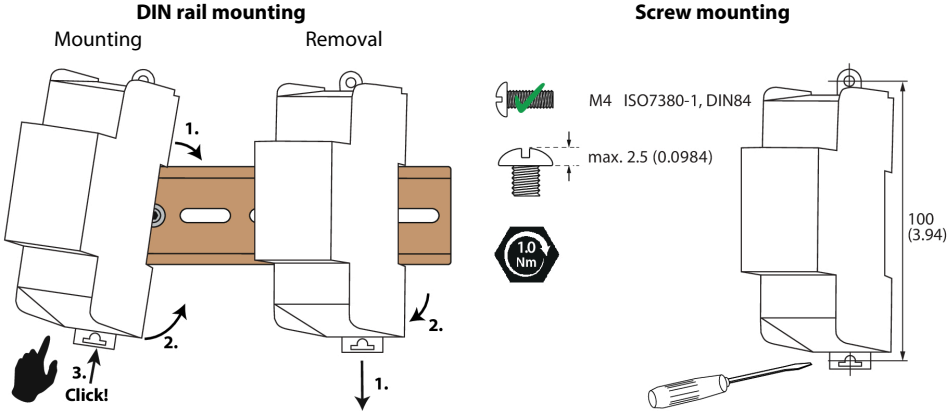
Before installing the device and before working on its connections, make sure that the installation has been de-energised. The rules for working on electrical systems must be observed.

3.1 Dimension diagrams

Dimensions in mm



3.2 Mounting and removal

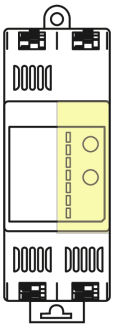


Dimensions in mm (inch)

3.3 Sealable transparent cover

The transparent cover prevents settings on the device from being changed. Hook the two hooks on the cover around the top of the enclosure and press the bottom edge around the bottom of the enclosure.

Position of the transparent cover (yellow)



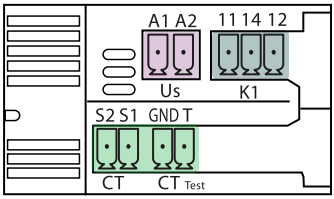
ADVICE

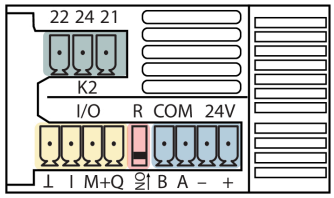
According to the product standard IEC60947-2 Annex M.7.1, it must only be possible to adjust the response value by means of an intentional action. This requires a cover that can be sealed.

The supplied sealing cover must be installed!

3.4 Connection

3.4.1 Connections overview

Top	Terminal	Description
	A1, A2	Supply voltage AC/DC
	11, 14, 12	Relay K1
	S1, S2 (CT)	Measuring-current transformer CT
	GND, T	Test measuring-current transformer

Bottom	Terminal	Description
	21, 24, 22	Relay K2
	⊥	GND
	I	Digital input
	M+	Multifunctional output
	Q	Digital input/output
	ON (R)	Termination of RS-485 interface
	A, B	RS-485 interface: Modbus RTU
	+, -	Supply voltage DC

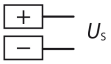
3.4.2 Supply voltage U_S

The device has two separate supply voltage connections US (A1, A2 and +, -). The technical data must be observed.

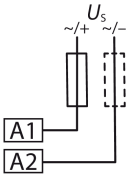
CAUTION
Incorrect connection of the power supply
Irreparable damage to the device
Incorrect wiring of the power supply (AC 230 V to DC 24 V connection) causes the device to be destroyed.
Ensure that the wiring is correct!

ADVICE
Only one of the two supply voltages is allowed to be connected!

ADVICE
The supply voltage of the device must always be taken **before** *the power switch.*



The wiring of + and - is done on the **bottom** of the device.
Only power supply units of protection classes 2 or 3 are to be used.



The wiring of A1, A2 is done on the **upper side** of the device.
Recommended backup fuse: 6 A fast acting
When the device is supplied from a **non-earthed** system, **two fuses** must be used.
At least **one** fuse must be used in **earthed** systems.

3.4.3 Measuring current transformer test

CTUB102 series measuring current transformers can be tested.

A measuring current transformer test must be carried out via the test terminals T and GND with 2 separate lines (< 10 m) between MRCDB425-L and the CTUB102.

3.4.4 Note on wiring diagrams

To fulfil the requirements of IEC 60947-2 Appendix M, the MRCDB425-L must be operated in the failsafe operation in conjunction with a circuit breaker with undervoltage trigger or working current trigger. The circuit breaker must be able to switch off in less than 20 ms and must comply with the IEC 60947-2 standard.

We recommend operating the signalling relay K2 in **failsafe operation**. This enables the failure of the power supply and the failure of the internal power supply unit to be detected and signalled.

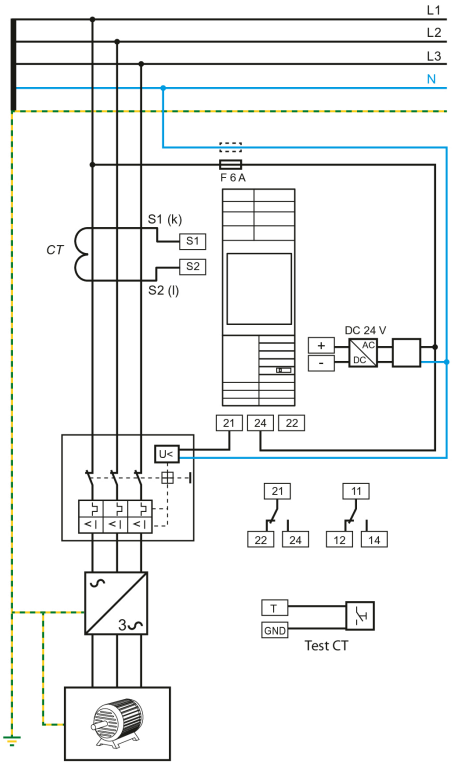
For reasons of economical installation, the signalling relay K2 can be operated in **non-failsafe operation**. Due to this mode of operation, it must be ensured that the test intervals are carried out at shorter intervals by means of a risk assessment in order to minimise the risk.

In the second case (**non-failsafe operation**), a concept for dealing with an interruption of the MRCD's power supply must generally be developed as part of the risk assessment.

3.4.5 Connection diagram with undervoltage release

Triggering via undervoltage release (fail-safe mode)

Parameter	Settings	Modbus register	Factory settings
Message assignment relay K2: Start with alarm	Enabled	32219	Enabled
Relay mode Relay K2	Failsafe mode	32200	Failsafe mode



Wiring diagram for undervoltage release

DC 24 V

MRCDB425-L and the connected CTUB102-CTBCxx must be supplied from the same power supply unit. **Alternatively**, a MRCDB425-L can be connected via terminals A1/A2 with AC 100…240 V. Fuses for US: 6 A fast

ADVICE

The supply voltage of the device must always be taken ***before*** *the circuit breaker.*

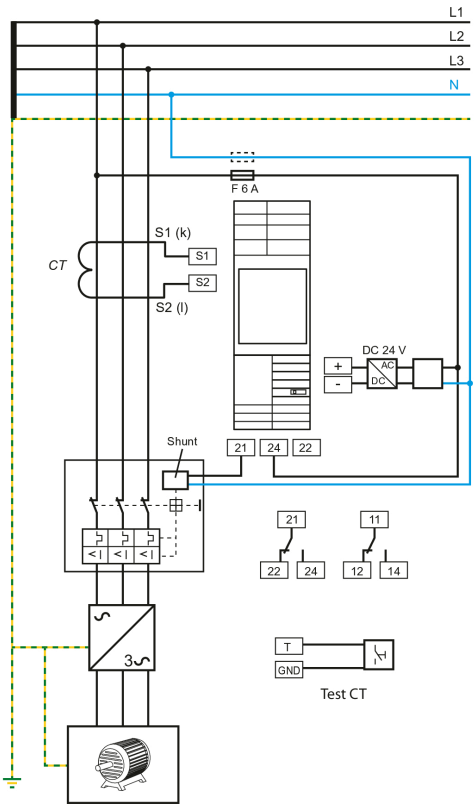
For UL applications:

The measuring current transformer must be connected before operation.

3.4.6 Connection diagram with shunt release

Triggering via shunt release

Parameter	Settings	Modbus register	Factory settings
Message assignment relay K2: Start with alarm	Disabled	32219	Enabled **ADVICE** *Manual configuration required!*
Relay mode Relay K2	Non-failsafe mode	32200	Failsafe mode **ADVICE** *Manual configuration required!*



Wiring diagram for shunt release

DC 24 V

MRCDB425-L and the connected CTUB102-CTBCxx must be supplied from the same power supply unit. **Alternatively**, a MRCDB425-L can be connected via terminals A1/A2 with AC 100…240 V. Fuses for US: 6 A fast

ADVICE

The supply voltage of the device must always be taken ***before*** *the circuit breaker.*

For UL applications:

The measuring current transformer must be connected before operation.

4 Interfaces

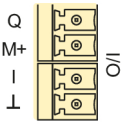
4.1 NFC (Near field Communication)

The NFC interface can be used to transmit a previously configured device parameter setting directly to the device.

This function is available only via the Bender Connect App. You can find this app in the Appstores for iOS and Android.

In the Bender Connect app the device first needs to be made known. Then the device-specific setting options are shown so that they can be configured. When the data is transferred, feedback is given whether the parameter configuration has been successful.
Parameter settings can be transmitted to the device via the Bender Connect app by holding the mobile phone close to the device.
To a **de-energised** device, a parameter setting can be transferred via the Bender Connect app. This setting is then activated automatically when the device is connected to the current supply.
When a device is **plugged in**, too, parameters can be configured via the Bender Connect App. To this end, the NFC interface first needs to be activated in the device.

4.2 Digital inputs and outputs (overview)



Element	Explanation
Q	**Digital input/output** • Input: Execute test or reset • Output: Common alarm according to alarm assignment
M+	**Multi-functional output** • Digital output: Common alarm according to alarm assignment • Analogue voltage or current output: For the direct connection of analogue instruments that analyse and display measured values.
I	**Digital input** Execute test and/or reset, configurable with low-active and high-active.
⊥	**GND** connection of the inputs/outputs

When commissioning the system, an output signal should be verified by an alternative method (e.g. Modbus interface or the behaviour of another output). In general, redundant monitoring (e.g. using the interface or another output) is recommended when using the analogue/digital outputs.

4.3 Digital input and output Q

Settings in registers 32400…32420

Bei Verwendung als **Ausgang** können mithilfe der Meldezuordnungen folgende Alarme zugewiesen werden (Register 32402…32420):

When it is used as an **input**, a test or reset can be triggered (register 32401).

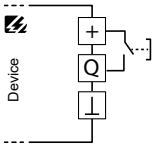
When it is used as an **output**, the following alarms can be assigned via the alarm assignments (registers 32402…32420):

Prewarning (AL1) CT AC/DC/RMS	The output becomes active if AL1 of the measuring channel is present.
Main alarm (AL2) CT AC/DC/RMS	The output becomes active if AL2 of the measuring channel is present.
CT-connection fault CT	The output becomes active if a CT-connection fault (short circuit or interruption) of the measuring channel is present.
Overloading of the measuring channel	The output becomes active if the measuring function no longer works properly since the residual current is too high.
Device error	The output becomes active when a device error is present.
Test	The output becomes active in the course of a manual self test in accordance with the test process.
Start with alarm	Output is active during device start-up.

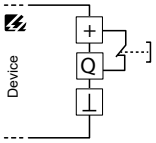
4.3.1 Input

The following settings can be assigned to input Q:

High-active: Event is carried out, when the digital input undergoes a signal change from low to high.



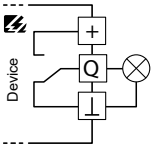
Low-active: Event is carried out, when the digital input undergoes a signal change from high to low.

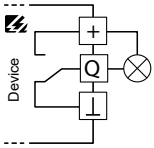


4.3.2 Output

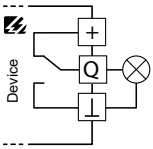
The output Q can be operated in the modes Active, Passive or Permanent. The following settings can be assigned:

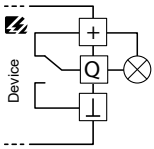
High-active: In the active mode +24 V are internally applied to output Q.



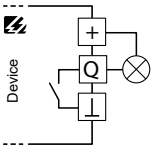


Low-active: In the active mode the GND potential is applied to output Q.

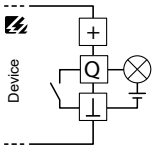




In the **passive mode** an external voltage can be connected (see Technical data). The output switches the applied potential to GND.

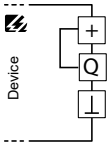


internally

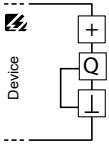


externally

Permanently high: The output is permanently set to +24 V.



Permanently low: The output is permanently switched to GND. In this manner e. g. an additional reference for the digital input can be created.



4.4 Output M+

M+ is a multifunctional digital/analogue output with reference to GND.

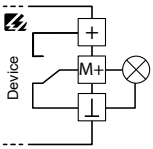
4.4.1 Digital mode

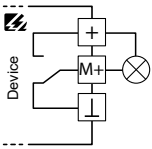
Settings in registers 32500…32501

In digital mode, M+ can be operated in Active, Passive or Permanent mode. The following settings can be assigned:

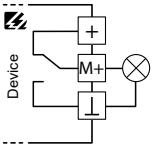
M+ = Active

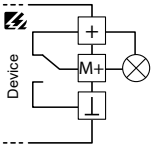
High-active: In the active mode +24 V are applied to output M+ internally.





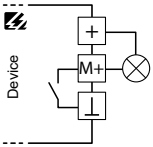
Low-active: In the active mode the GND potential is applied to output M+.

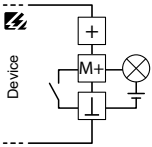




M+ = Passive

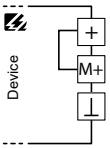
In the passive mode an external voltage can be connected (see Technical data). The output switches the applied potential to GND.





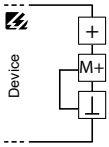
M+ = Permanently high

The output is permanently set to +24 V.



M+ = Permanently low

The output is permanently switched to GND. In this manner e. g. an additional reference for the digital input can be created.



Mithilfe der Meldezuordnungen können dem Ausgang M+ im Digitalmodus folgende Alarme zugewiesen werden (Register 32504…32530):

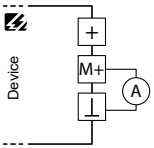
Prewarning (AL1) CT AC/DC/RMS	The output becomes active if AL1 of the measuring channel is present.
Main alarm (AL2) CT AC/DC/RMS	The output becomes active if AL2 of the measuring channel is present.
CT-connection fault CT	The output becomes active if a CT-connection fault (short circuit or interruption) of the measuring channel is present.
Overloading of the measuring channels	The output becomes active if the measuring function no longer works properly since the residual current is too high.
Device error	The output becomes active when a device error is present.
Test	The output becomes active in the course of a manual self test in accordance with the test process.
Start with alarm	Output is active during device start-up.

4.4.2 Analogue mode

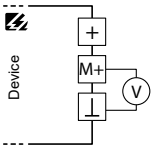
Settings in registers 32500…32503

The RMS value of channel CT is allocated to M+ as analogue output. Here a DC voltage or DC current signal that is proportional to the measured value is present at the output. The maximum scale value can be configured. The following settings can be assigned:

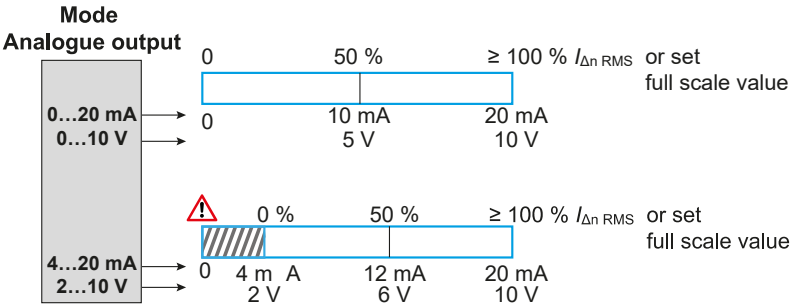
Current output: 0-20/4-20 mA



Voltage output: 0-10/2-10 V



The maximum scale value corresponds to $I_{\Delta n\ RMS}$ or it can be set at will up to 5 x $I_{\Delta n}$, max. 65 A. The overview shows how the measured values I_{Δ} (A) of the output signals (in A or V) are shown as proportional values.



Explanation to ⚠ in the diagram:
In the 4…20 mA or 2…10 V mode an output value of 0 mA or 0 V is a sign of a wiring fault of the analogue interface.

4.5 Digital input I

Settings in registers 32300…32301

The digital input "I" can read the status of a potential-free contact.

The digital input "I" can trigger either a test, a reset or the combined function T/R (register 32301). As with the test and reset function of the T/R-button, the combined function T/R is located at the front.

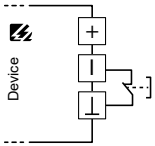
Example (high-active mode)

Closing the contact and opening it within 1…3 s.	Activates the reset function.
Closing the contact and opening it within 3…6 s.	Activates the test function.
Closing the contact and not opening it again (faulty contact).	No function change. A faulty switch can be detected immediately!

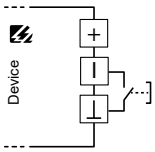
The NFC, address setting, and protect functions are not activated via this input.

The following settings can be assigned to input I:

High-active: Event is carried out, when the digital input undergoes a signal change from low to high.



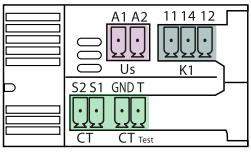
Low-active: Event is carried out, when the digital input undergoes a signal change from high to low.



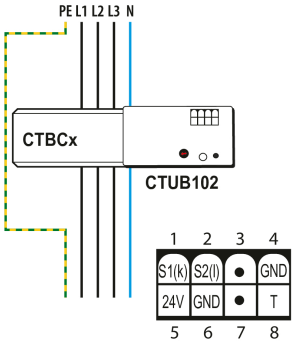
The response delay and the delay on release of the digital input are set to 100 ms each.

4.6 Input CT

4.6.1 Wiring of measuring current transformer type B/B+



MRCDB425-L top side



Ensure the connection of the measuring current transformer is correct.

Nr.	Terminal CTUB102	Terminal MRCDB425-L	Function
1	S1 (k)	S1	Connection of measuring current transformer
2	S2 (l)	S2	
4	GND	GND	Connection test input
8	T	T	
5	24 V	-	Power supply for measuring current transformer (external power supply unit)
6	GND		

For more information on the wiring of measuring current transformers, please refer to the relevant manuals for the measuring current transformers. The installation instructions provided there must be observed.

4.6.2 Suitable measuring current transformers

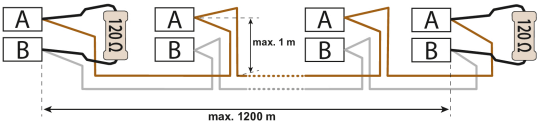
Series CTUB
CTUB102-CTBC20(P)
CTUB102-CTBC35(P)
CTUB102-CTBC60(P)
CTUB102-CTBC120(P)
CTUB102-CTBC210(P)

4.7 RS-485 interface

Spezification

The device has an RS-485 interface with Modbus RTU protocol. In a system setup it is therefore compatible with other Modbus RTU-capable device series from Bender, such as e. g. the RCMB300 series, RCMS150-01, and RCMB13…-01. Up to 247 Modbus-RTU devices can be used on the bus.

The RS-485 specification restricts the cable length to 1200 m and requires a daisy chain connection.



As bus cable a twisted-pair, shielded cable, shield on one side to PE, must be used. CAT6/CAT7 or J-Y(St)Y min. 2 x 0.8 are suitable.

If there are several devices with their own power supply units on the bus, protection against direct contact shall be ensured, as the maximum permissible total leakage current of 0.5 mA can be exceeded.

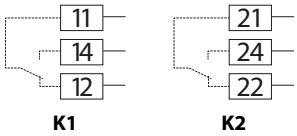
Termination

The bus line must be terminated at both ends with resistors (120 Ω, > 0.25 W).

A terminating resistor is installed in the device and can be enabled or disabled with the DIP switch at the underside of the housing.

4.8 Relay

The terminals 11, 14, 12 and 21, 24, 22 are the relay outputs of K1 and K2. The following settings can be made via the interface:



Function	Setting options		Description
	K1	K2	
Operating mode	Non-failsafe mode | Failsafe mode		This parameter determines the operating mode of the relay. Non-failsafe mode = coil is energised during alarm state Failsafe mode = coil is energised during normal operation
Message assignment **Test**	on | off	- (on, fixed)	This parameter determines whether the relay is actuated during a test
Message assignment **Device error**	on | off	- (on, fixed)	The relay switches if a device error exists
Message assignment **Prewarning**	on | off	-	The relay switches if the prewarning threshold has been exceeded
Message assignment **Main alarm** RMS	-	- (on, fixed)	The relay switches if the residual operating current has been exceeded
Message assignment **CT connection fault**	on | off	- (on, fixed)	The relay switches if a measuring current transformer connection fault exists

Function	Setting options		Description
	K1	K2	
Message assignment **Overload measuring channels**	on | off		Relay switches when the measuring range is exceeded
Message assignment **Start with alarm**	on | off		Relay switches during device start-up

ADVICE

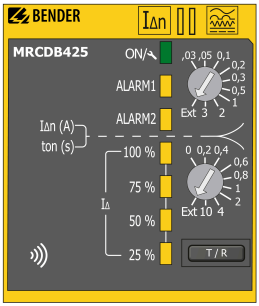
Attention! High contact currents damage the hard gold plating of the relay contacts. Damaged contacts prevent the relay from switching correctly at low contact currents.

When commissioning the system, an output signal should be verified by an alternative method (e.g. Modbus interface or the behaviour of another output). In general, redundant monitoring (e.g. using the interface or another output) is recommended when using the analogue/digital outputs.

If increased safety requirements apply, the error messages must also be monitored via Modbus RTU in addition to the relay.

5 Operation and settings on the device

5.1 Control panel



Control panel	Meaning
ON/	STATUS LED Operating mode
ALARM 1	ALARM LED Pre-warning
ALARM 2	ALARM LED Main alarm
25, 50, 75, 100 %	VALUE INDICATOR LEDs Residual current I_{Δ}
IΔn (A)	POTENTIOMETER 1 – Residual operating current $I_{\Delta n}$
ton (s)	POTENTIOMETER 2 – Response delay t_{on}
T/R	Test/reset button

5.2 Overview of the display menu

The menu button is used to access the device menu. The following items can be set or read out directly on the device. All other settings are only set or read out via Modbus.

Details follow in the next few paragraphs.

5.3 Settings

5.3.1 Measuring points

5.4 STATUS LED

Multicoloured display of various operating modes.

LED	Operating mode
Green	START PHASE Device booting after start NORMAL OPERATION Device in fault-free state
Yellow, flashing	CT FAULT Connection fault measuring current transformer
Yellow	DEVICE ERROR reversible Troubleshooting required.
Red	DEVICE ERROR irreversible Device replacement required.
Blue, flashing (frequency approx. 2 s)	NFC ACTIVE

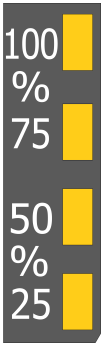
5.5 ALARM LEDs

Display of prewarning AL1 and main alarm AL2

LED	Operating state
ALARM1	PRE-WARNING Lights up continuously when the prewarning threshold has been exceeded.
ALARM2	MAIN ALARM Flashes when the residual-operating-current threshold $I_{\Delta n}$ has been exceeded.

5.6 VALUE DISPLAY LEDs

Display of the measured value as a percentage of the residual operating current $I_{\Delta n}$ (incl. relative uncertainty)



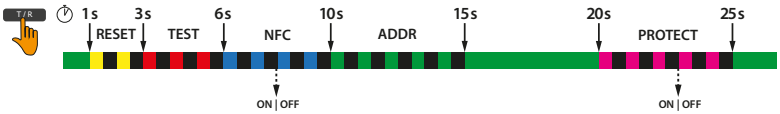
LED	Operating state
100	Lights permanently when the present measured value is > 100 % of $I_{\Delta n}$
75	Lights permanently when the present measured value is > 75 % of $I_{\Delta n}$
50	Lights permanently when the present measured value is > 50 % of $I_{\Delta n}$
25	Lights permanently when the present measured value is > 25 % of $I_{\Delta n}$

5.7 T/R BUTTON

The T/R button activates different operating modes depending on how long it is pressed.

Mode	Operating time	STATUS LED
RESET	1…3 s	flashes yellow
TEST	3…6 s	flashes red
NFC	6…10 s	flashes blue
ADDR	10…15 s	flashes green
PROTECT	20…25 s	flashes violet

Overview



"RESET" function

The "RESET" function on the button resets stored alarm states.

"TEST" function

The "TEST" function simulates a residual current of 1.5 x $I_{\Delta n}$ for a period of 5 seconds. During this period, the device has the following states:

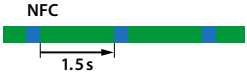
- Display of the alarm value via the LEDs and the interface.
- The test status can be read out via the interface:

- 0 = no test
- 1 = internal test
- 2 = external test (interface)

• For the duration of the test t_{on} and t_{off} are set to 0 s.

"NFC" function

The "NFC" function changes the current activation status of the NFC interface, when the T/R button is pressed and held for a period of 6…10 s. The NFC interface disables automatically within 5 minutes, in case it has not been disabled manually before.



Status indication of normal operation with the NFC interface activated

"ADDR" function

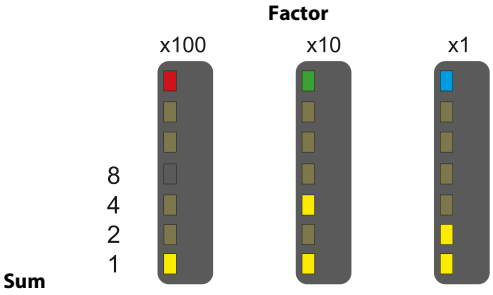
The "ADDR" function switches the device to address setting mode for the RS-485 address. The channel indication LEDs and the status LED indicate the device's address.

How to enter an address:

1. Press and hold the T/R button until status LED flashes green (10…15 s).
   – After the T/R button is released, the status LED lights red.
2. Set HUNDREDS digit. Press T/R button briefly until the desired value appears. Press and hold T/R button once (> 2 s) to confirm.
   – After the T/R button is released, the status LED lights green.
3. Set TENS digit. Press T/R button briefly until the desired value appears. Press and hold T/R button once (> 2 s) to confirm.
   – After the T/R button is released, the status LED lights blue.
4. Set UNITS digit. Press T/R button briefly until the desired value appears. Press and hold T/R button once (> 2 s) to confirm.
5. To exit the address setting mode, press and hold T/R button once (2 s).
   – After the T/R button is released, the status LED lights green.

The address values are displayed via BCD code.

Addresses can only be entered within the valid address range. When there is no input for a period of 5 minutes, the device automatically exits the address setting mode. The device then uses the currently set Modbus address.



Current address: 153

"PROTECT" function

The "PROTECT" function on the T/R button locks or enables write access to the Modbus registers of the individual parameters. Modbus register 32007 "Write access" can only lock write access but cannot enable it.

- When the T/R button is activated for at least 20 seconds, the status LED changes from continuously green to flashing violet and remains like this for the next 5 seconds when the button continues to be pressed.
- When the T/R button is released while the status LED is flashing violet, the activation state of the Modbus register " Write access" switches from the current selection of the two possible states to the other state, i. e. from "enabled" to "locked" or vice versa.

5.8 Potentiometer

The residual operating current $I_{\Delta n}$ and the response delay time can be set directly on the device using the potentiometers. A value set on the potentiometer is always effective.

A value can only be set via Modbus in the **Ext** position. A value set via Modbus remains temporarily stored in the Modbus register when the potentiometer is adjusted and is reloaded when the **Ext** position is selected again.

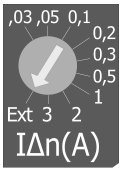
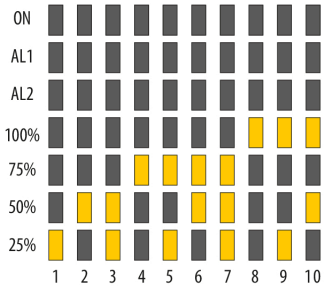
As soon as one of the two potentiometers is adjusted, its position is displayed in binary code via the LEDs.

5.8.1 Potentiometer residual operating current

As soon as the potentiometer is adjusted, its position is displayed in binary code via the LEDs.

ADVICE

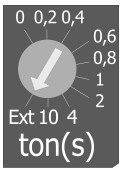
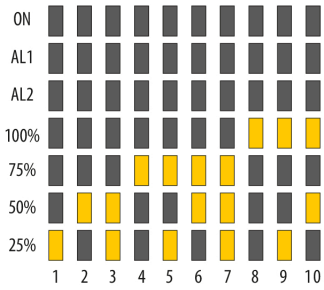
During commissioning and whenever a potentiometer is adjusted, check the correct potentiometer setting via the LED display.

Setting potentiometer		Position	Binary LED display
	0.03 A	1	
	0.05 A	2	
	0.1 A	3	
	0.2 A	4	
	0.3 A	5	
	0.5 A	6	
	1 A	7	
	2 A	8	
	3 A	9	
	Ext	10	

5.8.2 Potentiometer response delay

ADVICE

During commissioning and whenever a potentiometer is adjusted, check the correct potentiometer setting via the LED display.

Setting potentiometer		Position	Binary LED display
	0 s	1	
	0.2 s	2	
	0.4 s	3	
	0.6 s	4	
	0.8 s	5	
	1 s	6	
	2 s	7	
	4 s	8	
	10 s	9	
	Ext	10	

6 Modbus interface

Overview

The following Modbus function codes are supported:

- Holding registers for reading out values (Read Holding Register; function code 0x03)
- Registers for device programming (Write Multiple Registers; function code 0x10)

For a complete Modbus-protocol specification, visit http://www.modbus.org.

Read and write permissions

RO	Read Only (read access only)
RW	Read/Write (read and write access)
WO	Write Only (write access only)

Data types

Float	IEEE754 32-Bit (single precision floating point number)	4 bytes
INT16	Signed 16-Bit Integer	2 bytes
INT32	Signed 32-Bit Integer	4 bytes
UINT8	Unsigned 8-Bit Integer	1 byte (shown as 2 bytes)
UINT16	Unsigned 16-Bit Integer	2 bytes
UINT32	Unsigned 32-Bit Integer	4 Bytes
String UTF8	ASCII character string	

Register ranges

Range	Start address	End address
Info	0	998
Alarm and measuring values	999	1999
Monitoring functions	2000	2999
Status informationen	3000	3999
Harmonic analysis	5000	5699
Modbus RTU parameters	32000	32099
Relay 1	32100	32199
Relay 2	32200	32299
Input "I"	32300	32399
Input/output "Q"	32400	32499
Output "M+"	32500	32599
Response values	32600	32699
Function/response behaviour	32700	32799
Alarm behaviour	32800	32899
Time response	32900	32999
Monitoring functions	33000	33010
Measuring-current transformer	33100	33110
Device error codes	5800	58999
Control commands	59000	59010
Function-control commands	60000	60003

6.1 Device-information registers

Device information (registers 0…998)

Register	Description	Format	Bytes	Prop-erty	Value/Unit/Comment
0	Device name	String UTF8	32	RO	e.g.: MRCDB425-L-2
16	Article number	String UTF8	32	RO	e.g.: B74604040
32	Serial number	String UTF8	32	RO	10 digits, e.g.: 2002123456
48	Manufacturer	String UTF8	32	RO	Bender GmbH & Co. KG
64	Application D number	UINT16	2	RO	631 = D631

Register	Description	Format	Bytes	Property	Value/Unit/Comment
65	Application version number	UINT16	2	RO	xxx = Vx.xx
66	Application build number	UINT16	2	RO	Build#
67	Boot loader D number	UINT16	2	RO	632 = D632
68	Bootloader version number	UINT16	2	RO	xxx = Vx.xx
69	Boot loader build number	UINT16	2	RO	Build#
70	Device status	UINT16	2	RO	Bit 0 (LSB): NFC with 0 = disabled, 1 = enabled Bit 1…15: 0 (reserved)
71	Device characteristics	UINT16	2	RO	Bit 0 (LSB): Alarm-indicator relays CH1 and CH2 available Bit 1: Harmonic analysis available Bit 2: CT "type B/type B+" can be used Bit 3: External transformer ("Type A" only) can be used Bit 4: History memory can be used Bit 5…15: 0 (reserved) with 0 = no, 1 = yes
72	IsDevicePowered	UINT16	2	RO	Register to determine whether the device is switched on with 0 = no, 1 = yes
73	Device version	String UTF8	32	RO	

6.2 Alarm/measuring value registers

Measured values (Register 999…1999)

Register	Description		Format	Bytes	Property	Values / Unit / Comment
999	Number of active messages		UINT16	2	RO	0…n = Number of active messages (device error, alarms, connection faults, …) n is the number of messages that could also be attributed to an output (e.g. relay)
1000	Residual current measured value, max.	AC	UINT8	8	RO	**Measured-value block** [1] In each case the max. measured value incl. corresponding alarm and measuring-range states since the last Modbus query is output.
1016		DC	UINT8	8	RO	
1032		RMS	UINT8	8	RO	
1048	Current value of residual current	AC	Float	4	RO	Currently measured value
1056		DC	Float	4	RO	
1064		RMS	Float	4	RO	
1072	Residual current measured value, min.	AC	Float	4	RO	Smallest measured value since the last Modbus query
1080		DC	Float	4	RO	
1088		RMS	Float	4	RO	
1096	Residual current average	AC	Float	4	RO	Arithmetic mean of the measured value since the last Modbus query
1104		DC	Float	4	RO	
1112		RMS	Float	4	RO	
1120	Residual current measured value, max. [2]	AC	Float	8	RO	Reset register 1000
1128		DC	Float	8	RO	Reset register 1016
1136		RMS	Float	8	RO	Reset register 1032
1144	Current value of the unfiltered residual current	RMS	Float	4	RO	Current unfiltered RMS measured value

[1] Size of the measured-value block: 4 x UINT8 = 8 bytes

Content of the measured-value block

- Addr. Offset 0 (e.g. 1000): Measured value, part 1
- Addr. Offset 1 (e.g. 1001): Measured value, part 2
- Addr. Offset 2 (e.g. 1002): Alarm status
  0: No alarm | 1: Prewarning | 2: Main alarm
- Addr. Offset 3 (e.g. 1003): Measuring range
  0: "=" | 1: "<" | 2: ">"

[2] Largest measured value since the last Modbus query, display of the maximum values from the measured-value blocks (offset 0 and 1) of registers 1000…1044 as a **floating point number**.
When queried, simultaneously resets the measured-value block in the specified register.

6.3 Register monitoring functions

Status monitoring functions (registers 2000…2050)

Register	Description	Format	Bytes	Property	Values / Unit / Comment
2000	CT status	UINT16	2	RO	0 = OK 1 = CT error

6.4 Status information registers

Status information (registers 3000…3999)

Register	Description	Format	Bytes	Property	Values/Unit/Comment
3000	Test status	UINT16	2	RO	0 = no active test 1 = test active via T/R button 2 = test active via interface
3001	Status of input "I"	UINT16	2	RO	0 = input is not operated 1 = input is operated
3002	Status of input/output "Q"	UINT16	2	RO	0 = input is not operated 1 = input is operated 2 = input /output "Q" is configured as output
3003	Status of relay K1	UINT16	2	RO	Current status of the output: 0 = output inactive (no event of the message assignments occurred) 1 = output active (at least one event of the message assignments occurred)
3004	Status of relay K2	UINT16	2	RO	
3005	Status of output "Q"	UINT16	2	RO	Current status of the output: 0 = output inactive (no event of the message assignments occurred) 1 = output active (at least one event of the message assignments occurred)
3006	Status of output "M+"	UINT16	2	RO	
3007	Active status of relay K1	UINT16	2	RO	The last active status (1) of the output is retained until the next Modbus query.
3008	Active status of relay K2	UINT16	2	RO	
3009	Active status of input/output "Q"	UINT16	2	RO	
3010	Active status of output "M+"	UINT16	2	RO	
3011	Inactive status of relay K1	UINT16	2	RO	The last inactive status (0) of the output is retained until the next Modbus query.
3012	Inactive status of relay K2	UINT16	2	RO	
3013	Inactive status of input/output "Q"	UINT16	2	RO	
3014	Inactive status of output "M+"	UINT16	2	RO	
3015	Residual operating current $I_{\Delta n\ RMS\ ext}$	Float	4	RO	Last residual operating current stored via the interface / $_{\Delta n\ RMS\ ext}$ [A]
3017	Response delay $t_{on\ ext}$	Float	4	RO	Last response delay stored via the interface $t_{on\ ext}$ [s]
3019	Position potentiometer $I_{\Delta n\ RMS\ ext}$	UINT16	2	RO	0 = Position not set to "Ext" 1 = Position set to "Ext"
3020	Position potentiometer $t_{on\ ext}$	UINT16	2	RO	

Register	Description		Format	Bytes	Property	Values/Unit/Comment
3050	Alarm status of the device, binary coded (registers 3070…3071)		UINT16	2	RO	0 = No alarm | 1 = Alarm Bit 0 = Register 3070 Bit 1 = Register 3071 Bit 2…15 = Reserved
3051	Measuring channel CH binary coded (registers 3086…3101)		UINT16	2	RO	0 = No alarm | 1 = Alarm Bit 0 = Prewarning AC Bit 1 = Main alarm AC Bit 2 = Prewarning DC Bit 3 = Main alarm DC Bit 4 = Prewarning RMS Bit 5 = Main alarm RMS Bit 6 = Measuring current transformer connection fault Bit 7 = Measuring channel overload Bit 8…15 = Reserved
3070	Alarm status Test		UINT16	2	RO	For the device: 0 = No alarm | 1 = Alarm
3071	Alarm status device error		UINT16	2	RO	
3086	Alarm status CH	Prewarning AC	UINT16	2	RO	For the measuring channel: 0 = No alarm | 1 = Alarm
3088		Prewarning DC	UINT16	2	RO	
3090	Alarm status CH	Prewarning RMS	UINT16	2	RO	For the measuring channel: 0 = No alarm | 1 = Alarm
3091		Main alarm RMS	UINT16	2	RO	
3092		Measuring current transformer connection fault	UINT16	2	RO	
3093		Measuring channel overload	UINT16	2	RO	

6.5 Harmonic analysis register

Harmonic analysis (5200…5603)

The registers (5000…5603) are only available with the optional function module A "Harmonic analysis". Otherwise, the registers are reserved.

With ordering number the harmnoic analysis is already enabled as a default.

Register	Description	Format	Bytes	Property	Values / Unit / Comment
5200	DC full spectrum	UINT16	2	RO	Amount of the DC component [mA]
5201	H1	UINT16	2	RO	1st harmonic [mA]
5202	H2	UINT16	2	RO	2nd harmonic [mA]
5203… 5599	H3…399	UINT16	2	RO	3rd … 399th harmonic [mA]
5600	H400	UINT16	2	RO	400th harmonic [mA]
5601	Full spectrum THD	UINT16	2	RO	THD: Square root of the sum of the squares of the harmonics H1…400 (excluding fundamental) divided by the fundamental; range of values 0…10,000 [%]
5602	THD validity full spectrum	UINT16	2	RO	Validity of the THD value; 0: = 2: >
5603	RMS from full spectrum DFT	UINT16	2	RO	[A]

6.6 Modbus-parameter registers

Modbus RTU parameters (registers 32000...32010)

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Factory setting
32000	Device address	UINT16	2	RW	1…247	Last 2 digits of the serial number + 100
32001	Baud rate	UINT32	4	RW	9600, 19200, 38400, 57600, 115200	19200
32003	Parity	UINT16	2	RW	1 = even 2 = odd 3 = none	1
32004	Stop bits	UINT16	2	RW	1 = 1 2 = 2 3 = automatic	3
32005	Reserviert					
32006	Allow update	UINT16	2	RW	0 = do not allow SW-update via Modbus RTU 1 = allow SW-update via Modbus RTU	0

Register	Description	Format	Bytes	Prop-erty	Value/Unit/Comment	Factory setting
32007	Write access	UINT16	2	RW	1: Enable write access (parameters can be changed) 2: Write access disabled (parameters can only be read) *Achtung: Entsperren ist nur direkt am Gerät möglich!*	1

6.7 Relay 1 registers

Parameter relay 1 (32100…32199)

Register	Description	Format	Bytes	Prop-erty	Values / Unit / Comment	Factory settings
32100	Relay mode	UINT16	2	RW	1 = Non-fail-safe 2 = Fail-safe	2
32101	Alarm assignment Test	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32102	Alarm assignment Device error	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32103	Alarm assignment Prewarning AC	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32104… 32106	Reserved					
32107	Alarm assignment Prewarning DC	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32108… 32110	Reserved					
32111	Alarm assignment Prewarning RMS	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32112… 32114	Reserved					
32115	Alarm assignment Measuring current transformer connection fault	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32116	Alarm assignment Overload measuring channel	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32119	Alarm assignment Start with alarm	UINT16	2	RW	0 = Disabled 1 = Enabled	1

6.8 Relay 2 registers

Parameter Relay 2 (32200…32299)

Register	Description	Format	Bytes	Property	Values / Unit / Comment	Factory settings
32200	Relay mode	UINT16	2	RW	1 = Non-fail-safe 2 = Fail-safe	2
32201… 32215	Reserved					
32216	Alarm assignment Overload measuring channel	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32219	Alarm assignment Start with alarm	UINT16	2	RW	0 = Disabled 1 = Enabled	1

6.9 Registers of digital input "I"

Parameters of input "I" (32300)

Register	Description	Format	Bytes	Property	Values/Unit/Comment	Factory setting
32300	Mode	UINT16	2	RW	1 = high-active 2 = low-active	2
32301	Function	UINT16	2	RW	1 = none 2 = reset 3 = test 4 = T/R (test/reset combined)	3

6.10 Registers of input/output "Q"

Parameters of input/ output "Q" (32400)

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Factory setting
32400	Mode	UINT16	2	RW	1 = Output: Passive 2 = Output: High-active 3 = Output: Low-active 4 = Output: Permanently high 5 = Output: Permanently low 6 = Input: High-active 7 = Input: Low-active	3
32401	Function	UINT16	2	RW	0 = None Available with modes 6…7: 1 = Reset 2 = Test Available with modes 1…3: 3 = Prewarning 4 = Main alarm	4
32402	Test	UINT16	2	RW	0 = Disabled 1 = Enabled	1

Register	Description	Format	Bytes	Prop-erty	Value/Unit/Comment	Factory setting
32403	Device-error alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32404	AC CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32405… 32407	Reserved					
32408	DC CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32409… 32411	Reserved					
32412	RMS CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32413… 32415	Reserved					
32416	Connection-fault alarm assignment CT	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32417	Measuring-channel-overloading alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32420	Start with alarm	UINT16	2	RW	0 = Disabled 1 = Enabled	1

6.11 Registers of output "M+"

Parameters of output "M+" (registers 32500…32530)

Register	Description	Format	Bytes	Prop-erty	Values / Unit / Comment	Factory setting
32500	Mode	UINT16	2	RW	1 = Output: Passive 2 = Output: High-active 3 = Output: Low-active 4 = Output: Permanently high 5 = Output: Permanently low 6 = Output: 0…20 mA 7 = Output: 4…20 mA 8 = Output: 0…10 V 9 = Output: 2…10 V	3
32501	Function	UINT16	2	RW	Operative with modes 1…3: 1 = Prewarning 2 = Main alarm	2
32502	Linearity	UINT16	2	RW	Operative with functions 3…6: 1= Linear with respect to maximum scale value (see register 32503) 2= Linear with respect to 100 % of $I_{\Delta n\ RMS}$	2

Register	Description	Format	Bytes	Property	Values / Unit / Comment	Factory setting
32503	Scaling	UINT16	2	RW	Operative only with linearity 1: 6…65000 [mA], increment 1 mA, maximum scale value *Note: This value can be set to max. 5 x $I_{\Delta n\ RMS}$!*	0
32504	Test	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32505	Device-error alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32506	AC CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32507… 32509	Reserved					
32510	DC CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	0
32511… 32513	Reserved					
32514	RMS CT alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32515… 32517	Reserved					
32518	Alarm assignment, connection fault CT	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32519	Measuring-channels-overloading alarm assignment	UINT16	2	RW	0 = Disabled 1 = Enabled	1
32522	Start alarm	UINT16	2	RW	0 = Disabled 1 = Enabled	1

6.12 Registers of response-value parameters

Response-value parameters (registers 32600…32635)

Register	Description	Format	Bytes	Property	Values / Unit / Comment	Factory setting
32616	$I_{\Delta n}$ RMS	Float	4	RW	0.030…3 [A]; increment 0.001	0.03
32624	AC prewarning	UINT16	2	RW	10…100 [%]	70
32628	DC prewarning	UINT16	2	RW		70
32632	RMS prewarning	UINT16	2	RW		70

6.13 Function and operating-characteristics registers

Function and response behaviour parameters (32700…32720)

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Factory setting
32704	CT1 hysteresis	UINT16	2	RW	2…40 [%], increment 1 %	15
32708	CT1 filter setting	UINT16	2	RW	1 = 20 kHz 4 = Type B 5 = Type B+	4
32712	Fundamental-harmonic frequency	UINT16	2	RW	50…1000 Hz; increment 1 Hz	50

6.14 Alarm-behaviour registers

Alarm behaviour parameters (32800…32810)

Register	Description	Format	Bytes	Property	Values / Unit / Comment	Factory setting
32800	Fault memory	UINT16	2	RW	0 = disabled 1 = enabled	1

6.15 Time-behaviour registers

Time behaviour parameters (32900…32920)

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Factory setting
32900	Start-up delay *t*	Float	4	RW	0…900 [s], increment 1 ms	0
32902	Response delay t_{on}	Float	4	RW	$I_{\Delta n} \leq 30$ mA: 0 s $I_{\Delta n} > 30$ mA: 0…10 [s], increment 1 ms	0
32910	Delay on release t_{off}	Float	4	RW	0…900 [s], increment 1 ms	1

6.16 Device-error-code registers

Device error codes (58000)

Register content 0 = no error

Undocumented registers 58000...58199 are reserved.

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Reversible	Device faulty
58000	Number of device errors	UINT16	2	RO	Number of active device errors	X	
58001	0.10	UINT16	2	RO	10 = CT-connection fault, CT	X	
58005	0.57	UINT16	2	RO	57 = Connection fault at input/output "Q"	X	
58006	0.58	UINT16	2	RO	58 = Connection fault at output "M+"	X	
58007	3.21	UINT16	2	RO	321 = Internal error		X
58008	3.25	UINT16	2	RO	325 = Internal error		X

Register	Description	Format	Bytes	Property	Value/Unit/Comment	Reversible	Device faulty
58009	4.70	UINT16	2	RO	470 = Thermal overload at measuring inputs	X	
58010	4.71	UINT16	2	RO	471 = CT overload	X	
58018	4.79	UINT16	2	RO	479 = Invalid setting of CT: "type B+" filter combined with a response value > 300 mA	X	
58026	6.00	UINT16	2	RO	600 = Internal error		X
58027	6.10	UINT16	2	RO	610 = Internal error		X
58028	6.31	UINT16	2	RO	631 = Internal error		X
58029	6.51	UINT16	2	RO	651 = Internal error		X
58030	7.61	UINT16	2	RO	761 = Internal error		X
58031	7.62	UINT16	2	RO	762 = Internal error		X
58032	7.63	UINT16	2	RO	763 = Internal error		X
58033	8.20	UINT16	2	RO	820 = Internal error		X
58034	8.24	UINT16	2	RO	824 = T/R button defective	X	
58035	8.43	UINT16	2	RO	843 = Internal error		X
58036	8.44	UINT16	2	RO	844 = Internal error		X
58037	8.45	UINT16	2	RO	845 = Internal error		X
58038	8.46	UINT16	2	RO	846 = Internal error		X
58039	8.49	UINT16	2	RO	849 = Internal error		X
58040	6.20	UINT16	2	RO	620 = Measured offset is outside the limits	X	
58041	7.64	UINT16	2	RO	764 = Internal error		X
58042	6.95	UINT16	2	RO	695 = Internal error		X
58043	3.30	UINT16	2	RO	330 = The manual self-test was not completed without errors	X	
58044	0.56	UINT16	2	RO	56 = Shutdown check: Although the system is switched off, a (residual) current is still flowing	X	
58045… 58099	Reserved						
58100	3.21	UINT16	2	RO	321 = Internal error		X
58101	3.22	UINT16	2	RO	322 = Internal error		X
58102	3.23	UINT16	2	RO	323 = Internal error		X
58103	3.24	UINT16	2	RO	324 = Internal error		X
58104	3.26	UINT16	2	RO	326 = Internal error		X
58105	3.27	UINT16	2	RO	327 = Internal error		X
58106	6.30	UINT16	2	RO	630 = Internal error		X

Register	Description	Format	Bytes	Prop-erty	Value/Unit/Comment	Reversible	Device faulty
58107	7.64	UINT16	2	RO	764 = Internal error		X

6.17 Control-commands registers

Control commands (59000)

Register	Description	Format	Bytes	Prop-erty	Values / Unit / Comment	Factory setting
59000	NFC	UINT16	2	RW	0 = disabled 1 = enabled (automatic disabling after 5 min)	0
59001	Test Relay K1	UINT16	2	RW	0 = Switch off relay (automatic return to normal operating mode after 60 s) 1 = Switch on relay (automatic return to normal operating mode after 60 s) 2 = Relay test inactive (normal operating mode)	2
59002	Test Relay K2	UINT16	2	RW		2
59004	Start DC-offset fine matching	UINT16	2	WO	1 = Start synchronisation	-

6.18 Function-control-commands registers

Register 60000 (function-selection register) defines which function is enabled.
Only specified values are permitted.

0 = Find device via serial number
1 = Set Modbus address
2 = Find device
4 = Reset to factory settings with/without interface parameters
6 = Start test
7 = Reset
8 = Upload licence key

The registers 60000...60003 must always be written as a block!

Function-control commands (60000)

Register	Description	Format	Bytes	Prop-erty	Value/Unit/Comment
Function 0: Find device via serial number					
60000	Function selection	UINT16	2	WO	0 = selection of the function "Find device via serial number"
60001	Serial number	UINT32	4	WO	Seriennummer des zu findenden Geräts
60003	Period	UINT16	2	WO	0…300 [s] = time until the corresponding device lights up; 0 = end search function
Function 1: Set Modbus address					
60000	Function selection	UINT16	2	WO	1 = Selection of the function "Set Modbus address"

Register	Description	Format	Bytes	Property	Value/Unit/Comment
60001	Serial number	UINT32	4	WO	Serial number of the device to be given a new modbus address. Only the device with the corresponding serial number will accpet the new Modbus address.
60003	Modbus address	UINT16	2	WO	0…247 = new Modbus address
Function 2: Find device					
60000	Function selection	UINT16	2	WO	2 = Selection of the "Find device" function
60001	Pattern value part 1	UINT16	2	WO	61918 Security pattern must be written for the function to be executed.
60002	Pattern value part 2	UINT16	2	WO	0 Security pattern must be written for the function to be executed.
60003	Period	UINT16	2	WO	0…300 [s] = time until the device lights up. When the device receives the value "0", the function is stopped.
Function 4: Reset to factory settings with/without interface parameters					
60000	Function selection	UINT16	2	WO	4 = Selection of the function "Reset to factory settings with/ without interface parameters"
60001	Pattern value part 1	UINT16	2	WO	64199 Security pattern must be written for the function to be executed.
60002	Pattern value part 2	UINT16	2	WO	1304 Security pattern must be written for the function to be executed.
60003	Reset type	UINT16	2	WO	1 = Reset all parameters to the factory settings 2 = Reset to factory settings without interface parameters
Function 6: Start test					
60000	Function selection	UINT16	2	WO	6 = Selection of the function "Start test"
60001	Pattern value part 1	UINT16	2	WO	32343 Security pattern must be written for the function to be executed.
60002	Pattern value part 2	UINT16	2	WO	0 Security pattern must be written for the function to be executed.
60003	Type of test	UINT16	2	WO	3 = Start RCM test
Function 7: Reset					
60000	Function selection	UINT16	2	WO	7 = Selection of "Reset" function
60001	Pattern value part 1	UINT16	2	WO	13623 Security pattern must be written for the function to be executed.
60002	Pattern value part 2	UINT16	2	WO	0 Security pattern must be written for the function to be executed.
60003	Reset type	UINT16	2	WO	1 = Reset of the alarm message when fault memory is enabled
FunCtion 8: Upload licence key					
60000	Function selection	UINT16	2	WO	8 = Selection of “Upload licence key” function
60001	Pattern value part 1	UINT16	2	WO	29134 Security pattern must be written for the function to be executed.

Register	Description	Format	Bytes	Property	Value/Unit/Comment
60002	Pattern value part 2	UINT16	2	WO	0 Security pattern must be written for the function to be executed.
60003	licence key	UINT8 []	32	WO	[…] = licence key as a byte array

7 Error – Cause – Error correction

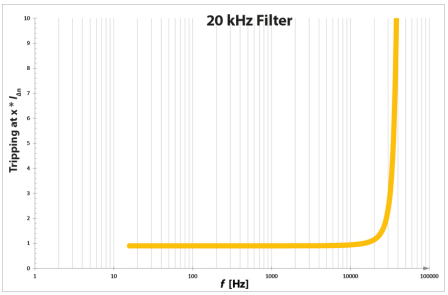
Error pattern	Cause	Correction
Complete device		
No device start	Terminal blocks incorrectly plugged in	Plug in terminal blocks correctly.
	Supply voltage incorrectly connected	Establish correct wiring.
RS-485		
Instable communication	Missing termination due to incorrect commissioning or defective component. No device is terminated.	Configure the terminating resistor, determine the terminating resistor value and replace it if necessary.
	Faulty termination due to incorrect commissioning or defective component. Either only one or more than two devices have been terminated.	Configure the terminating resistor, check quality of the bus signal.
No communication	Incorrect configuration: different baud rates between bus devices.	Calibrate baud rates between all bus devices.
	Incorrect connection: terminals A and B are interchanged.	Establish correct bus wiring.
Inputs and outputs		
No level change	Incorrect configuration: Output configured as input	Check configuration.
	Incorrect connection: external connections	Check configuration.
Alarm relays		
Relays do not energise	No alarm message due to defective component or defective controlling devices. No alarm source has been assigned.	Check relay for proper function, replace device if necessary. Assign alarm sources.
Relays do not de-energise	No alarm reset due to sticking or defective relay. Switching current > 5 A.	Replace device, if necessary. Observe technical data of the switching output.
	No switching of the relay due to excessive preloads on contacts.	Observe technical data of the switching output.
Enclosure		
Broken screw-mounting brackets	Device becomes detached due to broken mounting brackets.	Preventive measure: Use correct screw type and observe max. tightening torque. If the screw-mounting brackets are defective: mount on DIN rail or replace device.
Non-compliance with the insulation guideline	Insufficient insulation due to insufficient distance between mounting screws and connecting wires.	Use screws with plastic cover or mount on DIN rail.
Terminals		
Wires detach from the terminal	Due to splicing of wire ends, it is not possible to insert them into the terminal or fix them firmly in the terminal.	Use ferrules for mounting and connection to flexible cables.
Wires cannot be removed from terminal	Ferrules with strong crimp impressions get stuck in the terminal.	Use correct crimping pliers for mounting and connection with flexible cables.

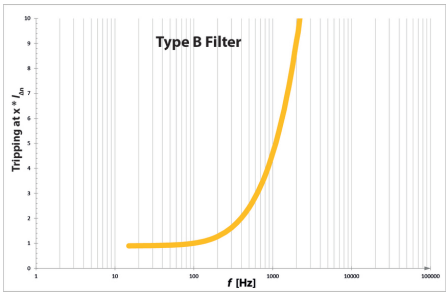
8 Technical data

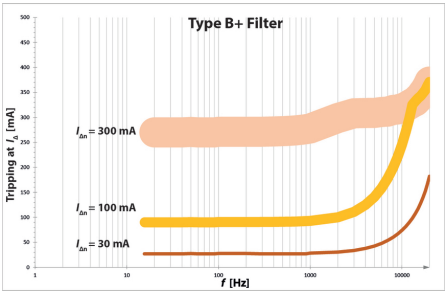
8.1 Frequency responses of the filters

The curves represent the area in which the device triggers a main alarm.

The frequency range below 15 Hz is not defined.







8.2 Tabular data

()* = Factory setting

Insulation coordination (IEC 60664-1/ IEC 60664-3)

Definitions	
Supply circuit (IC1)	A1, A2
Measuring circuit (IC2)	+, –, A, B, M+, Q, I, GND, CT, CT Test
Control circuit (IC3)	11, 12, 14
Control circuit (IC4)	21, 22, 24
Rated voltage	250 V
Overvoltage category	III
Operating altitude	≤ 2000 m AMSL

Rated impulse voltage	
IC1/(IC2-4)	6 kV
IC2/(IC3-4)	6 kV
IC3/IC4	6 kV

Rated insulation voltage	
IC1/(IC2-4)	250 V
IC2/(IC3-4)	250 V
IC3/IC4	250 V
Pollution degree	2

Protective separation (reinforced insulation) between	
IC1/(IC2-4)	300 V
IC2/(IC3-4)	300 V
IC3/IC4	300 V

Voltage test (routine test) acc. to IEC 61010-1	
IC1/(IC2-4)	AC 2.2 kV
IC2/(IC3-4)	AC 2.2 kV
IC3/IC4	AC 2.2 kV

Supply voltage (+, -)

Connection	+, –
Supply voltage U_s	DC 24 V
Protection class of power supply unit	2 or 3
Permissible tolerance	–30…+25 %
Permissible ripple	5 %
Power consumption	≤ 2 W
Inrush current (< 5 ms)	< 10 A

Supply voltage (A1, A2)

Connection	A1, A2
Supply voltage U_S	AC/DC 100…240 V
Tolerance of U_S	-30…+15 %
Frequency range of U_S	DC/47…460 Hz
Power consumption	≤ 15 VA at 50 Hz
Inrush current (< 5 ms)	< 25 A

Measuring circuit

Burden (internal)	33 Ω
Frequency range	DC, 15 Hz…20 kHz
Measuring range (peak)	3 mA…28 A
Measuring range rms	2 mA…20 A
Rated residual operating current (Type B)	3 A
Response value main alarm $I_{\Delta n}$ (Type B)	30 mA…3 A (30 mA)*
Prewarning	10…100 % x $I_{\Delta n}$ (70 %)*
Operating uncertainty	±10 % (at 0.5…5 x $I_{\Delta n}$)
Relative response uncertainty	-20…0 %
for Lloyd´s applications	-50…0 %
Hysteresis	10…25 % (15 %)*
Fault-memory alarm messages	on/off (on)*
Permissible continuous residual current	30 A

Measuring-current transformers

Connection	CT (S1, S2)
Measuring-current transformer series	CTUB-CTBC
CT connection monitoring	Yes
Rated voltage U_n	See manual of the measuring current transformer
Connecting wires	See manual of the measuring current transformer
Cable length	≤ 10 m

Test connection

Connection	T, GND
Cable length	≤ 10 m

Time response

Start-up delay t	0…900 s (0 s)*
Response delay t_{on}	
with $I_{\Delta n}$ ≤ 30 mA	0 s (fixed)
with $I_{\Delta n}$ > 30 mA	0…10 s (0 s)*
Delay on release t_{off}	0…900 s (1 s)*
Operating time t_{ae}	
with 1 x $I_{\Delta n}$	≤ 180 ms
with 2 x $I_{\Delta n}$	≤ 130 ms
with 5 x $I_{\Delta n}$	≤ 20 ms
with 10 x $I_{\Delta n}$	≤ 20 ms
Response time t_{an}	$t_{an} = t_{ae} + t_{on}$
Recovery time t_b	≤ 500 ms
Response time for CT connection monitoring	≤ 5 s

Operation

Display	status LED, alarm LEDs, channel LEDs
Display range measured value	25 / 50 / 75 / 100 %
Button T/R	reset / test / NFC / address setting
Terminating resistor DIP switches	on/off (off)*
Potentiometer $I_{\Delta n}$	0.03 A / 0.05 A / 0.1 A / 0.2 A / 0.3 A / 0.5 A / 1 A / 2 A / 3 A / EXT (EXT)*
Potentiometer t_{on}	0 s / 0.2 s / 0.4 s / 0.6 s / 0.8 s / 1 s / 2 s / 4 s / 10 s / EXT (EXT)*

RS-485 interface

Connection	A, B
Protocol	Modbus RTU
Baud rate	Max. 115.2 kbits/s (19.2 kbits/s)*
Parity	even, no, odd (even)*
Stop bits	1/2/auto (auto)*
Cable length (at 9.6 kbits/s)	≤ 1200 m
Recommended lines, shield on one side connected to PE	
CAT6/CAT7	Min. AWG23
min. J-Y(St)Y 2 x 0.6 mm²	Twisted pair
Device address	1…247 (100 + last two digits of serial number)*

NFC interface

Frequency	13.56 MHz
Transmitting power (modulating; in 0 m distance, e.g.)[1]	0 W

1 • EMC influences may lead to communication interruptions at the NFC interface.
• The device does not transmit any radio waves when used as intended.

Input I

Connection	I, ⊥
Max. cable length (recommended)	10 m
External connections	Potential-free contact

Input/output Q

Connection	Q, ⊥
Max. cable length (recommended)	10 m
Max. load	20 mA
Low voltage level (output)	0…2 V
High voltage level (output)	10 V…U_S
External voltage (passive mode)	DC 0…(U_S - 1 V)

Output M+

Connection	M+, ⊥
Max. cable length (recommended)	10 m
Max. load	20 mA
Burden	

Current output	≤ 600 Ω
Voltage output	≥ 20 kΩ
Tolerance with respect to final current/voltage value	±20 %
External voltage (passive mode)	DC 0…U_S

Switching elements

Relays	2 changeover contacts
Connection	11, 12, 14 21, 22, 24
Operating principle	Fail-safe or Non-fail-safe (Fail-safe)*
Maximum permitted voltage	AC 250 V / DC 30 V
Switching capacity	1250 VA / 150 W
Minimum current	10 mA at DC 10 V
Electrical endurance, number of cycles	10000

Connections (A1, A2, relays)

Terminals	Plug-in screw-type terminals
Terminal series	Phoenix Contact MSTBT 2,5/…-ST-5,08 BK
Connection properties	
Rigid	0.2…2.5 mm²
Flexible, without plastic sleeve	0.25…2.5 mm²
Flexible, with plastic sleeve	0.25…2.5 mm²
Stripping length	7 mm
Tightening torque	0.5…0.6 Nm
Conductor cross section AWG	24…12

Connections (other)

Terminals	Plug-in screw-type terminals
Terminal series	Phoenix Contact MC 1,5/ -ST-3,5 BK
Connection properties	
Rigid	0.14…1.5 mm²
Flexible, without plastic sleeve	0.25…1.5 mm²
Flexible, with plastic sleeve	0.25…0.5 mm²
Stripping length	7 mm
Tightening torque	0.22…0.25 Nm
Conductor cross section AWG	28…16

EMC/Environment

EMC	DIN EN IEC 62020-1
Operating temperature	
At U_S = DC 24 V	-25…+70 °C
At U_S = AC/DC 100…240 V	-25…+55 °C
Transport	-40…+85 °C
Long-time storage	-40…+70 °C

Classification of climatic conditions acc. to IEC 60721

Stationary use (IEC 60721-3-3)	3K22
Transport (IEC 60721-3-2)	2K11
Long-term storage (IEC 60721-3-1)	1K22

Classification of mechanical conditions acc. to IEC 60721

Stationary use (IEC 60721-3-3)	3M11
Transport (IEC 60721-3-2)	2M4
Long-term storage (IEC 60721-3-1)	1M12

Other

Operating mode	Continuous operation
Mounting	Vertical
Degree of protection (DIN EN 60529)	
terminals	IP20
internal components	IP30
Enclosure material	Polycarbonate
DIN rail mounting acc. to	IEC 60715
Flammability class	UL94 V-0
Weight	≤ 110 g

8.3 Approvals

Standards & certifications

The MRCDB425-L device has been developed in accordance with the following standards:

- DIN EN IEC 60947-2
- UL508

Licences

For a list of the open-source software used see our Homepage.

Declaration regarding the radio system

EU declaration of conformity

Bender GmbH & Co. KG hereby declares that the device covered by the Radio Equipment Directive complies with Directive 2014/53/EU. The full text of the EU Declaration of Conformity is available at the following internet address:

EU declaration of conformity MRCDB425

Hereby, Bender GmbH & Co. KG declares that this radio equipment complies with Radio Equipment Regulations 2017 (S.I. 2017/1206). The full text of the UK declaration of conformity is available at the following internet address:

UKCA-Declaration of Conformity MRCDB425

8.4 Ordering information

Type	Supply voltage U_S	Measuring current transformers that can be used	Art. No.
MRCDB425-L-2	DC 24 V AC/DC 100…240 V	CTUB102-CTBC…(P)	B84605030

Suitable measuring current transformers

Type	Shielding	ø Measuring current transformer	Supply voltage U_S	Art. No.
CTUB102-CTBC20	-	20 mm	DC 24 V	B78120011
CTUB102-CTBC20P	X			B78120021
CTUB102-CTBC35	-	35 mm		B78120013
CTUB102-CTBC35P	X			B78120023
CTUB102-CTBC60	-	60 mm		B78120015
CTUB102-CTBC60P	X			B78120025
CTUB102-CTBC120	-	120 mm		B78120017
CTUB102-CTBC120P	X			B78120027
CTUB102-CTBC210	-	210 mm		B78120019
CTUB102-CTBC210P	X			B78120029

Accessories		Art. No.
Sealable transparent cover (spare part)		B80609199
External power supply		
	STEP-PS/1 AC/24 DC/0.5	B94053110
	STEP-PS/1 AC/24 DC/1.75	B94053111
	STEP-PS/1 AC/24 DC/4.2	B94053112

8.5 Document revision history

Date	Document version	Status/changes
01.2026	00	Initial edition

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