



# NGRM500 (HRG) / NGRM550 (LRG)

Neutral Grounding Resistor Monitor





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## 1 General information

### 1.1 How to use this manual

**ADVICE**

This manual is intended for qualified personnel working in electrical engineering and electronics! In addition to this manual, the "Safety Instructions for Bender Products" package insert is also part of the device documentation.

**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 Signs and symbols



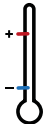
Disposal



Protect from moisture



Protect from dust



Temperature range



Recycling



RoHS directives

### 1.4 Service and Support

Information and contact details about customer service, repair service or field service for Bender devices are available on the following website: [Fast assistance | Bender GmbH & Co. KG.](#)

## 1.5 Training courses and seminars

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

[www.bender.de](http://www.bender.de) > know-how > seminars.

## 1.6 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.

The following applies to software products:



“Software clause in respect of the licensing of standard software as part of deliveries, modifications and changes to general delivery conditions for products and services in the electrical industry”

## 1.7 Inspection, transport and storage

Check the shipping and equipment packaging for transport damage and scope of delivery. In case of complaints, notify the company immediately, see “[www.benderinc.com](http://www.benderinc.com) > service & support.”.

The following must be observed when storing the equipment:



## 1.8 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.

## 1.9 Disposal of Bender devices

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



For more information on the disposal of Bender devices, refer to [www.benderinc.com](http://www.benderinc.com) > service & support.

## 1.10 Safety

If the device is used outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. The European standard EN 50110 can be used as a guide.



**DANGER** *Risk of electrocution due to electric shock!*

*Touching live parts of the system carries the risk of:*

- An electric shock
- Damage to the electrical installation,
- Destruction of the device

Before installing and connecting the device, make sure that the installation has been de-energized. Observe the rules for working on electrical installations.

## 2 Product description

### 2.1 Intended use

The NGRM500 is only intended for use in high-resistance grounded systems. The NGRM550 is only intended for use in low-resistance grounded systems.

In these systems, the device of the NGRM family monitors

- the current through the neutral grounding resistor (NGR),
- the voltage between the star point of the transformer and ground (voltage drop across the NGR),
- the condition of the neutral grounding resistor (NGR),
- line-to-line and line-to-ground voltages.

**i** *Systems with a resistance-grounded star point can be used when an **interruption of the power supply would involve excessive costs due to production stoppage** (e.g. automotive production, chemical industry). The ground fault that occurs between a phase and ground does not lead to a failure of the power supply in these systems.*

*A ground fault must be detected and eliminated as quickly as possible, since the occurrence of another ground fault in a second phase would lead to a tripping of the overcurrent protective device.*

In order to meet the requirements of applicable standards, customised parameter settings must be made on the equipment in order to adapt it to local equipment and operating conditions. Please heed the limits of the range of application indicated in the technical data. Intended use includes following all the instructions in this manual.

Any other use than that described in this manual is regarded as improper.

### 2.2 Device features NGRM

- Determination of  $R_{\text{NGR}}$  with passive and active measurement methods
- Continuous monitoring of the  $R_{\text{NGR}}$  even if the installation is de-energized
- Alarm or trip on ground fault
- Monitoring of the current  $I_{\text{NGR}}$
- Monitoring of the voltage  $U_{\text{NGR}}$
- Ethernet communication
- Web server
- Language selection (German, English GB and US, Spanish, French)
- Test button (internal, external) with/without tripping
- FFT analysis of neutral current and voltage
- Pulser control for manual ground fault location
- Relay outputs for detection of ground faults and resistor faults
- Relay output for shutdown of the installation after a configurable time
- Can be combined with RCMS... for automatic shutdown of feeders
- Graphical user interface
- Integrated wide-range power supply unit for operating the NGR monitor (AC/DC 24...240 V)
- Range of use up to 2000 m AMSL
- Fault/History memory
- Analogue output of measured values (0...10 V, 4...20 mA etc., selectable parameter)
- Password protection



- Tripping on RMS, fundamental component signal or harmonics
- Detection of AC and DC ground faults
- Variants High Resistance Grounded (HRG), Low Resistance Grounded (LRG)

	HRG		LRG	
	NGRM500	NGRM700	NGRM550	NGRM750
$U_{\text{sys LL}}$	400...25000 V			
$I_{\text{NGR nom}}$	0.5...100 A		10...2000 A	
$R_{\text{NGR nom}}$	15...5000 $\Omega$		0.1...200 $\Omega$	

## 2.3 Functional description

The NGRM monitors NGR resistance  $R_{\text{NGR}}$ , neutral voltage  $U_{\text{NGR}}$  and current  $I_{\text{NGR}}$ . The NGR resistance is monitored using an active and a passive procedure:

**active**                      The device generates an active test pulse and measures  $R_{\text{NGR}}$  even if the installation is de-energized..

**passive**                    The resistance  $R_{\text{NGR}}$  is determined when  $I_{\text{NGR}}$  or  $U_{\text{NGR}}$  exceeds an internal threshold. The device measures the existing current and voltage and calculates  $R_{\text{NGR}}$ .

In the case of the “auto” method, monitoring switches automatically between “active” and “passive” when the measured current or voltage value exceeds or falls below the internal threshold. The threshold is 15 % of the nominal value and can be adjusted by Bender if required.

A shorted or open NGR is reliably detected in an energized as well as a de-energized installation with the active measurement method.

When the “passive” method is selected, no switching of the monitoring takes place. The NGR is not monitored if the installation is shut down or the current and voltage are too low.

The measurement method can be selected as a set point or via the configurable digital input I1 if the NGR method “external” has been selected (for software versions from July 2021).

Should the use of frequency inverters lead to interferences with the  $R_{\text{NGR}}$  measured value during the active measurement, a filter for active resistance measurement can be added. To this end, 3 pre-defined filters (weak, medium, strong) have been implemented. In addition, the filter parameters can be adapted individually in the setting “Customer- specific”.

The NGR-fault relay switches from the operating state (selectable as fail-safe or non-failsafe) to the alarm state when the measured resistance  $R_{\text{NGR}}$  is outside of the configured thresholds.

A ground fault is signalled via the corresponding ground-fault relay when  $I_{\text{NGR}}$  or  $U_{\text{NGR}}$  exceeds the selectable thresholds. After the adjustable time delay has elapsed, the trip relay operates.

A connection to installations ranging from 400 V to 25 kV is possible via the appropriate CD-series coupling device.

$I_{\text{NGR}}$  is measured with **measuring current transformers** with a 5 A or 50 mA secondary rating.

## 2.4 Recommended minimum value $R_{NGR}$ (tripping level 50 %)

Temperature range  $-40...+60$  °C, field calibration at 20 °C

( ) = Limited temperature range at any field calibration temperature  $\pm 20$  K. The temperatures must be within the limits of the operating temperature range of  $-40...+60$  °C.

Recommended  $R_{NGR}$  for system voltage  $U_{sys} \leq 4300$  V

	CD1000/CD1000-2			CD1000-2	CD5000	
$U_{sys}$	400 V	600 V	690 V	1000 V	2400 V	4200 V
$I_{NGR}$						
1 A	231 $\Omega$	346 $\Omega$	398 $\Omega$	577 $\Omega$	1386 $\Omega$	—
5 A	46 $\Omega$	69 $\Omega$	80 $\Omega$	115 $\Omega$	277 $\Omega$	485 $\Omega$
10 A	(23 $\Omega$ )	35 $\Omega$	40 $\Omega$	58 $\Omega$	139 $\Omega$	242 $\Omega$
15 A	(15 $\Omega$ )	(23 $\Omega$ )	(27 $\Omega$ )	38 $\Omega$	92 $\Omega$	162 $\Omega$
20 A	—	(17 $\Omega$ )	(20 $\Omega$ )	29 $\Omega$	69 $\Omega$	121 $\Omega$
25 A	—	—	(16 $\Omega$ )	(23 $\Omega$ )	55 $\Omega$	97 $\Omega$
30 A	—	—	—	(19 $\Omega$ )	(46 $\Omega$ )	81 $\Omega$
40 A	—	—	—	—	(35 $\Omega$ )	61 $\Omega$
50 A	—	—	—	—	(28 $\Omega$ )	(48 $\Omega$ )
100 A	—	—	—	—	—	(24 $\Omega$ )

Recommended  $R_{NGR}$  for system voltage  $U_{sys} > 4300$  V

	CD14400					CD25000
$U_{sys}$	6000 V	6600 V	7200 V	11,000 V	14,400 V	25,000 V
$I_{NGR}$						
1 A	—	—	—	—	—	—
5 A	693 $\Omega$	762 $\Omega$	831 $\Omega$	1270 $\Omega$	1663 $\Omega$	—
10 A	346 $\Omega$	381 $\Omega$	416 $\Omega$	635 $\Omega$	831 $\Omega$	1443 $\Omega$
15 A	231 $\Omega$	254 $\Omega$	277 $\Omega$	423 $\Omega$	554 $\Omega$	962 $\Omega$
20 A	(173 $\Omega$ )	191 $\Omega$	208 $\Omega$	318 $\Omega$	416 $\Omega$	722 $\Omega$
25 A	(139 $\Omega$ )	(152 $\Omega$ )	(166 $\Omega$ )	254 $\Omega$	333 $\Omega$	577 $\Omega$
30 A	(115 $\Omega$ )	(127 $\Omega$ )	(139 $\Omega$ )	212 $\Omega$	277 $\Omega$	481 $\Omega$
40 A	(87 $\Omega$ )	(95 $\Omega$ )	(104 $\Omega$ )	(159 $\Omega$ )	208 $\Omega$	361 $\Omega$
50 A	—	(76 $\Omega$ )	(83 $\Omega$ )	(127 $\Omega$ )	(166 $\Omega$ )	289 $\Omega$

	<b>CD14400</b>					<b>CD25000</b>
$U_{\text{sys}}$	<b>6000 V</b>	<b>6600 V</b>	<b>7200 V</b>	<b>11,000 V</b>	<b>14,400 V</b>	<b>25,000 V</b>
$I_{\text{NGR}}$						
100 A	—	—	—	—	(83 $\Omega$ )	(144 $\Omega$ )

### 3 Mounting



Only qualified personnel are permitted to carry out the work necessary to install, commission and run a device or system.



**DANGER Risk of electrocution due to electric shock!**

Touching live parts of the system carries the risk of:

- An electric shock
- Damage to the electrical installation,
- Destruction of the device

Before installing and connecting the device, make sure that the installation has been de-energized. Observe the rules for working on electrical installations.

#### Dimension diagram NGRM5...

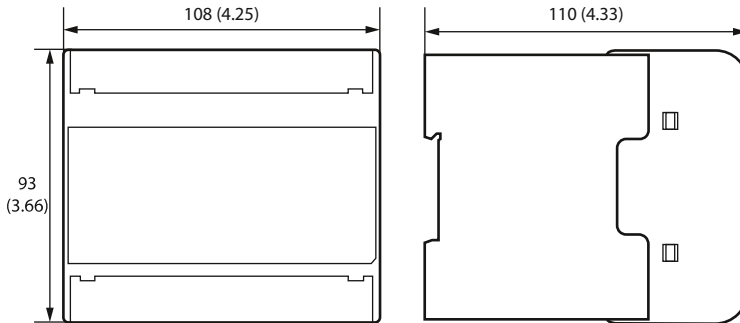


Figure 3-1: Dimension diagram NGRM5...; Dimensions in mm (in)

**Enclosure view**

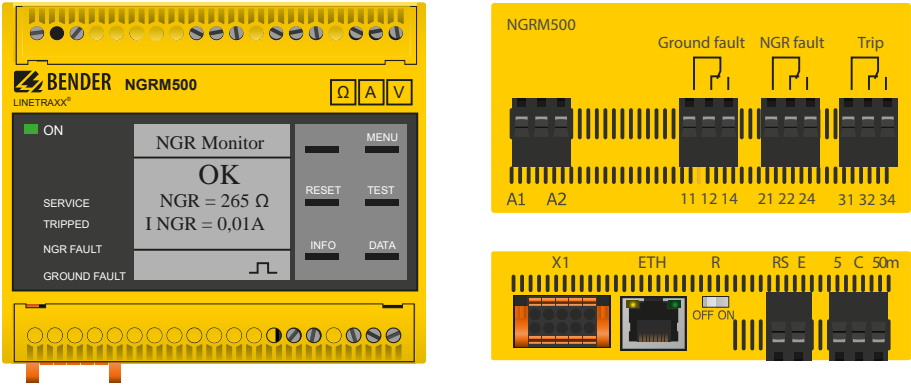


Figure 3-2: Enclosure view: Front (left), Top (right), Bottom (right bottom)

**Screw mounting**

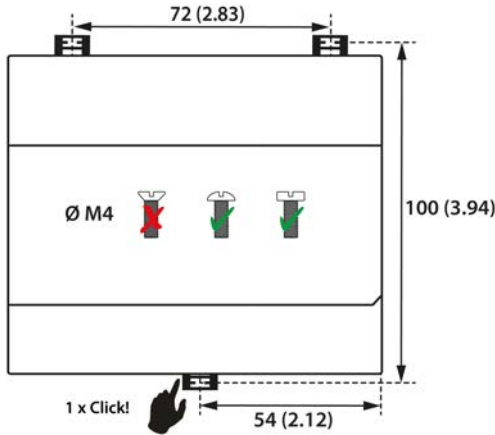
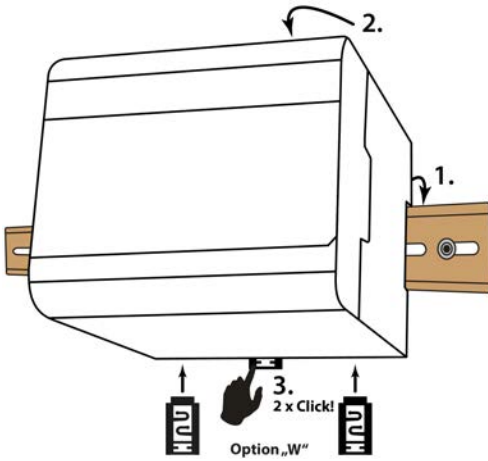


Figure 3-3: Screw mounting; dimensions in mm (in)

1. Fix the three mounting clips delivered with the device (two of them packed separately) manually or using a tool, as illustrated below.
2. Drill the mounting holes for the M4 thread according to the drilling template.
3. Fix the device with three M4 or #10 screws.

## DIN rail mounting



Fix the mounting clips delivered with the device as illustrated.

1. Snap the device on the DIN rail.
2. Press the device lightly onto the DIN rail.
3. Fix the device to the DIN rail by pushing the mounting clips until they you hear them click into place.

Figure 3-4: DIN rail mounting

## 4 Connection

### 4.1 Connection requirements



Only qualified personnel are permitted to carry out the work necessary to install, commission and run a device or system.



**DANGER Risk of electrocution due to electric shock!**

Touching live parts of the system carries the risk of:

- An electric shock
- Damage to the electrical installation,
- Destruction of the device

Before installing and connecting the device, make sure that the installation has been de-energized. Observe the rules for working on electrical installations.



**CAUTION Provide line protection!**

According to DIN VDE 0100-430, a line protection shall be provided for the supply voltage.



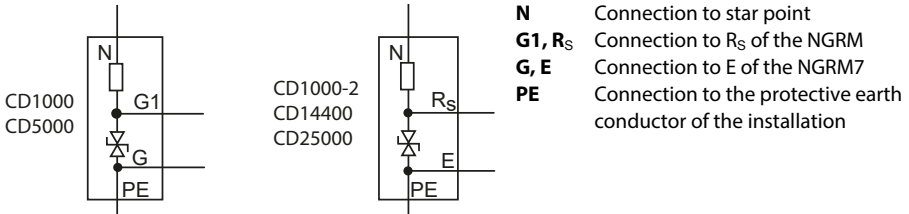
Check proper connection. Prior to commissioning of the installation, check that the device has been properly connected and check that the device functions.



For UL applications:

- Use 60/70 °C copper lines only.
- For UL and CSA applications, the supply voltage must be protected via 5A fuses.

### 4.2 Connection descriptions of CD-series coupling device



### 4.3 Recommended connecting cable coupling device CD...

CD...	Connection CD...	Cable lug	Metrical	Imperial
CD1000	N, G1, G	—	1.5 mm <sup>2</sup>	AWG 16
CD1000-2	N, R <sub>S</sub> , E	—	1.5 mm <sup>2</sup>	AWG 16
	PE	M4	≥ 1.5 mm <sup>2</sup>	AWG 16 or bigger
CD5000	G1, G	—	1.5 mm <sup>2</sup>	AWG 16
	N	M8 oder M10	≥ 1.5 mm <sup>2</sup>	AWG 16 or bigger
	PE	M6	≥ 1.5 mm <sup>2</sup>	AWG 16 or bigger
CD14400 CD25000	R <sub>S</sub> , E	—	1.5 mm <sup>2</sup>	AWG 16
	N	M5 oder M10	≥ 1.5 mm <sup>2</sup>	AWG 16 or bigger
	PE	M5	≥ 1.5 mm <sup>2</sup>	AWG 16 or bigger

### 4.4 Star connection

#### Connection

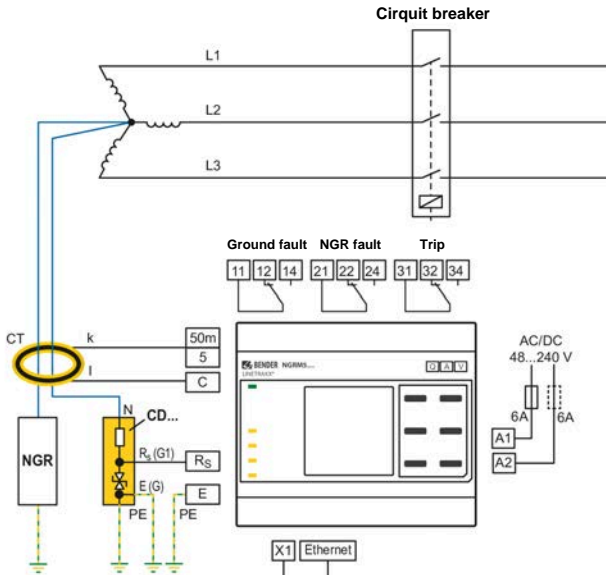


Figure 4-1: Star configuration

**i** The “N” connection of the CD-series coupling device should be as close to the transformer star point as possible.



**Connection with Pulsers**

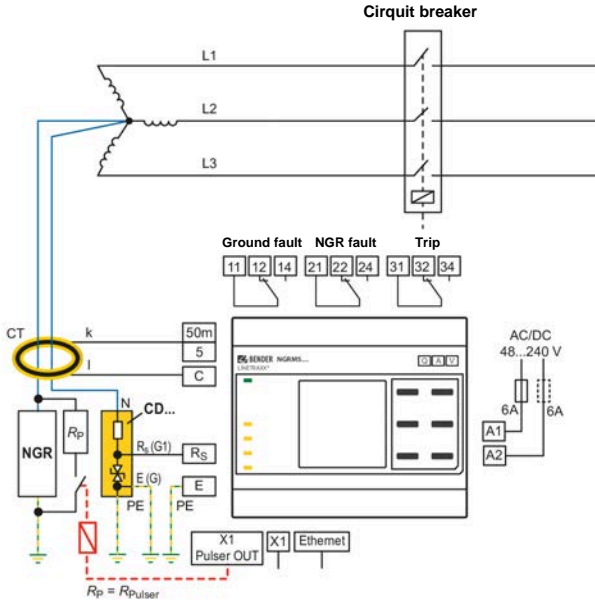


Figure 4-2: Connection with pulser

- i** The "N" connection of the CD-series coupling device should be as close to the transformer star point as possible.
- i** An intermediate relay may be required between the power contactor of the pulser and the digital output X1.

### Artificial neutral (delta connection)

If no star point is available, the following circuit can create an artificial neutral.

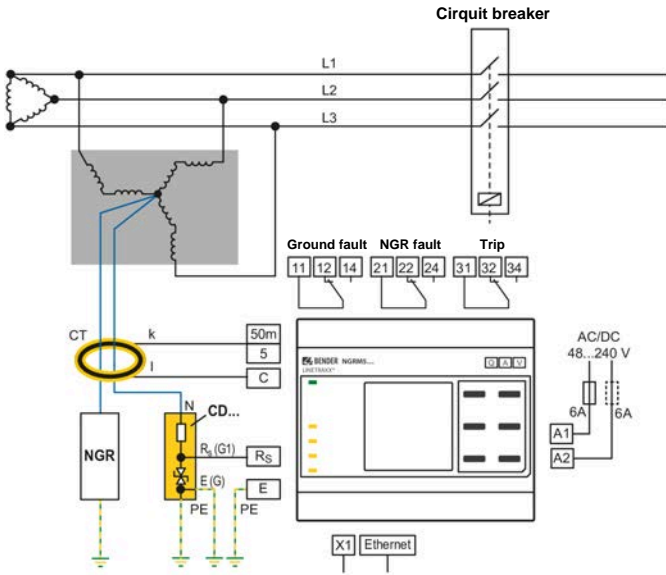
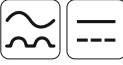



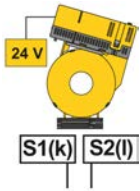

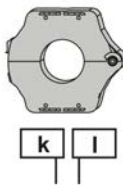
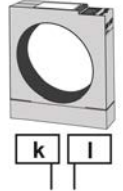


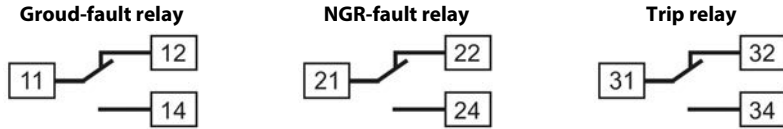
Figure 4-3: Artificial neutral with a zigzag transformer

## 4.5 Connection current transformer

Choose a measuring current transformer suitable for the network to be monitored. All common measuring current transformers (50 mA or 5 A on the secondary side) can be used. The following table helps you with the choice:

System type	AC + DC	AC	AC	AC
$I_{NGR}$	0.5...25 A	5...30 A	5...1000 A	10...2000 A
$f$	0...3800 Hz	42...3800 Hz	50/60 Hz	50/60 Hz
Transformation ratio, Bender CT	Measuring ranges (see CTUB103 manual) 5 A 100:1 10 A 200:1 25 A 500:1	600:1		
Connecting cable	max. 30 m	max. 40 m	max. 25 m: 4 mm <sup>2</sup> / AWG 12 max. 40 m: 6 mm <sup>2</sup> / AWG 10	
	provided cable or 0.75...1.5 mm <sup>2</sup> / AWG 18...16			
$I_{dn}$				
Type	CTUB103 	CTAC...  CTAS... 	CTB31...51 	Any standard current transformer can be used.
CT terminal k	NGRM: 50 mA	NGRM5...: 50 mA	NGRM5...: 5 A	NGRM5...: 5 A
CT terminal l	NGRM5...: C	NGRM5...: C	NGRM5...: C	NGRM5...: C

## 4.6 Connection of relays



The delay times of the various relays are not the same. See table "Trip times", Page 42.

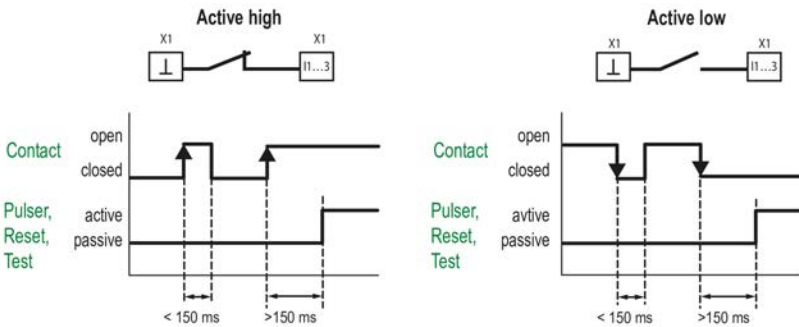
## 4.7 Connection to the X1 interface

Pin assignment X1 interface

	I1	Digital 1 (configurable: pulser, NGR method)
	I2	Reset IN
	I3	Test IN
	A	Modbus RTU (A)
	B	Modbus RTU (B)
	⊥	Common
	M+	Analogue output
	Q2	Open Collector: Pulser OUT
	Q1	Open Collector: Device health
	+	Output for supply of external relays (+24 V, max. 100 mA)

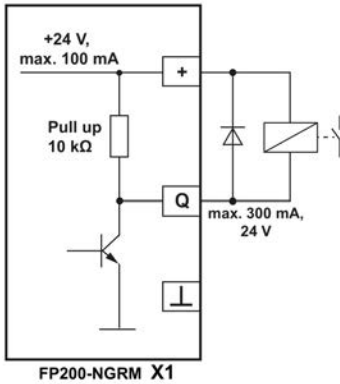
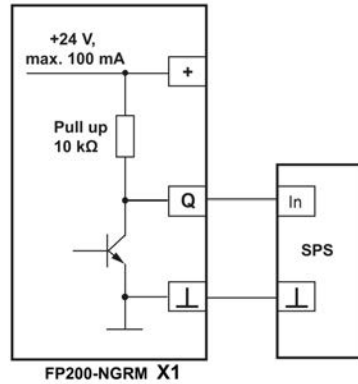
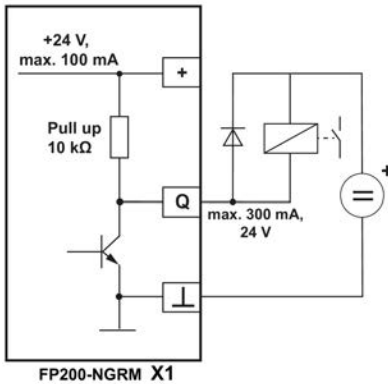
### 4.7.1 X1: Input I1...3

The input is only detected as "activated" after the contact has been activated for at least 150 ms. This way, short interference pulses are ignored.



**Input I1...3:** Potential-free contact to ground or 0 V and 24 V in conjunction with a PLC

## 4.7.2 X1: Output Q1...2

**Internal 24 V**

**Connection to SPS**

**External supply e. G. 12...24 V**


**Connection to Q1, Q2:** external relay or PLC

**i**

Observe maximum current values! The maximum output current on X1(+24 V) is **100 mA**.

In case of higher currents, the relays require an external 24-V supply.

The maximum current on **Q1 and Q2 is 300 mA each**.

### 4.7.3 X1: Analogue output

Analogue output	Mode	Permissible load
Current output 	0...20 mA	$\leq 600 \Omega$
	4...20 mA	$\leq 600 \Omega$
	0...400 $\mu\text{A}$	$\leq 4 \text{ k}\Omega$
Voltage output 	0...10 V	$\geq 1 \text{ k}\Omega$
	2...10 V	$\geq 1 \text{ k}\Omega$

Either NGR **current**  $I_{\text{NGR}}$  or NGR **resistance**  $R_{\text{NGR}}$  can be assigned to the analogue output. A voltage or current signal proportional to the measured value is applied to the output.

The following overview shows how the output signals (A or V) are proportional to the measured values ( $\Omega$  or A):

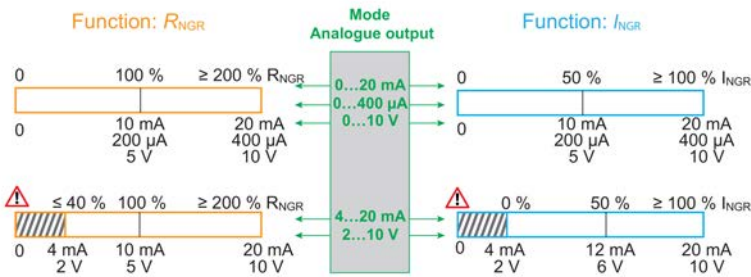


Figure 4-4: Assignment of measured value to output signal

**i** In "4...20 mA" and "2...10 V" mode an output signal of 0 mA or 0 V indicates a wiring error of the analogue interface.

## 5 User interface

### 5.1 Operating elements

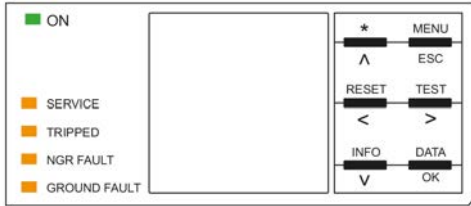


Figure 5-1: Display elements and device buttons

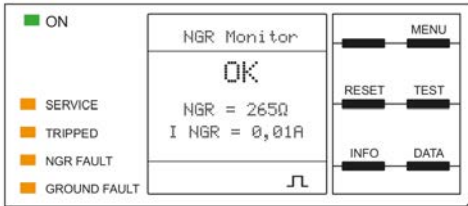
#### Display elements

ON	Operation LED (green) on: power supply available
SERVICE	LED on: device fault, connection fault, or maintenance mode
TRIPPED	LED on: trip relay tripped due to NGR fault, ground fault or device error
NGR FAULT	LED flashes (prewarning): NGR fault detected, NGR-fault relay tripped, trip relay not tripped yet ( $t_{NGR\ trip}$ elapses) LED on: NGR fault detected. Trip relay and NGR-fault relay tripped.
GROUND FAULT	LED flashes (prewarning): ground fault detected, groundfault relay tripped, trip relay not tripped yet ( $t_{GF\ trip}$ elapses). LED on: ground fault detected, trip relay tripped, installation not shut down yet.
DISPLAY	The LC display shows device and measurement information.
Buzzer	on: alarm / test

#### Device buttons

^	Navigates up in a list or increases a value.
MENU	Opens the device menu.
ESC	Cancels the current process or navigates one step back in the device menu.
RESET	Resets alarms.
<	Navigates backwards (e.g. to the previous setting step) or selects parameter.
TEST	Starts the device self test.
>	Navigates forwards (e.g. to the next setting step) or selects parameter.
INFO	Shows information.
v	Navigates down in a list or reduces a value.
DATA	Shows data and values.
OK	Confirms an action or a selection.

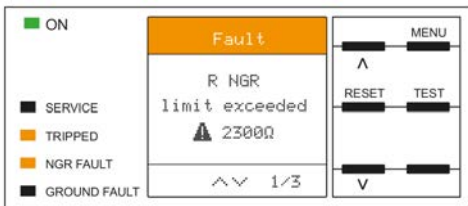
## 5.2 Standard display



The pulse symbol in the lower part of the display indicates that the resistance of the  $R_{NGR}$  is actively measured.

**i** Return from any (sub)menu to the **standard display** by pressing and holding ESC for more than 2 s.

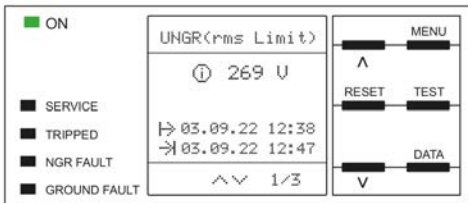
## 5.3 Fault indication (active)



An active fault is indicated on the display with a warning triangle while the upper part of the display turns orange and displays the fault message.

Depending on the fault type, the GROUND FAULT, NGR FAULT, TRIPPED or SERVICE LEDs will be on. If several fault messages appear, navigate through the faults using the  $\wedge$  and  $\vee$  buttons.

## 5.4 Fault indication (inactive)



An inactive fault is indicated on the display with a circled "i".

This message means that there has been a fault in the past but the device is no longer in fault condition. If more than one fault has occurred, the number of faults is also indicated in the lower part of the display. Navigate through the faults using the  $\wedge$  and  $\vee$  buttons. In addition to the type of fault and the associated alarm value, you can see when the fault occurred and for how long it was active.



## 5.5 Acknowledging a fault message

In order to return to the standard display of the NGR monitor, the fault message must be acknowledged by means of the RESET button. Fault messages can only be reset when the cause of fault has been eliminated.

**Acknowledging:** Press the RESET button, select “Acknowledge” and then OK to mute the buzzer (if enabled) and delete the messages from the standard display. After this, the NGR monitor returns to the standard display. No restart attempt takes place. The fault messages remain stored in the history memory.

**Reset:** Press the RESET button, select “Reset” and then OK. The buzzer is muted and the fault messages are deleted from the standard display. If the installation is de-energized, restart attempts will be carried out, which will only be successful after the fault has been eliminated. The device returns to the standard display. The faults remain stored in the history.

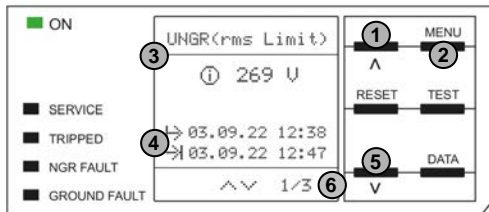
## 5.6 History memory



A **reset** can also be carried out via the input **I2**. It must be active for more than 150 ms.

Up to 1023 alarm messages and device errors with date and time stamp can be stored in the history memory. If the maximum number of memory entries has been reached, the oldest entry will be overwritten by a new event record.

Display the history memory at **MENU > 3. History**.



- 1 View next message
- 2 Exit view
- 3 Fault description; Alarm value
- 4  $\Rightarrow$  Fault appeared (fault start time)
- 5 View previous message
- 6 Number of the selected fault / Fault message count

## 6 Menu

### 6.1 Overview

#### 1. Data meas. values

$R_{NGR}$ ,  $R_{NGR}$  rel, Method,  $R_{sense}$ ,  $I_{rms}$ ,  $I_{rms}$  rel,  $U_{rms}$ ,  $U_{rms}$  rel,  $I_{fund}$ ,  $I_{fund}$  rel,  $U_{fund}$ ,  $U_{fund}$  rel,  $I_{harm}$ ,  $I_{harm}$  rel,  $U_{harm}$ ,  $U_{harm}$  rel,

#### 2. Harmonics



#### 3. History

History, Delete

#### 4. Pulser

Pulser,  $t_{impuls}$

#### 5. Display

$R_{NGR}$ ,  $I_{NGR}$

#### 6. HRG settings

HRG/LRG system	$U_{sys}$ (L-L), $f$ , $I_{NGR}$ nom, $R_{NGR}$ no m
CT	CT primary, CT secondary, CT connection
NGR	Method, Filter, Filter type, Filter size, Ignore values
Response values	$U_{NGR}$ Trip, $I_{NGR}$ Trip, $>R_{NGR}$ , $<R_{NGR}$ (HRG only), $t_{NGR}$ trip, GF trip, $t_{GF}$ trip, Alarm stored, $t_{restart}$ , Max. no. of restarts, Trip signal, Upper limit harmonics, Lower limit harmonics
System settings	Ground fault relay ..... Mode, Relay test NGR relay ..... Mode, Relay test Trip relay ..... Mode, Relay test Analogue ..... Mode, Function Digital in/out ..... Device OUT, Pulser OUT, Digital 1, Reset IN, Test IN Buzzer ..... Buzzer alarm, Buzzer test
Field calibration	

#### 7. Device settings

Language, Clock, Interface, Display, Password, Factory setting, Software, Service

#### 8. Commissioning

Setting Language, Clock,  $U_{sys}$  L-L,  $f$ ,  $I_{NGR}$  nom,  $R_{NGR}$  nom, CT<sub>primary</sub>, CT<sub>secondary</sub>, CT<sub>Connection</sub>, Field calibration

#### 9. Info

Device information, Software information, Clock and date information, Ethernet information

#### 10. Alarm

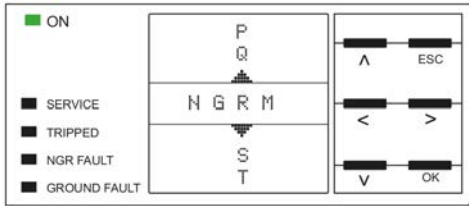
Acknowledge, Reset, Test

## 6.2 Navigating through the menu

- ^ / v Select submenu.
- > / OK Enter submenu.
- < / ESC Return from submenu to main menu.
- ESC (2 s) Return to standard display.

## 6.3 Changing settings

Enter settings with text/numbers directly. There is a corresponding representation in the menu items:



- ^ / v Scroll to the letter/number.
- < / > Shift left and right in the word.
- ESC Reject entry.
- OK Save entry.

## 6.4 Data measured values (menu 1)

List of measured values. Navigate through the list using the buttons ^ and v.

Parameter	Explanation
$R_{NGR}$	NGR resistance value
$R_{NGR\ rel}$	Relative <sup>1)</sup> resistance value NGR
Method	Measurement method (see menu 6.3)
$R_{Sense}$	Resistance value; CD-series coupling device
$I_{RMS}$	Current; RMS value
$I_{RMS\ rel}$	Current; relative <sup>1)</sup> RMS value
$U_{RMS}$	Neutral voltage; RMS value
$U_{RMS\ rel}$	Neutral voltage; relative <sup>1)</sup> RMS value
$I_{fund}$	Current; RMS value (fundamental frequency)
$I_{fund\ rel}$	Current; relative <sup>1)</sup> RMS value (fundamental frequency)
$U_{fund}$	Neutral voltage; RMS value (fundamental frequency)
$U_{fund\ rel}$	Neutral voltage; relative <sup>1)</sup> RMS value (fundamental frequency)
$I_{harm}$	Current; RMS value (for selected harmonic frequency range) <sup>2)</sup>
$I_{harm\ rel}$	Current; relative <sup>1)</sup> RMS value (for selected harmonic frequency range) <sup>2)</sup>

Parameter	Explanation
$U_{\text{harm}}$	Neutral voltage; RMS value (for selected harmonic frequency range) <sup>2)</sup>
$U_{\text{harm rel}}$	Neutral voltage; relative <sup>1)</sup> RMS value (for selected harmonic frequency range) <sup>2)</sup>

1) Relative measured values always indicate the ratio of the measured value to the nominal value in %.

2) The selected harmonics are configured in menu 6.4.

## 6.5 Harmonics (menu 2)

The measured harmonics are represented in a bar graph as a percentage of the measured value in relation to the nominal value.

Change between the harmonic **voltage** and **current** displays using the  $\wedge$  and  $\vee$  buttons.

Scroll through the **harmonics up to the 64<sup>th</sup> order** using the  $<$  and  $>$  buttons.



*All harmonics are always represented, regardless of the settings in menu 6.4.*

Use ESC to return to the main menu.

## 6.6 History (menu 3)

Alarm messages (since switching on the device or deleting the last history) are saved.

**History:** Navigate through the list using the  $\wedge$  and  $\vee$  buttons.

**Delete:** After confirming, the history is irreversibly deleted.

## 6.7 Pulser (menu 4)

A ground fault can be located by means of a measuring clamp-on ammeter and the pulser function. The pulser relay is designed as Open Collector.

### Pulser (menu 4.1)

- **Active** - The pulser is continuously active regardless of ground faults that have occurred.
- **External** - If the digital input I1 is set to "Pulser", it can enable the pulser at any time.
- **Auto** - The pulser activates automatically in the event of a ground fault.
- **Inactive** - The pulser output is disabled.

$t_{\text{pulse}}$  (menu 4.2)

The pulse period can be set between 1...10 s.

**i** The set pulse period is only effective if the pulser (menu 4.1) is not "inactive".

The following diagram shows an overview of the pulser control:

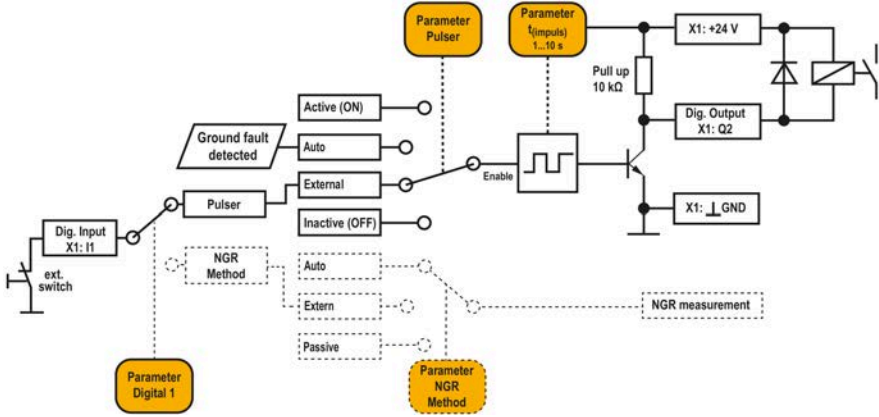


Figure 6-1: Configuration Digital 1 as pulser

## 6.8 Display (menu 5)

Choose whether the measured values for  $R_{\text{NGR}}$  and  $I_{\text{NGR}}$  are displayed as absolute (in  $\Omega$  or A) or relative (in % to the reference value). The relative value is the ratio of the measured value to the nominal value.

## 6.9 HRG, LRG settings (menu 6)

### HRG, LRG system (menu 6.1)

Menu	Parameter	Setting range	Explanatory notes
6.1.1	$U_{\text{sys}}$ (L-L)	400 V ... 25 kV	System phase-to-phase voltage
6.1.2	CD-NGRM	CD1000, CD5000, CD14400, CD25000, other	For CD1000 and CD1000-2, select "CD1000" in the menu. The selection depends on the system voltage $U_{\text{sys}}$ .
6.1.3	Frequency	50 or 60 Hz	Nominal frequency
6.1.4	$I_{\text{NGR nom}}$	0,5...100 A (HRG) 10...2000 A (LRG)	Nominal value of the NGR current
6.1.5	$U_{\text{NGR nom}}$	15...5000 $\Omega$ (HRG) 0.1...200 $\Omega$ (LRG)	Nominal value of the used NGR resistance

**CT (Current Transformer, menu 6.2)**

Menu	Parameter	Setting range	Explanatory notes
6.2.1	CT primary	1...10,000	Ratio of the CT on the primary side
6.2.2	CT secondary	1...10,000	Ratio of the CT on the secondary side
6.2.3	CT connection	5 A, 50 mA	Used CT connection

**NGR (menu 6.3)**

Menu	Parameter	Setting range	Explanatory notes
6.3.1	Method	auto, passive, external	<p><b>auto:</b> automatic changeover between active and passive resistor monitoring; setting for field calibration</p> <p><b>passive:</b> only passive resistor monitoring (see chapter 2.3, Functional description)</p> <p><b>external:</b> If "Digital 1 &gt; NGR method" (menu 6.5.5.3) is set, switching takes place depending on the condition of the digital input I1:</p> <ul style="list-style-type: none"> <li>• I1 active: method is set to "auto"</li> <li>• I1 passive: method is set to "passive"</li> </ul>
6.3.2	Filter	off, weak, medium, strong, customer-specific	Filter for active measurement of the NGR's resistance. For instance in installations with a frequency converter.
6.3.3	Filter type*	Mean, RMS	Selection between <b>mean filter</b> or <b>RMS filter</b>
6.3.4	Filter size*	2...40	Number of filter elements
6.3.5	Ignore values*	0...10	Number of ignored measured-value outliers

\* The filter parameters "type", "size", and "ignore values" are only taken into account in the setting "customer-specific".

Diagram for selecting the NGR method

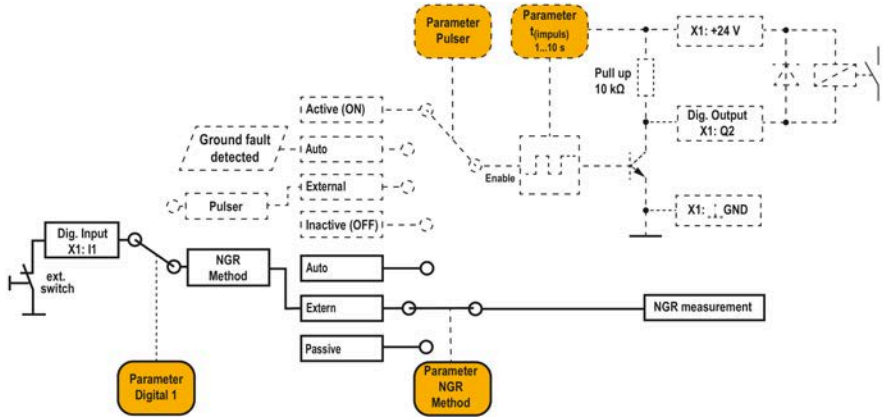


Figure 6-2: Configuration Digital 1 as NGR method

## Response values (menu 6.4)

### Behaviour of the trip relay in the event of a ground fault

Set whether a ground fault (response value violation  $U_{NGR}$  and/or  $I_{NGR}$ ) should switch the trip relay or not. Set the filter type for NGR current and voltage ("total RMS", "fundamental", or "harmonics") that leads to a violation of the response value at "Trip signal".

- a) **Ground-fault trip „on“:** When a ground fault is detected
  - the **ground-fault relay** (connections 11, 12, 14) switches **immediately** (40 ms),
  - the **trip relay** (connections 31, 32, 34) switches **after  $t_{GF Trip}$  has elapsed**.
- b) **Ground-fault trip „off“:** When a ground fault is detected
  - the **ground-fault relay** (connections 11, 12, 14) switches **immediately** (40 ms),
  - the **trip relay** (connections 31, 32, 34) **does not switch**,  $t_{GF Trip}$  is ignored.



When using a coupling device CD14400 or CD25000, the menu item "Ground-fault trip = off" is not available.

### Resistor faults

Resistor faults (response value violation  $R_{NGR}$ ) are independent of the "GR trip" settings: The **NGR-fault relay** (connections 21, 22, 24) switches within the response time of approx. 7.5 s. The **trip relay** (connections 31, 32, 34) switches with a **delay** according to the  $t_{NGR trip}$  setting.

### Restart of the installation (restart attempts)

Set whether the installation should be restarted manually or automatically after a fault.

#### a) Restart installation manually (alarm stored "on")

In the event of a fault, the trip relay changes state and the installation shuts down. The fault must be eliminated and the installation is restarted via a manual reset (menu 9) or via input I2. If the restart is not successful, it must be retried (after further fault elimination).

#### b) Restart installation automatically (alarm stored "off")

In the event of a fault, the trip relay changes state and the installation shuts down. The fault must be eliminated. After the configured time delay  $t_{\text{restart}}$  has elapsed, the NGRM attempts to restart the installation automatically. If the restart is not successful,  $t_{\text{restart}}$  elapses again and another restart attempt takes place. The number of restart attempts can be selected between 1 and 5.



*The NGRM remains in "Alarm stored" mode even after a shutdown.*

For the delay times, see also "Trip times", Page 42.

Response values (menu 6.4)

Menu HRG	Menu LRG	Parameter	Setting range	Explanatory notes
6.4.1	6.4.1	$U_{\text{NGR trip}}$	10...90 %	Value in % of the nominal value at which the trip relay and the ground-fault relay trip.
6.4.2	6.4.2	$I_{\text{NGR trip}}$	10...90 %	<b>Note:</b> The trip relay only trips if "Ground-fault trip > on" is selected.
6.4.3	6.4.3	$> R_{\text{NGR}}$	110...200 % (HRG) 200...500 $\Omega$ (LRG)	Resistance value in % of the nominal value (HRG) or $\Omega$ value (LRG) at which the trip relay and the NGR-fault relay operate.
6.4.4	/	$< R_{\text{NGR}}$	10...90 % (nur HRG)	
6.4.5	6.4.4	$t_{\text{NGR trip}}$ On the device: t(NGRtrip)	0...48 h	Time delay between NGR fault detection and shutdown by the trip relay. $t_{\text{NGR trip}}$ is added to the response time.
6.4.6	6.4.5	Ground-fault trip	on	<b>Ground fault:</b> Trip relay switches after the time delay $t_{\text{trip}}$ has elapsed. <b>NGR fault:</b> Trip relay switches immediately (< 7.5 s) or after the time delay $t_{\text{NGR trip}}$ (0...48 h) has elapsed.
			off <sup>1)</sup>	<b>Ground fault:</b> Trip relay does not switch. <b>NGR fault:</b> Trip relay switches immediately (< 7.5 s) or after the time delay $t_{\text{NGR trip}}$ (0...48 h) has elapsed.
6.4.7	6.4.6	$t_{\text{GF trip}}^2)$ On the device: t(GFtrip)	100 ms ... 48 h	Time delay between ground-fault detection and operation of the trip relay; only used when "Ground-fault trip > on" is selected.



Menu HRG	Menu LRG	Parameter	Setting range	Explanatory notes
6.4.8	6.4.7	Alarm stored <sup>t</sup>	on	Triggered trip relay must be reset <b>manually</b> (RESET or input I2)
			off	<b>Automatic</b> restart attempts after t <sub>restart</sub> has elapsed (max. number like setting "Number restart")
6.4.9	6.4.8	t <sub>restart</sub> On the device: t(restart)	100 ms ... 24 h	Time delay between fault elimination and automatic restart of the installation; only used when "Alarm stored > off" is selected.
6.4.10	6.4.9	Max. no. of restarts	1...5	Number of restart attempts within 24 h; only used when "Alarm stored > off" is selected.
6.4.11	6.4.10	Trip signal	RMS	Trips on the full-spectrum RMS value ( $f = DC \dots 3.8 \text{ kHz}$ )
			Fundamental	Trips on the RMS value of the fundamental.
			Harmonics	
6.4.12	6.4.11	Upper limit harmonic	0...32: 0 = DC 1 = fundamental	Indicate range of harmonic to trigger the trip relay if the threshold value is exceeded; only active when "Trip signal > Harmonic" is selected.
6.4.13	6.4.12	Lower limit harmonic	2 = 2 <sup>nd</sup> harmonic ... 32 = 32 <sup>th</sup> harmonic	

- 1) When using a coupling device CD14400 or CD25000, the menu item "Ground-fault trip > off" is not available.
- 2) Observe the maximum trip time and the restart time ( $t_{\text{restart}}$ ) for the installed CD-series coupling device when setting the time delay  $t_{\text{trip}}$  (see "Trip times", Page 42).

### System settings (menu 6.5)

Menu	Parameter		Setting range	Explanatory notes
6.5.1	Ground-fault relay	Mode (6.5.1.1)	Fail-safe, non-fail-safe	1)
		Relay test (6.5.1.2)	on, off	2)
6.5.2	NGR-fault relay	Mode (6.5.2.1)	Fail-safe, non-fail-safe	1)
		Relay test (6.5.2.2)	on, off	2)
6.5.3	Trip relay	Mode (6.5.3.1)	Fail-safe, non-fail-safe	1)
		Relay test (6.5.3.2)	on, off	2)

Menu	Parameter		Setting range	Explanatory notes	
6.5.4	Analogue	Mode (6.5.4.1)	0...20 mA 4...20 mA 0...400 $\mu$ A 0...10 V 2...10 V	3)	
		Function (6.5.4.2)	$I_{NGR}$ , $R_{NGR}$		
6.5.5	Digital inputs/ outputs	Device OUT (6.5.5.1)	Fail-safe, non-fail-safe	1)	
		Pulser OUT (6.5.5.2)			
		Digital 1 (6.5.5.3) configurable Pulser/ NGR method	Active high Active low		<b>Active high:</b> Activation of the function when input level changes from "low" to "high" <b>Active low:</b> Activation of the function when input level changes from "high" to "low"
		RESET IN (6.5.5.4)			
		TEST IN (6.5.5.5)			
6.5.6	Buzzer	Buzzer alarm (6.5.6.1)	on, off	<b>on:</b> alarm activates buzzer <b>off:</b> alarm does not activate buzzer	
		Buzzer test (6.5.6.2)	on, off	<b>on:</b> test activates buzzer <b>off:</b> test does not activate buzzer	

- 1) Fail-safe: The relay is energized during normal operation and is de-energized in the event of a fault ("fail-safe")  
Non-fail-safe: The relay is de-energized in normal operation and is energized in the event of a fault ("non-fail-safe")
- 2) When set to "on", the function of the relay is checked during a test by switching it.
- 3) Analogue output (menu 6.5.4) Either NGR **current**  $I_{NGR}$  or NGR **resistance**  $R_{NGR}$  (HRG devices only) can be assigned to the analogue output. In doing so, the voltage or current is proportional to the measured value. See "Analogue output (menu 6.5.4)", Page 46. for more details.

### Field calibration (menu 6.6)

During field calibration, all tolerances of the connected CD-series coupling device and the NGR are considered. The current measured value is calibrated to the set nominal value of the NGR ( $R_{NGR\ nom}$ ).

In order to achieve high accuracy, start the device and let it run for at least one hour in the operating environment before carrying out the field calibration.



*For the field calibration the device must be in auto mode (menu 6.3.1 = auto).*

*If the digital input I1 is used with "Digital 1 > NGR method" (menu 6.5.5.3), "Method > external" (menu 6.3.1) must be selected and I1 must be active (refer also to "NGR (menu 6.3)", Page 30).*

*The trip relay is switched during field calibration!*

## 6.10 Device settings (menu 7)

Further information on the configurable parameters can be found following the overview in the table.

### Device settings overview (menu 7)

Menu	Parameter	Note
7.1	Language	German English GB English US Spanish French
7.2	Clock	
	Time (7.2.1)	Set local time
	Format (7.2.2)	12 h (am/pm) 24 h
	Summer time (7.2.3)	Automatic change? see Summer time (menu 7.2.3), Page 37
	Date (7.2.4)	Set date
	Format (7.2.5)	dd.mm.yy mm-dd-yy
	NTP (7.2.6)	on: Synchronization switched on (Configure the NTP server for this.)
		off: Synchronization switched off
NTP server (7.2.7)	IP address NTP server	
UTC (7.2.8)	Set time zone according to UTC (Coordinated Universal Time).	

Menu	Parameter	Note	
7.3	Interface see Interface (menu 7.3), Page 37	Write access (menu 7.3.1)	Allow, Deny
		Ethernet (7.3.2)	DHCP (7.3.2.1)
			IP (7.3.2.2)
			SN (7.3.2.3)
			Std.GW (7.3.2.4)
			DNS server (7.3.2.5)
			Domain (7.3.2.6)
		BCOM (7.3.3)	System name (7.3.3.1)
			Subsystem (7.3.3.2)
			Device address (7.3.3.3)
			Timeout (7.3.3.4)
			TTL for subscription (7.3.3.5)
		Modbus TCP (7.3.4)	Port 502 (7.3.4.1)
		Modbus RTU (7.3.5)	Address (7.3.5.1)
			Baud rate (7.3.5.2)
			Parity (7.3.5.3)
Stop bits (7.3.5.4)			
7.4	Display see Display (menu 7.4), Page 39	Brightness (7.4.1)	0...100 %
		Decimal separators (7.4.2)	Comma, point
7.5	Password	Password (7.5.1)	Factory setting 0000
		Status (7.5.2)	on, off
7.6	Factory settings	Discarded changes and reset to factory settings.	
7.7	Software	Update via interface (7.7.1)	see Software (menu 7.7), Page 39
		UPDATE (7.7.2)	
7.8	Service	For Bender service only	

## Summer time (menu 7.2.3)

**off** No automatic change between summer time and standard time.

### **DST** Daylight Saving Time

Automatic change between summer time and standard time according to North American regulation. North American summer time begins on each second Sunday in March at 02:00 local time by setting the clock forward by one hour from 02:00 to 03:00 local time. Summer time always ends the first Sunday in October at 03:00 local time by setting the clock back one hour from 03:00 to 02:00.

### **CEST** Central European Summer Time

Automatic change between summer time and standard time according to Central European regulation. Central European summer time begins on each last Sunday in March at 02:00 CEST by setting the clock forward by one hour from 02:00 to 03:00. Central European summer time always ends on the last Sunday in October at 03:00 CEST by setting the clock back one hour from 03:00 to 02:00.

**i** When set to "DST" or "CEST", changing between summer time and normal time is only done on the date of the official time change.

## Interface (menu 7.3)

Set the parameters for connecting other communication devices in the interface menu:

### **Write access (menu 7.3.1)**

Set whether the parameters of the device can be changed via Modbus or web server. Displaying and reading out data via Modbus and web server is always possible, regardless of this setting.

- **Allow:** Allow external parameter setting.
- **Deny:** Deny external parameter setting.

### **Ethernet (menu 7.3.2)**

Set the parameters for communication with other devices via the Ethernet interface. The Ethernet interface can be used for communication with Modbus, web server and BCOM.

#### **DHCP (menu 7.3.2.1)**

- **on:** Enable automatic IP address assignment (IP address, subnet mask, standard gateway). Manual address settings are ignored.
- **off:** Disable automatic IP address assignment. Enter settings (IP address, subnet mask and standard gateway) manually in the menu.

**i** The used IP address is displayed in the Info menu (INFO button or menu 9).

#### **IP (menu 7.3.2.2)**

Set the appropriate IP address for the NGRM.

#### **SN (menu 7.3.2.3)**

Set the appropriate subnet mask.

#### **Std. GW (menu 7.3.2.4)**

If a standard gateway is used, enter the IP address here.

**DNS server (menu 7.3.2.5)**

If a DNS server is used, enter the server's IP address. For questions regarding the configuration of a DNS server, please contact your network administrator.

**Domain (menu 7.3.2.6)**

Enter the domain. For questions regarding the configuration of the domain, please contact your network administrator.

**BCOM (menu 7.3.3)**

Set the parameters for communication with other devices via BCOM.

**System name (menu 7.3.3.1)**

Enter the system name of the network in which the devices are located. In order to guarantee that all devices are able to communicate via BCOM, all devices must have the same system name.

**Subsystem (menu 7.3.3.2)**

Configure the subsystem address of the network in which the devices are located. The devices can communicate with subsystems with the same or different subsystem addresses.

**Device address (menu 7.3.3.3)**

Assign a device address. Each device must have a different address to distinguish it from others in the system and ensure correct communication.

**Timeout (menu 7.3.3.4)**

Set the timeout for messages between 100 ms ... 10 s. This time specification defines the maximum permissible time for a device to respond.

**TTL for subscription (menu 7.3.3.5)**

Set a time between 1 s and 1092 min. This time determines in what intervals the NGRM sends messages to e.g. a gateway. Severe alarms are always sent immediately.

**Modbus TCP (menu 7.3.4)**

Set communication with other devices via Modbus TCP.

**Port 502 (menu 7.3.4.1)**

- **on:** Modbus TCP can be used for communication with other devices.
- **off:** Modbus TCP cannot be used for communication with other devices.

**Modbus RTU (menu 7.3.5)**

Set communication with other devices via Modbus RTU.

**Address (menu 7.3.5.1)**

1...247

**Baud rate (menu 7.3.5.2)**

Options: 9.6 kBaud; 19.2 kBaud; 38.4 kBaud; 57.6 kBaud

**Parity (menu 7.3.5.3)**

Options: "even", "uneven", "none"

**Stop Bits (menu 7.3.5.4)**

Options: "1", "2", "auto"

## Display (menu 7.4)

### Brightness (menu 7.4.1)

Adjust the display brightness between 0...100 % in steps of 10. If no button is pressed for 15 minutes, the display brightness decreases. After pressing a button, the display returns to the adjusted brightness.

## Software (menu 7.7)

### Update via interface (menu 7.7.1)

- **on:** Software updates can be carried out via the web interface.
- **off:** Software updates cannot be carried out via the web interface.

### UPDATE (menu 7.7.2)

If a software package was transferred to the device, the package can be installed (again) here.

## 6.11 Commissioning (menu 8)

The commissioning wizard queries all relevant parameters.

Language (8.2)	Select
Date (8.3)	Set
Time (8.4)	Set
Usys L-L (8.5)	System voltage
Frequency (8.6)	50 or 60 Hz
INGR nom (8.7)	
RNGR nom (8.8)	
CT primary (8.9)	
CT secondary (8.10)	
CT connection (8.11)	50 mA oder 5 A
Field calibration (8.12)	Start or do not start

## 6.12 Info (menu 9)

The current settings of the NGRM can be viewed in the Info menu. Navigate through the different views using the arrow buttons:

<b>Device</b>	name, serial number, article number
<b>Software</b>	Measurement equipment software version, HMI software version
<b>Clock</b>	Time, date, summer time
<b>Ethernet</b>	IP address, DHCP status, MAC address

## 6.13 Alarm (menu 10)

- Acknowledge** Mute buzzer, delete message from the standard display, fault message remains stored in the history memory. If the installation is de-energized, no restart attempts will take place.
- Reset** Mute buzzer, delete message from the standard display, fault message remains stored in the history memory. If the installation is de-energized, restart attempts will be carried out, which will only be successful after the fault has been eliminated. The device returns to the standard display.
- Test** Since the relays are not monitored in the hardware or software, the relays must be tested at regular intervals on proper functioning. The frequency of the test cycle is subject to the safety requirements of the operator but it must be carried out at least every six months.

**i** *During the test it must be ensured that the relays can actually switch! The following settings are required:*

<i>Ground-fault relay</i>	<b>menu 6.5.1.2</b> relay test "on"
<i>NGR-fault relay</i>	<b>menu 6.5.2.2</b> relay test "on"
<i>Trip relay</i>	<b>menu 6.5.3.2</b> relay test "on"



## 7 Commissioning

The following parameters must be entered for initial commissioning:

- **System voltage**  $U_{\text{sys}}$  (phase-to-phase)  
The corresponding coupling device must be used depending on the system voltage:  
for  $U_{\text{sys}} \leq 4.3$  kV: CD1000, CD1000-2, CD5000 (20 k $\Omega$ )  
for  $U_{\text{sys}} > 4.3$  kV: CD14400, CD25000 (100 k $\Omega$ )
- **Ratio** of the used **potential transformers** ( $U_{\text{NGR nom}}$ ), if used
- NGR rated **current** ( $I_{\text{NGR nom}}$ )
- **Ratio** of the used **measuring current transformer** (600:1 for W... measuring current transformers)
- NGR rated **resistance**  $R_{\text{NGR nom}}$



*Parameters are set in the **main menu > 6. HRG/LRG settings**.*

*Alternatively, follow the setup wizard (**Main menu > 8. Commissioning**).*

### 7.1 Response values

The following parameters can be adjusted:

- Trip threshold for voltage ( $U_{\text{NGR}}$ )
- Trip threshold for current ( $I_{\text{NGR}}$ )
- Trip threshold for resistance ( $R_{\text{NGR}}$ )



***Low trip threshold values** may lead to **false tripping**, while with **high trip threshold values** the device may not trip at all.*

#### Voltage trip threshold ( $U_{\text{NGR}}$ )

The threshold is set as a percentage of  $U_{\text{NGR nom}}$ .

Einstellbereich Abschaltswelle  $U_{\text{NGR}}$ : 10...90 % (Werkseinstellung 60 %)

#### Current trip threshold ( $I_{\text{NGR}}$ )

The threshold is set as a percentage of  $I_{\text{NGR nom}}$ .

Setting range of trip threshold  $I_{\text{NGR}}$ : 10...90 % (factory setting 60 %).

#### Resistance trip threshold ( $R_{\text{NGR}}$ )

##### HRG

Both trip thresholds for the resistance are set as a percentage of the nominal NGR ( $R_{\text{NGR nom}}$ ).

Setting range of trip threshold  $R_{\text{NGR}}$

10...90 % (factory setting 50 %)

110...200 % (factory setting 200 %).

##### LRG

The upper trip threshold for the resistance is set in  $\Omega$ .

Setting range trip threshold  $R_{\text{NGR}}$  200...500  $\Omega$  (factory setting 250  $\Omega$ )

In the case of the **passive measurement** method the resistance  $R_{\text{NGR}}$  determined using the current and voltage measurements. Accuracy depends on the measuring current transformer.

In the case of the **active measurement** method the device generates an active test pulse and measures  $R_{\text{NGR}}$  even if the installation is de-energized.

For jumping measured values in systems with frequency converters, a filter can be switched on. The switch-off time for  $R_{NGR}$  is extended by the filter time and can be up to one minute.

## 7.2 Output relays operating modes

The factory setting for the relays is fail-safe. In the case of a device test, the relays change state. The settings can be changed in menu 6.5.1...6.5.6 (see "System settings (menu 6.5)", Page 33).

### Field calibration

After the parameters have been entered, a field calibration must be carried out. During this process, the set resistance value of the NGR calibrates to the measurement equipment of the NGRM. For the field calibration, the device must be in auto mode (menu 6.3.1 = auto).

**i** Start field calibration in the **main menu > 6.6 Field calibration**.

If calibration is not possible (e.g. due to incorrect settings) an error message appears (error code 6.10).

### Trip times

Trip times relays

Relais	Trip	Delay	Description
Groundfault relay	$I_{NGR} > \text{Threshold}$ $U_{NGR} > \text{Threshold}$	<b>40 ms</b> , not configurable	For signalling an ground fault without delay
NGR Relais	$R_{NGR} < \text{Threshold}^{1)}$ $R_{NGR} > \text{Threshold}$	<b>100 ms ... 7,5 s</b> , not configurable	For signalling a resistance error without delay <sup>2)</sup>
Trip Relais	$I_{NGR} > \text{Threshold}$ $U_{NGR} > \text{Threshold}$ $R_{NGR} < \text{Threshold}^{1)}$ $R_{NGR} > \text{Threshold}$ $N_{GRM}$ device failure	<b>100 ms ... 48 h</b> configurable for ground fault <b>0...48 h</b> configurable for NGR fault <b>Undelayed</b> for NGR monitor Device error	For switching off the system in the case of ground fault, NGR or device fault with individually adjustable switch-off delay

1) HRG only

2) When using the NGR filter, the error detection can shift into the minute range.

### Explanatory notes on trip relay

- In case of a ground fault,  $t_{GF \text{ Trip}}$  is only considered when "Ground-fault trip" (menu 6.4) is enabled. When "Ground-fault trip" is disabled, the trip relay does not switch in the event of a ground fault.
- In case of an NGR fault,  $t_{GF \text{ Trip}}$  is ignored, the trip relay switches after time delay  $t_{NGR \text{ Trip}}$  has elapsed.
- The setting for  $t_{GF \text{ Trip}}$  must under no circumstances be longer than the maximum possible operating time of the CD-NGRM... coupling device. The table shows an overview of the  $t_{GF \text{ Trip}}$  settings for the coupling device used (menu 6.4):

Maximum trip times  $t_{GF Trip}$  for the used CD-NGRM

$U_{sys}$	Coupling device	Ground-fault trip setting	max. $t_{GF Trip}$
400... 690 V	CD1000	on or off	48 h
	CD1000-2	on or off	48 h
691... 1000 V	CD1000	on	300 s
	CD1000-2	on or off	48 h
	CD5000	on or off	48 h
1001... 4300 V	CD5000	on or off	48 h
4301... 14,550 V	CD14400	on	60 s
	CD25000	on	90 s
14,551... 25,000 V	CD25000	on	10 s

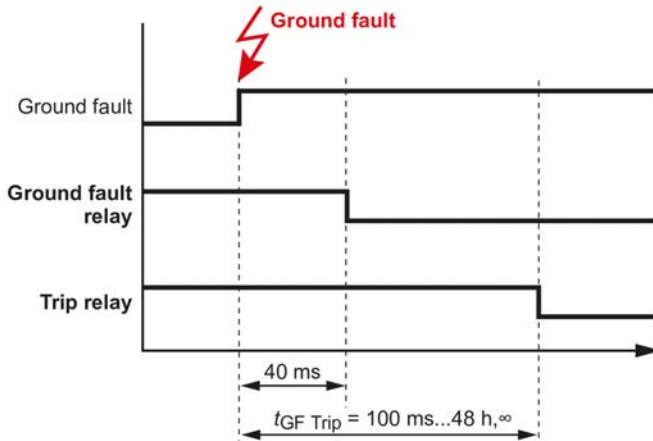
**Ground fault relay timing diagram**


Figure 7-1: Ground fault relay timing diagram

### NGR fault relay timing diagram

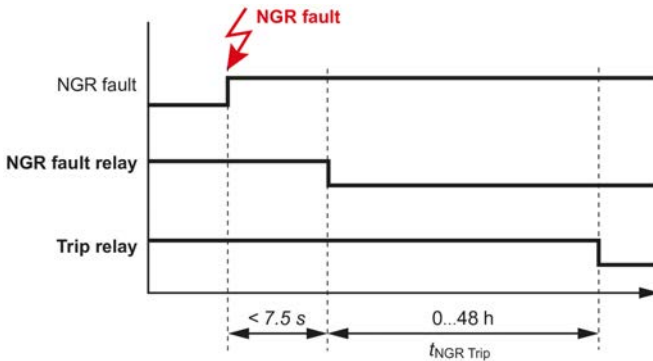


Figure 7-2: NGR fault relay timing diagram



#### ADVICE

The NGR fault detection of <7.5 s can extend to minutes by using the NGR filter, depending on the setting.

### 7.3 RMS trip signal, fundamental, harmonics

The measured value which causes tripping can be selected via the "Trip signal" parameter (menu 6.4). Trip signal can be:

<b>RMS</b>	The RMS value of current or voltage over the entire frequency range (up to approx. 3.8 kHz).
<b>Fundamental</b>	Only the RMS value of the fundamental component (50 or 60 Hz).
<b>Harmonics</b>	The filtered RMS value on the selected range of harmonics H0 = DC H1 = fundamental H2 = 2nd harmonic ... H32 = 32nd harmonic

**i** In the "Harmonics" measured value display (menu 2) all spectral lines are always displayed. This is independent of the trip signal setting.

**i** On the standard display, measured values are displayed as:

- resistance in  $\Omega$  or % (HRG devices only)
- current in A or %

Setting is entered in the main menu > 5: Display.

## 7.4 Filter NGR measurement

Parameter Filter NGR measurement

Filter	off	weak	medium	strong	customized
Filter type	–	Average value	Average value	RMS	Average value, RMS
Filter size	–	6	8	14	2...40
Ignore values	–	0	1	3	0...10

## 7.5 Initial measurement

During device start, all measured values are recorded.

### Timing diagram device start

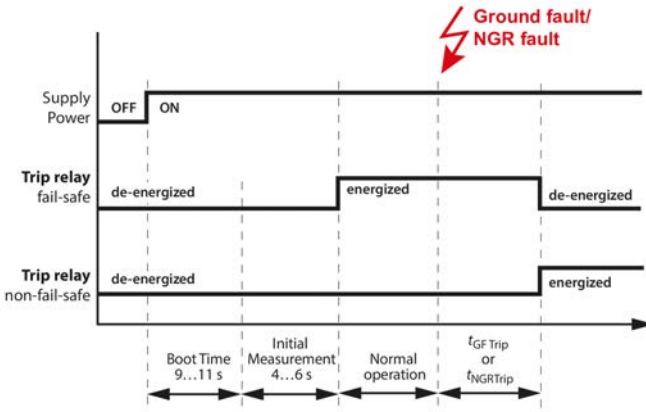


Figure 7-3: Timing diagram device start

## 8 Interfaces

### 8.1 Analogue output (menu 6.5.4)

Either NGR **current**  $I_{NGR}$  or NGR **resistance**  $R_{NGR}$  (HRG devices only) can be assigned to the analogue output. A voltage or current signal proportional to the measured value is applied to the output. The following settings are possible:

#### Mode (menu 6.5.4.1)

- 0...20 mA (Permissible load  $\leq 600 \Omega$ )
- 4...20 mA (Permissible load  $\leq 600 \Omega$ )
- 0...400  $\mu$ A (Permissible load  $\leq 4 \text{ k}\Omega$ )
- 0...10 V (Permissible load  $\geq 1 \text{ k}\Omega$ )
- 2...10 V (Permissible load  $\geq 1 \text{ k}\Omega$ )

For further information, refer to refer to “X1: Analogue output”, Page 22.

#### Function (menu 6.5.4.2)

Set which measured values are assigned to the analogue output. Options:

- $I_{NGR}$
- $R_{NGR}$  (HRG devices only)

### 8.2 Digital outputs (Q1, Q2)

The digital outputs can draw current (sink).

The current rating for the Open-Collector output is 300 mA for each output. Since the „+24 V” connection can only provide 100 mA, it might be required to use an external voltage supply (+24 V) for the relays.

#### Use of Q1: Device health

Mode	No device error detected	Device error detected <sup>1)</sup>	
Fail-safe	on energized Q1 low	off de-energized Q1 high	<p>FP200-NGRM X1</p>
Non-failsafe	off de-energized Q1 high	on energized Q1 low	

1) The SERVICE LED is also on

**Use of Q2: Pulsar**

Mode	Inactive	Active	
<b>Fail-safe</b>	on energized Q2 low	off de-energized Q2 high	<p>FP200-NGRM X1</p>
<b>Non-failsafe</b>	off de-energized Q2 high	on energized Q2 low	

**8.3 Digital input**

The input is only detected as “activated” after the contact has been **activated for at least 150 ms**. This way, short interference pulses are ignored.

For further information, see X1: Input I1...3, Page 20.

## 9 Test cycle

Since the relays are not monitored in the hardware or software, the relays must be tested at regular intervals on proper functioning. The frequency of the test cycle is subject to the safety requirements of the operator but it must be carried out at least every six months.

**i** *During the test it must be ensured that the relays can actually switch! The following settings are required:*

*Ground-fault relay*      **menu 6.5.1.2** relay test "on"

*NGR-fault relay*      **menu 6.5.2.2** relay test "on"

*Trip relay*      **menu 6.5.3.2** relay test "on"

### Starting the test

- With the TEST button or
- in the Menu 10.3 or
- via Input I3



## 10 Technical data

### 10.1 Factory settings

Menu	Factory settings
<b>Menu 6.1: HRG/LRG system</b>	
1. $U_{\text{sys}}$ (L-L)	400 V
2. CD-NGRM	CD1000
3. Frequenz	50 Hz
4. $I_{\text{NGR nom}}$	5 A
5. $R_{\text{NGR nom}}$	150 $\Omega$
<b>Menu 6.2: CT</b>	
1. CT primary	600
2. CT secondary	1
3. CT connection	50 mA
<b>Menu 6.3: NGR</b>	
1. Method	auto
2. Filter	off
<b>Menu 6.4: Response values</b>	
<b>HRG</b>	<b>LRG</b>
1. $U_{\text{NGR Trip}}$	60 %
2. $I_{\text{NGR Trip}}$	60 %
3. $> R_{\text{NGR}}$	150 % (HRG) 250 $\Omega$ (LRG)
4. $< R_{\text{NGR}}$ (HRG only)	/ 50 % (HRG)
5. $t_{\text{NGR Trip}}$	4. $t_{\text{NGR Trip}}$ 0 s
6. Ground-fault trip	5. Ground-fault trip on
7. $t_{\text{GF Trip}}$	6. $t_{\text{GF Trip}}$ 5 s
8. Alarm stored	7. Alarm stored on
9. $t_{\text{restart}}$	8. $t_{\text{restart}}$ 5 s
10. Restart count	9. Restart count 2
11. Trip signal	10. Trip signal RMS
12. Upper limit harmonic	11. Upper limit harmonic 32
13. Lower limit harmonic	12. Lower limit harmonic 0

Menu	Factory settings	
<b>Menü 6.5: System settings</b>		
1. Ground-fault relay	Mode	fail-safe
	Rel. test	on
2. NGR relay	Mode	fail-safe
	Rel. test	on
3. Trip relay	Mode	fail-safe
	Rel. test	on
4. Analogue	Mode	4...20 mA
	Function	R NGR (HRG) I NGR (LRG)
5. Dig. in/out	Device OUT	fail-safe
	Pulser OUT	non-fail-safe
	Digital 1	pulser, active high
	RESET IN	active high
	TEST IN	active high
6. Buzzer	Buzzer alarm	off
	Buzzer test	on

## 10.2 Error codes

Error code/ Service code	Description/Cause	Action
6.10	Error during field calibration	Restart field calibration. If the error persists, contact service.
6.11	Field calibration could not be started	The installation must operate error-free before starting a field calibration. Restart field calibration. If the error persists, contact service.
7.61...7.63	Connection between measuring equipment and display unit interrupted or disturbed.	Check connection between measuring equipment and display unit. Restart device.
8.03 und 8.12	Error in the measuring signal generation	Restart device. If the error persists, contact service.
8.43	Error in the internal power supply unit ( <i>positive supply voltage</i> )	Restart device. If the error persists, contact service.
8.44	Error in the internal power supply unit ( <i>negative supply voltage</i> )	Restart device. If the error persists, contact service.
8.46	Error in the internal power supply unit ( <i>supply voltage</i> )	Restart device. If the error persists, contact service.
8.48	Error in the internal power supply unit ( <i>reference voltage</i> )	Restart device. If the error persists, contact service.
Anderer Fehlercode		Contact service.

### 10.3 Technical Data NGRM500/550

#### Insulation coordination according to IEC 60664-1/IEC 60664-3/DIN EN 50178

##### Definitions

Supply circuit (IC1)	(A1, A2)
Measuring circuit/Control circuit (IC2)	(RS, E, CT), (X1, ETH)
Output circuit 1 (IC3)	(11, 12, 14)
Output circuit 2 (IC4)	(21, 22, 24)
Output circuit 3 (IC5)	(31, 32, 34)
Rated voltage	250 V
Overvoltage category	III

##### Rated impulse voltage

IC1/(IC2...5)	4 kV
IC2/(IC3...5)	4 kV
IC3/(IC4...5)	4 kV
IC4/(IC5)	4 kV

##### Rated insulation voltage

IC1/(IC2...5)	250 V
IC2/(IC3...5)	250 V
IC3/(IC4...5)	250 V
IC4/(IC5)	250 V
Pollution degree exterior	3

##### Rated insulation voltage

IC1/(IC2...5)	300 V
IC2/(IC3...5)	300 V
IC3/(IC4...5)	300 V
IC4/(IC5)	300 V

##### Voltage tests (routine test) acc. to IEC 61010-1

IC1/(IC2...5)	AC 2.2 kV
IC2/(IC3...5)	AC 2.2 kV
IC3/(IC4...5)	AC 2.2 kV
IC4/(IC5)	AC 2.2 kV

**Supply voltage  $U_s$** 

Nominal supply voltage	AC/DC, 48...240 V
for UL applications	AC/DC, 48...240 V
for AS/NZS 2081 applications	AC/DC, 48...230 V
Tolerance	±15 %
for UL applications	-50...+15 %
for AS/NZS 2081 applications	-25...+20 %
Frequency range	DC, 40...70 Hz
Power consumption (max.)	≤ 7 W / 16 VA

**Monitoring  $R_{NGR}$** 

Measuring input $R_s$	< 33 V RMS
Measuring range NGR (with $R_S = 20 \text{ k}\Omega$ ) active	0...10 k $\Omega$
Measurement uncertainty for $T = 0...+40 \text{ }^\circ\text{C}$	±20 $\Omega$
Measurement uncertainty for $T = -40...+70 \text{ }^\circ\text{C}$	±40 $\Omega$
Measuring range NGR (with $R_S = 100 \text{ k}\Omega$ ) active	0...10 k $\Omega$
Measurement uncertainty for $T = 0...+40 \text{ }^\circ\text{C}$	±30 $\Omega$
Measurement uncertainty for $T = -40...+70 \text{ }^\circ\text{C}$	±80 $\Omega$

**HRG**

Setting range $R_{NGR \text{ nom}}$	15 $\Omega$ ... 5 k $\Omega$
Response value < $R_{NGR \text{ nom}}$	10...90 % $R_{NGR \text{ nom}}$
Response value > $R_{NGR \text{ nom}}$	110...200 % $R_{NGR \text{ nom}}$

**LRG**

Setting range $R_{NGR \text{ nom}}$	0,1...200 $\Omega$
Response value > $R_{NGR \text{ nom}}$	200...500 $\Omega$
Response delay NGR-fault relay	7 s (±2.5 s)
Response delay Trip relay	0...48 h

## Monitoring $I_{NGR}$

### Measuring circuit 5 A

Frequency ranges	DC 50/60 Hz 10...3200 Hz
Nominal measuring current $I_n$	5 A
Maximum continuous current	$2 \times I_n$
Overload capacity	$10 \times I_n$ for 0.03 s
Measurement accuracy	$\pm 2\%$ von $I_n$
Load	10 m $\Omega$

### Measuring circuit 50 mA

Frequency ranges	DC 50/60 Hz 10...3200 Hz
Nominal measuring current $I_n$	50 mA
Maximum continuous current	$2 \times I_n$
Overload capacity	$10 \times I_n$ for 2 s
Measurement accuracy	$\pm 2\%$ von $I_n$
Load	68 $\Omega$

### Measuring circuits 5 A and 50 mA

Response value $I_{NGR}$	$10...90\%$ $I_{NGR\ nom}$
Response delay ground-fault relay	$\leq 40$ ms ( $\pm 10$ ms)
Response delay Trip relay (configurable)	100 ms...48 h, $\infty$

### Tolerance $t_{trip}$ when set to

RMS	-20...0 ms
Fundamental	0...+150 ms (filter time)
Harmonics	0...+150 ms (filter time)
Measuring current transformer ratio primary	1...10.000
Measuring current transformer ratio secondary	1...10.000
Measuring range	$2 \times I_{NGR\ nom}$

**Monitoring  $U_{\text{NGR}}$** 

Frequency ranges	DC 50/60 Hz 10...3200 Hz
$U_{\text{NGR}}$ with $R_S = 20 \text{ k}\Omega$	$(400/\sqrt{3}) \dots \leq (4300/\sqrt{3}) \text{ V}$
$U_{\text{NGR}}$ with $R_S = 100 \text{ k}\Omega$	$> (4.3/\sqrt{3}) \dots (25/\sqrt{3}) \text{ kV}$
Measuring range	$1.2 \times U_{\text{NGR nom}}$
Overload capacity	$2 \times U_{\text{NGR}}$ for 10 s
Measurement accuracy	2 % von $U_{\text{NGR nom}}$ with $U_{\text{NGR nom}} = (U_{\text{sys (L-L)}}/\sqrt{3})$
Response value voltage	$10 \dots 90 \% U_{\text{NGR nom}}$
Response delay ground-fault relay	$\leq 40 \text{ ms } (\pm 10 \text{ ms})$
Response delay trip relay (configurable)	100 ms...48 h, $\infty$

**Tolerance  $t_{\text{Trip}}$  when set to**

RMS	-20...0 ms
Fundamental	0...+150 ms (filter time)
Harmonics	0...+150 ms (filter time)

**DC immunity** in case of active RNGR measurement

with $R_S = 20 \text{ k}\Omega$	DC $\pm 12 \text{ V}$
with $R_S = 100 \text{ k}\Omega$	DC $\pm 60 \text{ V}$

**Digital inputs**

Galvanic separation	no
Length connecting cables	max. 10 m
$U_{\text{in}}$	24 V
Overload capacity	-5...32 V

**Digital outputs**

Galvanic separation	no
Length connecting cables	max. 10 m
Currents (sink) for each output	max. 300 mA
Voltage	24 V
Overload capacity	-5...32 V

### Analogur output (M+)

Operating principle	linear
Functions	$I_{NGR}$ , $R_{NGR}$
Current	0...20 mA ( $\leq 600 \Omega$ ), 4...20 mA ( $\leq 600 \Omega$ ), 0...400 $\mu$ A ( $\leq 4 \text{ k}\Omega$ )
Voltage	0...10 V ( $\geq 1 \text{ k}\Omega$ ), 2...10 V ( $\geq 1 \text{ k}\Omega$ )
Tolerance related to the current/voltage end value	$\pm 20 \%$

### Ground-fault, NGR, trip relay

Switching elements	changeover contacts
Operating mode	configurable fail-safe/non-fail-safe
Electrical endurance, number of cycles	10,000
Switching capacity	2000 VA / 150 W

### Contact data acc. to IEC 60947-5-1

Utilisation category	AC-13 / AC-14 / DC12 / DC12 / DC12
Rated operational voltage	250 V / 250 V / 220 V / 110 V / 24 V
Rated operational current	5 A* / 3 A / 0.1 A / 0.2 A / 1 A
Minimum current	1 mA at AC/DC > 10 V

\* 3 A for UL applications

### Environment / EMV

EMC immunity	DIN EN 61000-6-2 IEC 60255-26 Ed. 3.0
EMC emission	DIN EN 61000-6-4 IEC 60255-26 Ed. 3.0
Operating temperature	-40...+60 °C
Operating temperature for UL applications	-40...+60 °C
Transport	-40...+85 °C
Long-term storage	-40...+70 °C
Humidity	$\leq 98 \%$
Operating altitude	$\leq 2000 \text{ m AMSL}$
Classification of climatic conditions acc. to IEC 60721 (with respect to temperature and rel. humidity)	
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 / IEC 60255-21 / DIN EN 60068-2-6

Stationary use	3M12
Transport	2M4
Long-term storage	1M12

**Connection with Screw-type terminals**

Tightening torque	0,5...0,6 Nm (5...7 lb-in)
Stripping length	7 mm
Recommended connecting cables	
rigid/flexible	0.2...2.5 mm <sup>2</sup> (AWG 24...13)
flexible with ferrule with/without plastic sleeve	0.25...2.5 mm <sup>2</sup> (AWG 24...13)
Multiple conductor rigid	0.2...1 mm <sup>2</sup> (AWG 24...18)
Multiple conductor flexible	0.2...1.5 mm <sup>2</sup> (AWG 24...16)
Multiple conductor, flexible with ferrule without plastic sleeve	0.25...1 mm <sup>2</sup> (AWG 24...18)
Multiple conductor, flexible with TWIN ferrule with plastic sleeve	0.5...1.5 mm <sup>2</sup> (AWG 21...16)

**Connection with Push-wire terminal X1**

Stripping length	10 mm
Recommended connecting cables	
rigid/flexible	0.2...1.5 mm <sup>2</sup> (AWG 24...16)
flexible with ferrule without plastic sleeve	0.25...1.5 mm <sup>2</sup> (AWG 24...16)
flexible with ferrule with plastic sleeve	0.25...0.75 mm <sup>2</sup> (AWG 24...18)

**Other**

Operating mode	continuous operation
Mounting	display-oriented
Degree of protection, internal components (DIN EN 60529)	IP30
Flammability class	UL 94V-0
Protective coating measurement equipment	SL1307, UL file E80315
Weight	< 500 g

## 10.4 Standards, approvals, certifications

The specified standards take into account the edition valid until 09.2021 unless otherwise indicated.



UL File Number: E493737, E173157

### EU Declaration of Conformity

The EU Declaration of Conformity is available at the following Internet address:

[https://www.bender.de/fileadmin/content/Products/CE/CEKO\\_NGRM.pdf](https://www.bender.de/fileadmin/content/Products/CE/CEKO_NGRM.pdf)

## 10.5 Ordering details

### 10.5.1 NGR Monitor

#### NGR Monitor

Type	Supply voltage/Frequency range $U_S$	Art. No.
NGRM500	AC 48...240 V, 40...70 Hz	B94013500
NGRM550	DC 48...240 V	B94013550

### 10.5.2 Accessories

#### Measuring current transformers

Frequency/Ground-fault current	Type	Art. No.
AC up to 30 A	CTAC35	B98110007
	CTAC60	B98110017
	CTAC60	B98110009
	CTAC60	B98110010
	CTAC120	B98110011
AC/DC up to 10 A	CTUB103-CTBC35	B78120030
AC/DC up to 25 A	CTUB103-CTBC60	B78120031
	CTUB103-CTBC120	B78120032

#### Connecting cables CTUB103

Length (m)	Type	Art. No.
1	CTXS-100	B98110090
2,5	CTXS-250	B98110091
5	CTXS-250	B98110092
10	CTXS-250	B98110093

#### Voltage supply for CTUB103... measuring current transformers

max. connected current transformers	Type	Art. No.
2	STEP-PS/1 C/24 DC/0.5	B94053110
7	STEP-PS/1 AC/24 DC/1.75	B94053111
17	STEP-PS/1 AC/24 DC/4.2	B94053112

**CD series coupling device**

<b>Voltage <math>U_{\text{sys}}</math></b>	<b>Type</b>	<b>Art. No.</b>
400...690 V	CD1000	B98039010
400...1000 V	CD1000-2	B98039053
1000...4200 V	CD5000	B98039011
4300...14550 V	CD14400	B98039054
14551...25000 V	CD25000	B98039055

## 10.6 Document revision history

Date	Version	State/Changes
04-2021	05	<i>Editorial revision</i> Distinction between "system" and "device" <i>Deleted</i> W...AB measuring current transformers (discontinued)
02-2022	06	<i>Added</i> LRG variant NGRM550; Digital input I1 switchable <i>Editorial revision</i> Several error corrections
09-2022	07	<i>Changes</i> P.13 Variants... characteristic P.14 Functional description P.23 et seq. Wiring diagrams P.26 Measuring current transformer table P.27 Connection of relays P.40/42 Diagrams for pulser control changed P.42 NGR menu P.56 Table on trip times added P.59 Chapter 8.4 new with table P.64 Factory settings changed P.68 et seq. Technical data changed
07-2023	08	SMC import; editorial revision P. 68 W... CTs exchanged for CTAS models

## Glossary

CD	<b>C</b> oupling <b>D</b> evice CD-series
CT	<b>C</b> urrent <b>T</b> ransformer
FFT	<b>F</b> ast <b>F</b> ourier <b>T</b> ransformation
HMI	Human Machine Interface, display unit
HRG	<b>H</b> igh <b>R</b> esistance <b>G</b> rounding
$I_{NGR}$	NGR rated current
$I_{NGR\ nom}$	Nominal current through the NGR
LRG	<b>L</b> ow <b>R</b> esistance <b>G</b> rounding
NER	<b>N</b> eutral <b>E</b> arthing <b>R</b> esistor (NER = NGR)
NGR	<b>N</b> eutral <b>G</b> rounding <b>R</b> esistor
NTP	<b>N</b> etwork <b>T</b> ime <b>P</b> rotocol
PT	<b>P</b> otential <b>T</b> ransformer
$R_{NGR}$	NGR resistance value
$R_{NGR\ nom}$	NGR nominal resistance
$R_S$	Sense resistor; CD-series coupling device
PLC	<b>P</b> rogrammable <b>L</b> ogic <b>C</b> ontroller
$U_{NGR}$	Voltage on the NGR
$U_{NGR\ nom}$	Nominal voltage across the NGR
$U_{sys}$	System voltage
UTC	<b>U</b> niversal <b>T</b> ime <b>C</b> oordinated





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