MFR 300 Series

Manual | Multifunction Relay

MFR 300

Software Version 1.0213 or higher

37538C

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Brief Overview

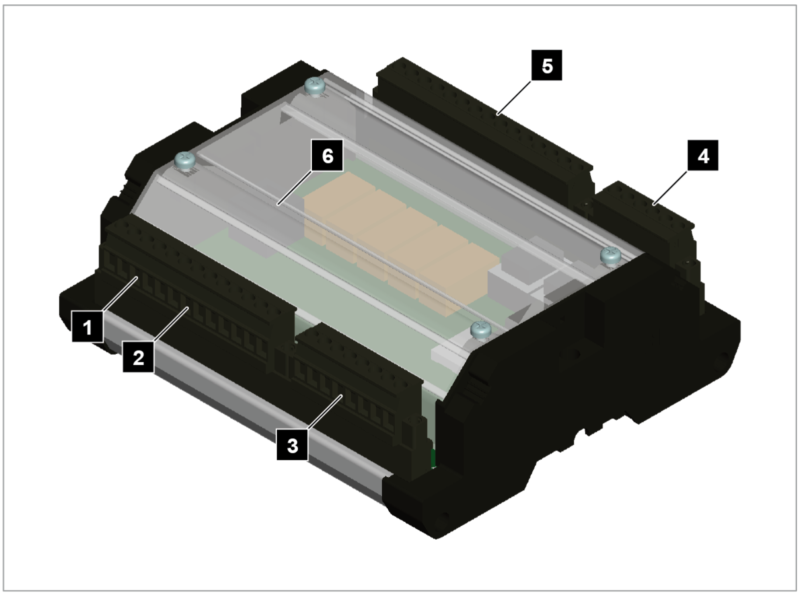


Fig. 1: MFR 300 Series (housing)

1 CAN bus interface connector
2 RS-485 interface connector
3 Voltage PT terminal
4 Current CT terminal
5 Relay outputs terminal
6 Service port connector (USB/RS-232)[1]

[1] Optional configuration cable for ToolKit configuration software and external extensions/applications required:

- *USB connector: DPC-USB direct configuration cable – P/N 5417-1251*
- *RS-232 connector: DPC-RS-232 direct configuration cable – P/N 5417-557*

The MFR 300 Series are multifunction relays which combine measuring and protection capabilities into one single system.

Sample application setup

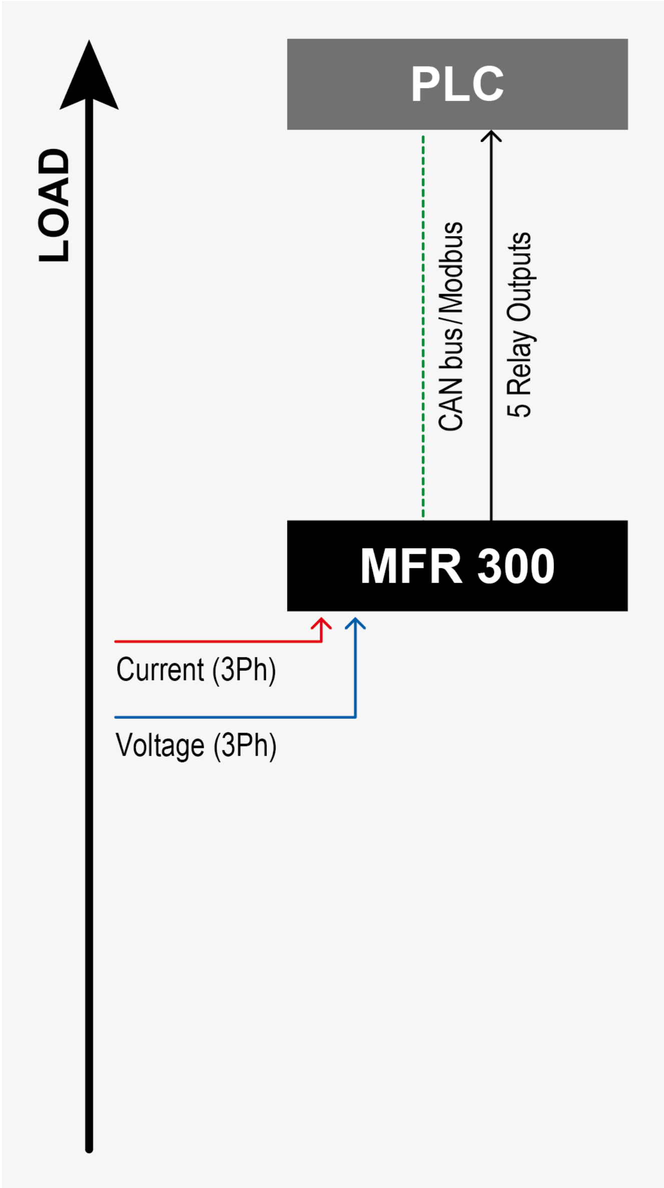


Fig. 2: Sample application setup

A typical application for the control unit is to use it as a power transducer for a PLC.

> *For a listing of additional applications and setups please refer to chapter ↬ Chapter 6 "Application" on page 99.*

Versions

> *The MFR 300 Series multifunction relays are available in different versions. The differences are listed below.*

MFR 300 Series	MFR 300			
	11M	**15M**	**71M**	**75M**
MFR 300-**[x]**1M Measuring voltage	**[1]** = 120 Vac		**[7]** = 690 Vac	
MFR 300-1**[x]**M Current voltage	**[1]** = ../1 A	**[5]** = ../5 A	**[1]** = ../1 A	**[5]** = ../5 A
MFR 300-11**[x]** Mounting	**[M]** = DIN rail mounting			

Options

In addition to the above shown device standard versions (↳ *"Versions" on page 4*) are the following MFR 300 Series options available:

- MFR 300-75M/K28
- MFR 300-75M/SU03

The MFR 300 Series option devices use the same hardware than the standard devices. The software functions are slightly modified to add special features. Please refer to the following chapters for details:

- ↳ *Chapter 9.2.1 "MFR 300 Profibus/CAN Coupler (Option K28)" on page 129*
- ↳ *Chapter 9.2.2 "MFR 300 CAN Protocol (Option SU03)" on page 135*

Scope of delivery

The following parts are included in the scope of delivery. Please check prior to the installation that all parts are present.

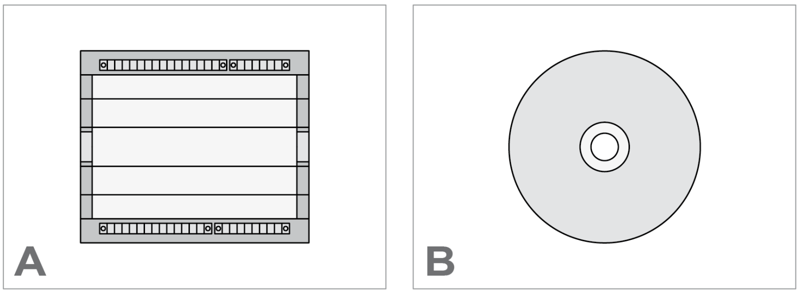


Fig. 3: Scope of delivery - schematic

A MFR 300 multifunction relay
B Product CD (configuration software and manual)

Table of contents

1 General Information

1.1 About This Manual

1.1.1 Revision History

Rev.	Date	Editor	Changes
C	2016-05-10	GG	**Device (hardware)** No changes. **Software version 1.0213 or higher** ■ With software version 1.0213 or higher just a few functional corrections/issues have been done: – relay fallback delay with phase shift alarm – CANopen writing of enumerated values – improvements in dfdt monitoring to prevent erroneous trips with highly distorted AC voltages – fixed issue with inaccurate reactive and apparent power measurement when measurement was set to 3ph3w and the battery minus was shifted relative to the center of the three phases ■ Use with ToolKit version 5.0 or higher **Manual** ■ No corrections necessary. Device works as already described before. ■ Version numbers of ToolKit and .NET software updated for latest edition. ■ Typo corrections and layout optimizations.
B	2014-10-30	GG	**Device** No changes. **Software version 1.02xx or higher** ■ With software version 1.0209 or higher: New parameter 2536 ➩ p. 47 "Counter value preset [Giga]". This parameter enlarges the counter preset range to giga values. It is an additional preset used on top of the well known parameter 2515 ➩ p. 46 "Counter value preset". Both parameters together now allow to enter a number of up to 213.999,999,9 GWh or Gvarh to the energy counters parameters 2510 ➩ p. 47, 2511 ➩ p. 47, 2512 ➩ p. 47, and 2513 ➩ p. 47. Refer to ➩ *4.2.4 "Counters" on page 46* for details. ■ Use with ToolKit version 4.6. **Manual** ■ Counter settings updated. Refer to ➩ *4.2.4 "Counters" on page 46* for details. ■ Multipliers of parameters 2520, 2522, 2524, and 2526 corrected from 0.01 to 0.1. Refer to ➩ *9.1.1.2 "Protocol 4500 (Formatted Data)" on page 116* and ➩ *9.1.2.1 "Protocol 4610 (Basic Visualization)" on page 123* for details.

Rev.	Date	Editor	Changes
			Notes MFR-300 version 2 and the changes from version 1 to version 2 had been already described in the former revisions of this manual (see row "NEW", below). Additionally new for users familiar with MFR-300 version 1 are: ■ RS-485 interface using Modbus. Description can be found in: – *4.2.3 "Serial Interface" on page 46* – *7.1 "Interfaces Overview" on page 101* – *7.5 "Modbus Protocol" on page 104* – *9.1.2.1 "Protocol 4610 (Basic Visualization)" on page 123* – *"RS-485 interface" on page 111* ■ "Load overrun/underrun" monitoring is renamed to "Positive/negative load" monitoring. See *4.3.5 "Positive Load (Level 1 & 2) ANSI# 32" on page 57* and *4.3.6 "Negative Load (Level 1 & 2) ANSI# 32R/F" on page 59* for details. ■ All MFR-300 version 2 devices and most of version 1 devices came with Password Protection. If your formerly used MFR-300 did not, please find description: *4.4.2 "Password System" on page 85*.

Rev.	Date	Editor	Changes
A	2013-09-23	GG	**Manual** Updated for ToolKit version 4.3. Correction: Prefix "-" deleted for parameter 2524 Negative energy and 2526 Negative reactive energy. See ↪ *Chapter 9.1.1.2 "Protocol 4500 (Formatted Data)" on page 116* for details.
NEW	2012-03-16	TE	**Manual** ■ Release The present publication (37538) replaces the following manuals which will no longer be supported. ■ MFR 300 (WK0200) manual (37396) ■ MFR 300 (WK0600) manual (37497) **New device features & updates** Requirements: MFR 300 multifunction relay with software version 1.02xx or higher. The described changes relate to the previous software version 1.01xx. New features ■ QV monitoring. Refer to ↪ *Chapter 4.3.12 "QV Monitoring" on page 69* for details. ■ Time-dependent voltage 3 and 4 monitoring. Refer to ↪ *Chapter 4.3.17 "Time-Dependent Voltage 3" on page 80* and ↪ *Chapter 4.3.18 "Time-Dependent Voltage 4" on page 82* for details. ■ Voltage increase monitoring. Refer to ↪ *Chapter 4.3.11 "Voltage Increase" on page 68* for details. ■ Overcurrent monitoring. Refer to ↪ *Chapter 4.3.13 "Overcurrent (Level 1, 2 & 3) ANSI# 50/51" on page 71* for details. ■ Ground fault monitoring. Refer to ↪ *Chapter 4.3.14 "Ground Fault (Level 1 & 2)" on page 73* for details. ■ Monitoring fallback delay. Refer to ↪ *Chapter 4.2.5 "Monitoring" on page 48* for details. Feature updates ■ Voltage monitoring. Refer to ↪ *Chapter 4.2.1 "Measurement" on page 41* for details. The setting range of "Voltage monitoring" (parameter 1770 ↪ p. 44) was extended to the entry "All". ■ Time-dependent voltage 1 and 2 monitoring. Refer to ↪ *Chapter 4.3.15 "Time-Dependent Voltage 1" on page 75* and ↪ *Chapter 4.3.16 "Time-Dependent Voltage 2" on page 77* for details. The time-dependent voltage monitoring can be configured to over- or undervoltage monitoring. The parameter "Monitoring at" (parameter 4953 ↪ p. 76 and 4957 ↪ p. 79) was added. ■ Voltage asymmetry monitoring. Refer to ↪ *Chapter 4.3.8 "Voltage Asymmetry (Level 1 & 2)" on page 63* for details. The voltage asymmetry monitoring was extended to a second monitoring level. The following parameters were added (parameter 3931 ↪ p. 64, 3932 ↪ p. 65, 3934 ↪ p. 65 and 3935 ↪ p. 65). ■ Overvoltage/undervoltage monitoring. Refer to ↪ *Chapter 4.3.1 "Overvoltage (Level 1 & 2) ANSI# 59" on page 49* and ↪ *Chapter 4.3.2 "Undervoltage (Level 1 & 2) ANSI# 27" on page 51* for details. The setting range of "Limit" (parameter 2004 ↪ p. 51, 2010 ↪ p. 51, 2054 ↪ p. 53 and 2060 ↪ p. 53) has been increased from 125.0 % to 150.0 %. ■ Overfrequency/underfrequency monitoring. Refer to ↪ *Chapter 4.3.3 "Overfrequency (Level 1 & 2) ANSI# 81O" on page 53* and ↪ *Chapter 4.3.4 "Underfrequency (Level 1 & 2) ANSI# 81U" on page 55* for details. The setting range of "Limit" (parameter 1904 ↪ p. 55, 1910 ↪ p. 55, 1954 ↪ p. 57 and 1960 ↪ p. 57) has been increased from 130.0 % to 140.0 %. ■ df/dt (ROCOF) monitoring. Refer to ↪ *Chapter 4.3.10 "df/dt (ROCOF)" on page 67* for details. The setting range of "Limit" (parameter 3104 ↪ p. 67) has been lowered from 1.0 Hz/s to 0.1 Hz/s.

1.1.2 Depiction Of Notes And Instructions

Safety instructions

Safety instructions are marked with symbols in these instructions. The safety instructions are always introduced by signal words that express the extent of the danger.

> **DANGER!**
> This combination of symbol and signal word indicates an immediately-dangerous situation that could cause death or severe injuries if not avoided.

> **WARNING!**
> This combination of symbol and signal word indicates a possibly-dangerous situation that could cause death or severe injuries if it is not avoided.

> **CAUTION!**
> This combination of symbol and signal word indicates a possibly-dangerous situation that could cause slight injuries if it is not avoided.

> **NOTICE!**
> This combination of symbol and signal word indicates a possibly-dangerous situation that could cause property and environmental damage if it is not avoided.

Tips and recommendations

> *This symbol indicates useful tips and recommendations as well as information for efficient and trouble-free operation.*

Additional markings

To emphasize instructions, results, lists, references, and other elements, the following markings are used in these instructions:

Marking	Explanation
➜	Step-by-step instructions
⇨	Results of action steps
↷	References to sections of these instructions and to other relevant documents
■	Listing without fixed sequence
[Buttons]	Operating elements (e.g. buttons, switches), display elements (e.g. signal lamps)
"Display"	Screen elements (e.g. buttons, programming of function keys)

Marking	Explanation
"Screen xx ➔ Screen xy ➔ Screen xz" ...	Menu path. The following information and setting refer to a page on HMI screen or ToolKit located as described here.
TKit HMI	Some parameters/settings/screens are available only either in ToolKit **or** in HMI/display.

1.2 Copyright And Disclaimer

Disclaimer

All information and instructions in this manual have been provided under due consideration of applicable guidelines and regulations, the current and known state of the art, as well as our many years of in-house experience. Woodward assumes no liability for damages due to:

- Failure to comply with the instructions in this manual
- Improper use / misuse
- Willful operation by non-authorized persons
- Unauthorized conversions or non-approved technical modifications
- Use of non-approved spare parts

The originator is solely liable to the full extent for damages caused by such conduct. The agreed upon obligations in the delivery contract, the general terms and conditions, the manufacturer's delivery conditions, and the statutory regulations valid at the time the contract was concluded, apply.

Copyright

This manual is protected by copyright. No part of this manual may be reproduced in any form or incorporated into any information retrieval system without written permission of Woodward GmbH.

Delivery of this manual to third parties, duplication in any form - including excerpts - as well as exploitation and/or communication of the content, are not permitted without a written declaration of release by Woodward GmbH.

Actions to the contrary will entitle us to claim compensation for damages. We expressly reserve the right to raise any further accessory claims.

1.3 Service And Warranty

Our Customer Service is available for technical information. Please see page 2 for the contact data.

In addition, our employees are constantly interested in new information and experiences that arise from usage and could be valuable for the improvement of our products.

Warranty terms

Please enquire about the terms of warranty from your nearest Woodward representative.

For our contact search webpage please go to: http://www.woodward.com/Directory.aspx

1.4 Safety

1.4.1 Intended Use

The multifunction relay unit has been designed and constructed solely for the intended use described in this manual.

The multifunction relay unit must be used exclusively for power measurement applications.

- Intended use requires operation of the control unit within the specifications listed in *Chapter 8.1 "Technical Data" on page 109*.
- All permissible applications are outlined in *Chapter 6 "Application" on page 99*.
- Intended use also includes compliance with all instructions and safety notes presented in this manual.
- Any use which exceeds or differs from the intended use shall be considered improper use.
- No claims of any kind for damage will be entertained if such claims result from improper use.

NOTICE!
Damage due to improper use!
Improper use of the multifunction relay unit may cause damage to the control unit as well as connected components.

Improper use includes, but is not limited to:

– Operation outside the specified operation conditions.

1.4.2 Personnel

WARNING!
Hazards due to insufficiently qualified personnel!
If unqualified personnel perform work on or with the control unit hazards may arise which can cause serious injury and substantial damage to property.

– Therefore, all work must only be carried out by appropriately qualified personnel.

This manual specifies the personnel qualifications required for the different areas of work, listed below:

- Well trained for electrical installations.
- Skilled and competent to be aware especially of the local safety regulations.
- Experienced in working on electronic measuring and control devices.
- Allowed to manage the controlled (engine/generator) system.

The workforce must only consist of persons who can be expected to carry out their work reliably. Persons with impaired reactions due to, for example, the consumption of drugs, alcohol, or medication are prohibited.

When selecting personnel, the age-related and occupation-related regulations governing the usage location must be observed.

1.4.3 General Safety Notes

Electrical hazards

DANGER!

Life-threatening hazard from electric shock!

There is an imminent life-threatening hazard from electric shocks from live parts. Damage to insulation or to specific components can pose a life-threatening hazard.

- Only a qualified electrician should perform work on the electrical equipment.
- Immediately switch off the power supply and have it repaired if there is damage to the insulation.
- Before beginning work at live parts of electrical systems and resources, cut the electricity and ensure it remains off for the duration of the work. Comply with the five safety rules in the process:
  - cut electricity;
  - safeguard against restart;
  - ensure electricity is not flowing;
  - earth and short-circuit; and
  - cover or shield neighboring live parts.
- Never bypass fuses or render them inoperable. Always use the correct amperage when changing fuses.
- Keep moisture away from live parts. Moisture can cause short circuits.

Modifications

WARNING!
Hazards due to unauthorized modifications
Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment.

Any unauthorized modifications:

– constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage
– invalidate product certifications or listings.

Electrostatic discharge

Protective equipment:

- ESD wrist band

NOTICE!
Damage from electrostatic discharge
All electronic equipment sensitive to damage from electrostatic discharge, which can cause the control unit to malfunction or fail.

– To protect electronic components from static damage, take the precautions listed below.

1. Avoid build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as easily as synthetics.

2. Before working on terminals on the control unit, ground yourself by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.) to discharge any static electricity.

   Alternatively wear an ESD wrist band connected to ground.

3. Before any maintenance work on the control unit, ground yourself by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.) to discharge any static electricity.

   Alternatively wear an ESD wrist band connected to ground.

4. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, etc.) away from the control unit, modules and work area.

5. Opening the control cover may void the unit warranty. Do not remove the printed circuit board (PCB) from the control cabinet unless instructed by this manual.

If instructed by this manual to remove the PCB from the control cabinet, follow these precautions:

- *Ensure that the device is completely voltage-free (all connectors have to be disconnected).*
- *Do not touch any part of the PCB except the edges.*
- *Do not touch the electrical conductors, connectors, or components with conductive devices or with bare hands.*
- *When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.*

For additional information on how to prevent damage to electronic components caused by improper handling, read and observe the precautions in:

- *"Woodward manual 82715, Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules".*

1.4.4 Protective Equipment And Tools

Protective gear

Personal protective equipment serves to protect risks to the safety and health of persons as well as to protect delicate components during work.

Certain tasks presented in this manual require the personnel to wear protective equipment. Specific required equipment is listed in each individual set of instructions.

The cumulative required personal protective equipment is detailed below:

ESD wrist band
The ESD (**e**lectro**s**tatic **d**ischarge) wrist band keeps the user's body set to ground potential. This measure protects sensitive electronic components from damage due to electrostatic discharge.

Tools

Use of the proper tools ensures successful and safe execution of tasks presented in this manual.

Specific required tools are listed in each individual set of instructions.

The cumulative required tools are detailed below:

2 System Overview

This chapter provides a basic overview of the control unit.

Refer to the comprehensive chapters indicated below to commission the control unit:

- *Chapter 3 "Installation" on page 25* provides information on how to mount the unit and setup connections.
- *Chapter 4 "Configuration" on page 41* provides information on basic setup and reference information on all configurable parameters.
- *Chapter 5 "Operation" on page 89* provides information on how to access the unit remotely using the ToolKit software provided by Woodward.
- *Chapter 6 "Application" on page 99* provides application examples as well as instructions for the corresponding required configuration.
- *Chapter 7 "Interfaces And Protocols" on page 101* provides reference information on the usage of the interfaces and protocols provided by the control unit.

2.1 Status Indicators

MFR 300 LEDs

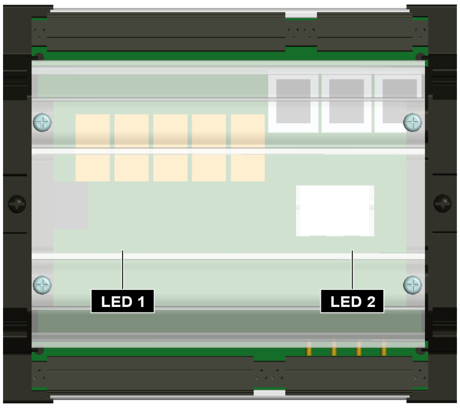


Fig. 4: Position of LEDs

The MFR 300 unit features two LEDs (Fig. 4) on the front plate.

The two LEDs indicate the following states:

State	Indication
Illuminated green	Unit is ready for operation.

Table 1: LED 1 (Ready for operation)

State	Indication
Illuminated red	Three CAN transmission PDOs are configured for SYNC messages and no CAN SYNC message is received for at least three seconds.

Table 2: LED 2 (No communication)

2.2 Hardware Interfaces (Terminals)

The MFR 300 (Fig. 5) provides the following terminals.

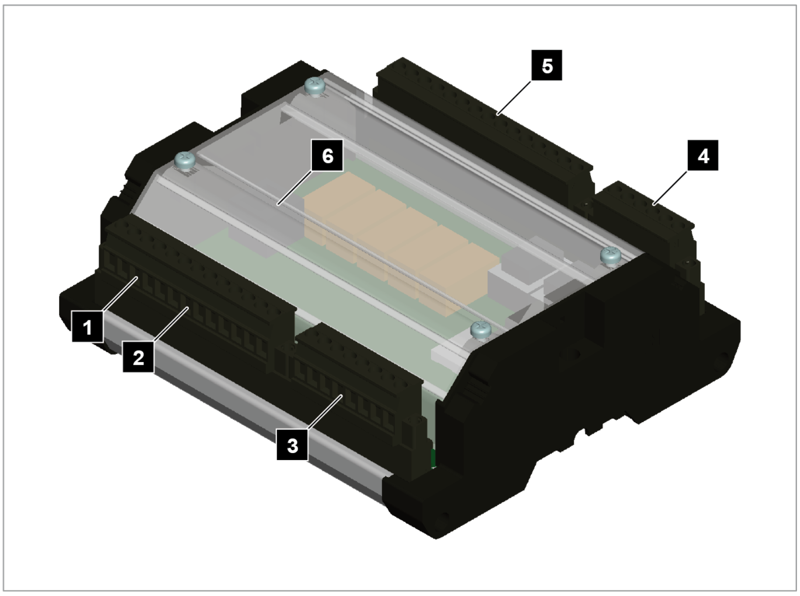


Fig. 5: MFR 300 Series (housing)

1 CAN bus interface connector
2 RS-485 interface connector
3 Voltage PT terminal
4 Current CT terminal
5 Relay outputs terminal
6 Service port connector (USB/RS-232)[1]

[1] Optional configuration cable for ToolKit configuration software and external extensions/applications required:

- *USB connector: DPC-USB direct configuration cable – P/N 5417-1251*
- *RS-232 connector: DPC-RS-232 direct configuration cable – P/N 5417-557*

For information on how to setup connections refer to *➾ Chapter 3.2 "Setup Connections" on page 25.*

For information on the interfaces and protocols refer to *➾ Chapter 7 "Interfaces And Protocols" on page 101.*

2.3 Measuring Values

Measuring principle

The device measures alternating voltage/current utilizing a sampling measuring method. All values are sampled for each phase with a rate of 5 kHz, integrated over one period, and the RMS value is calculated. The real power RMS value is calculated by multiplying and integrating the current and voltage values. The frequency is established from the time intervals of the voltage passing through zero. The reactive power is calculated from the phase shift between current and voltage.

Measuring values

Measuring value	Definition
Voltage	Three-phase RMS value measuring of the wye and delta voltages.
Frequency	Frequency measurement is extracted from the digitally filtered measuring voltages. The frequency is measured if the measured voltage exceeds 5 % of the rated voltage (120 V or 690 V). If the system is configured for three phases, all three phases are used for measurement. However the frequency is still measured correctly even if voltage is only applied to one phase.
Current	Three-phase RMS value measuring. Instantaneous value of the current.
Real power	The real power RMS value is measured though real time multiplication and integration of the instantaneous values of the wye voltage and the conductor current for each cycle.
Reactive power	Three-phase measurement, calculated from the RMS values of voltage and current and the phase angle between voltage and current.
Power factor	Calculated from the phase angle between voltage and current.
Active energy	Active energy combines a time measurement with the measured positive and negative real power. The counter is incorporated in the non-volatile memory and only computes positive energy. The memory is updated every 3 minutes with a resolution of 0.1 kWh. This counter is not calibrated by the Physikalisch-Technische Bundesanstalt (PTB).
Inductive reactive energy	Reactive energy combines a time measurement with the measured positive and negative reactive power. The counter is incorporated in the non-volatile memory and only computes positive energy. The memory is updated every 3 minutes with a resolution of 0.1 kvarh. This counter is not calibrated by the Physikalisch-Technische Bundesanstalt (PTB).
Phase angle	Measuring of the phase angle between the single wye voltages.

3 Installation

3.1 Mount Unit

Dimensions

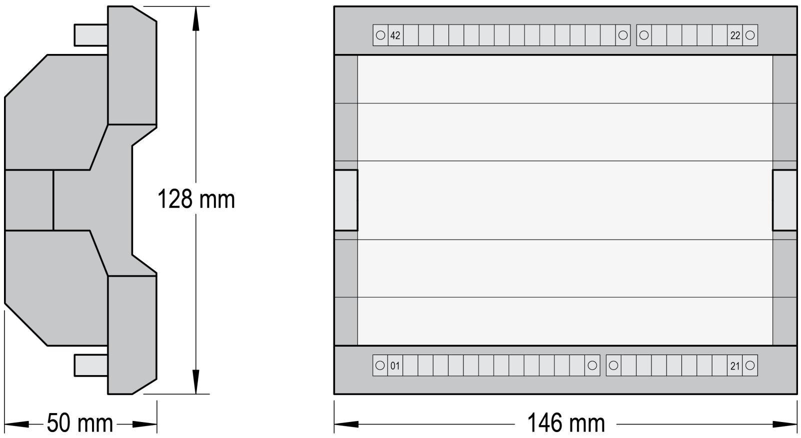


Fig. 6: Housing - dimensions

3.2 Setup Connections

General notes

> **NOTICE!**
> **Malfunctions due to literal use of example values**
> All technical data and ratings indicated in this chapter are merely listed as examples. Literal use of these values does not take into account all actual specifications of the control unit as delivered.
>
> – For definite values please refer to chapter *Chapter 8.1 "Technical Data" on page 109*.
> – Connected inductances (e.g. operating current coils, undervoltage tripping devices, auxiliary contactors, and/or power contactors) must be wired with an appropriate interference protection.

Wire sizes

AWG	mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG	mm²
30	0.05	21	0.38	14	2.5	4	25	3/0	95	600MCM	300
28	0.08	20	0.5	12	4	2	35	4/0	120	750MCM	400
26	0.14	18	0.75	10	6	1	50	300MCM	150	1000MCM	500
24	0.25	17	1.0	8	10	1/0	55	350MCM	185		
22	0.34	16	1.5	6	16	2/0	70	500MCM	240		

Table 3: Conversion chart - wire sizes

3.2.1 Terminal Allocation

General notes

The device terminals are allocated as follows:

- Plastic housing - shown in Fig. 7

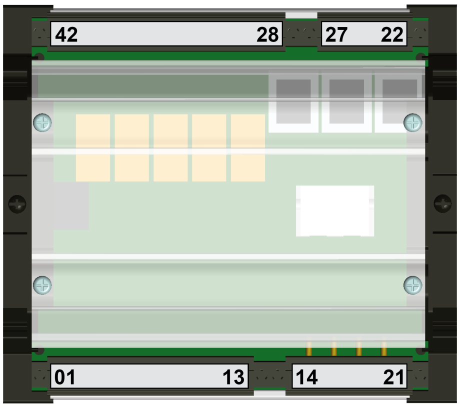
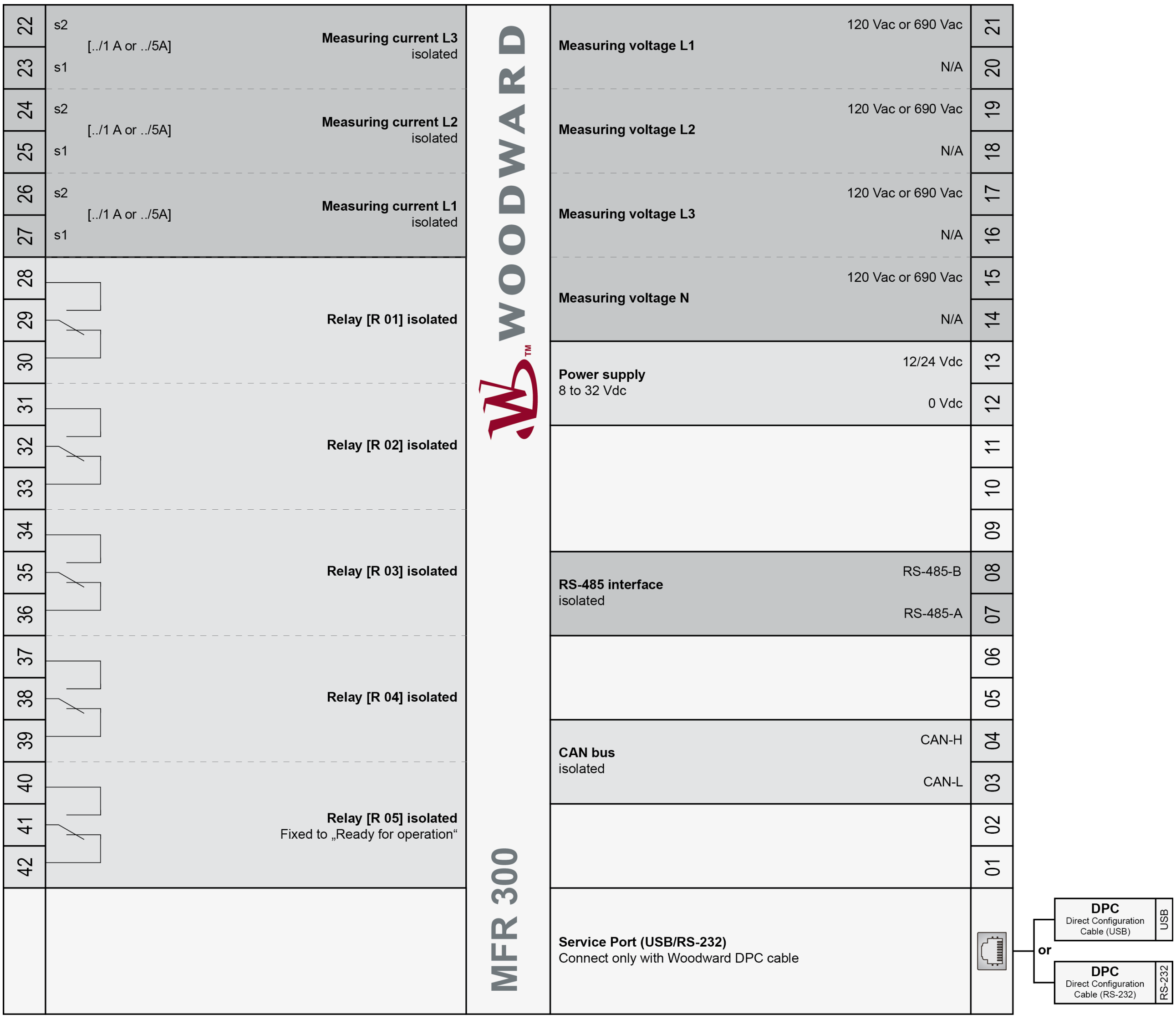


Fig. 7: Plastic housing

3.2.2 Wiring Diagram



Subject to technical modifications. MFR 300 Wiring Diagram | Rev. NEW

Fig. 8: Wiring diagram

3.2.3 Power Supply

Schematic and terminals

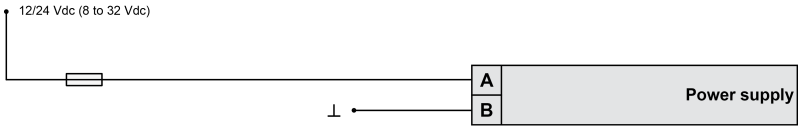


Fig. 9: Power supply - wiring

Terminal		Description	A_{max}
A	13	12/24Vdc (8 to 32.0 Vdc)	2.5 mm²
B	12	0 Vdc	2.5 mm²

Table 4: Power supply - terminal assignment

3.2.4 Voltage Measuring

General notes

NOTICE!
Versions
The MFR 300 Series multifunction relays are available in different versions. Please make sure to use the description which is valid for your device.

Woodward recommends protecting the voltage measuring inputs with slow-acting fuses rated for 2 to 6 A.

Schematic and terminals

The following description is only valid for units with 690 Vac voltage.

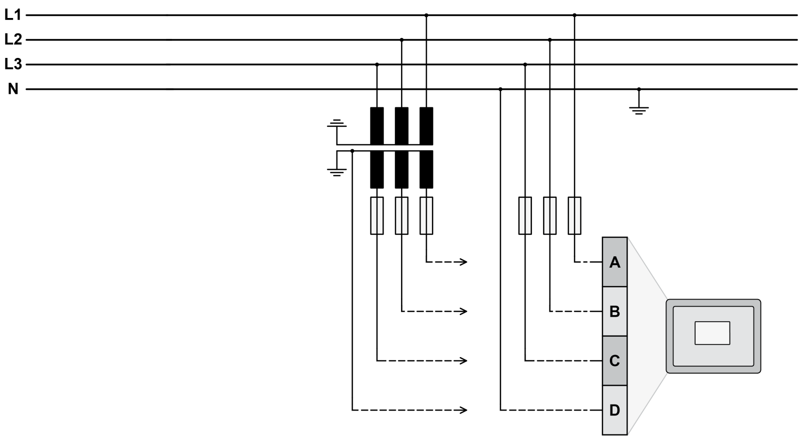


Fig. 10: Voltage measuring - 690 Vac - wiring

Terminal		Description		A_{max}
A	21	Measuring voltage L1	690 Vac	2.5 mm²
B	19	Measuring voltage L2	690 Vac	2.5 mm²
C	17	Measuring voltage L3	690 Vac	2.5 mm²
D	15	Measuring voltage N	690 Vac	2.5 mm²

Table 5: Voltage measuring - 690 Vac - terminal assignment

Schematic and terminals

The following description is only valid for units with 120 Vac voltage.

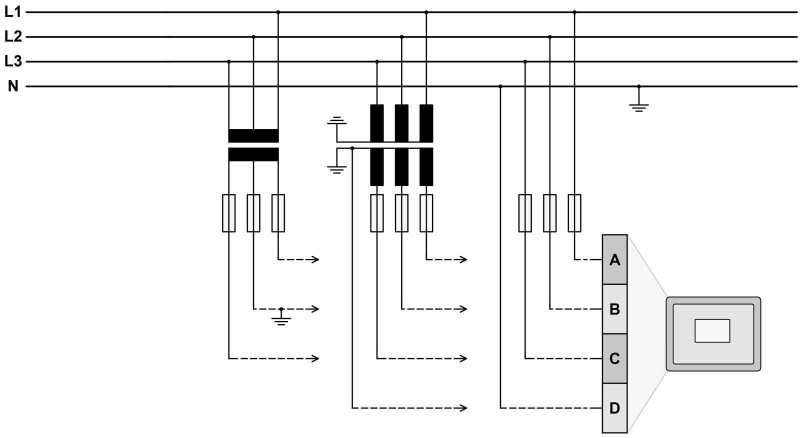


Fig. 11: Voltage measuring - 120 Vac - wiring

Terminal		Description		A_{max}
A	21	Measuring voltage L1	120 Vac	2.5 mm²
B	19	Measuring voltage L2	120 Vac	2.5 mm²
C	17	Measuring voltage L3	120 Vac	2.5 mm²
D	15	Measuring voltage N	120 Vac	2.5 mm²

Table 6: Voltage measuring - 120 Vac - terminal assignment

3.2.4.1 Parameter Setting '3Ph 4W' (3-phase, 4-wire)

Generator windings

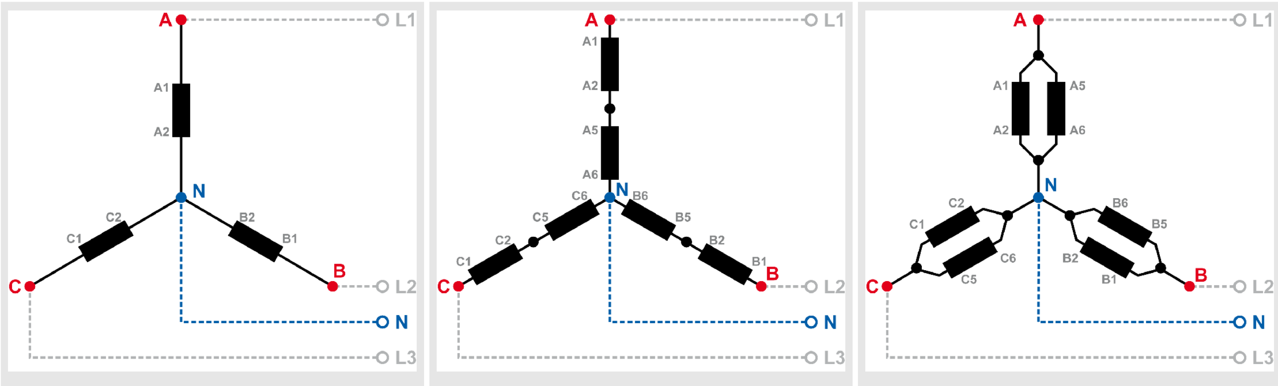


Table 7: Generator windings - 3Ph 4W

Measuring inputs

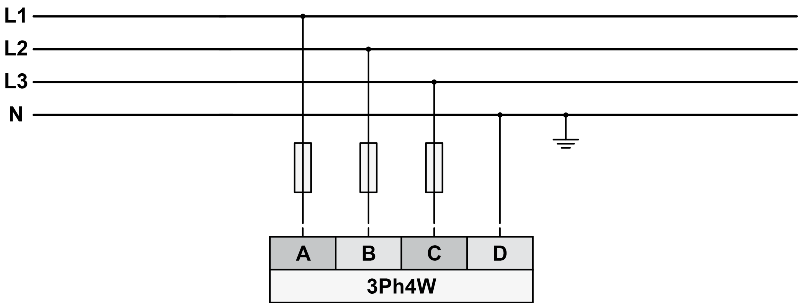


Fig. 12: Measuring inputs - 3Ph 4W

Terminal assignment

3Ph 4W	Wiring terminals							
Rated voltage (range)	120 V (50 to 130 $V_{eff.}$)				690 V (131 to 690 $V_{eff.}$)			
Measuring range (max.)	0 to 150 Vac				0 to 800 Vac			
Terminal	A	C	E	G	B	D	F	H
	21	19	17	15	21	19	17	15
Phase	L1	L2	L3	N	L1	L2	L3	N

3.2.4.2 Parameter Setting '3Ph 3W' (3-phase, 3-wire)

Generator windings

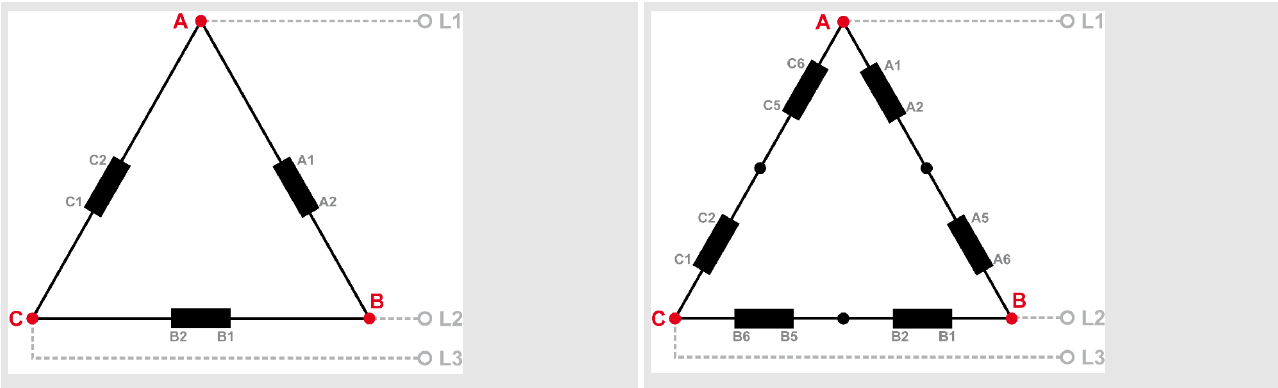


Table 8: Generator windings - 3Ph 3W

Measuring inputs

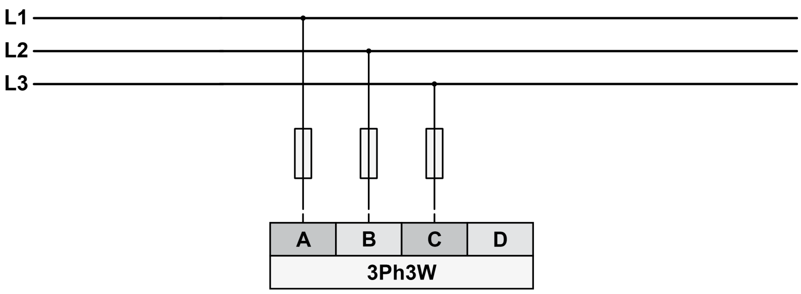


Fig. 13: Measuring inputs - 3Ph 3W

Terminal assignment

3Ph 3W	Wiring terminals							
Rated voltage (range)	120 V (50 to 130 $V_{eff.}$)				690 V (131 to 690 $V_{eff.}$)			
Measuring range (max.)	0 to 150 Vac				0 to 800 Vac			
Terminal	A	C	E	G	B	D	F	H
	21	19	17	15	21	19	17	15
Phase	L1	L2	L3	---	L1	L2	L3	---

If L1, L2 or L3 are connected to PE or N the single reactive powers VL1-I1, VL2-I2 and VL3-I3 cannot be calculated correctly. So the overall reactive power does not fit. The apparent power is calculated out of the reactive power and cannot be correct too.

The at all active power and the single currents are calculated all the time correct.

3.2.4.3 Parameter Setting '1Ph 3W' (1-phase, 3-wire)

Generator windings

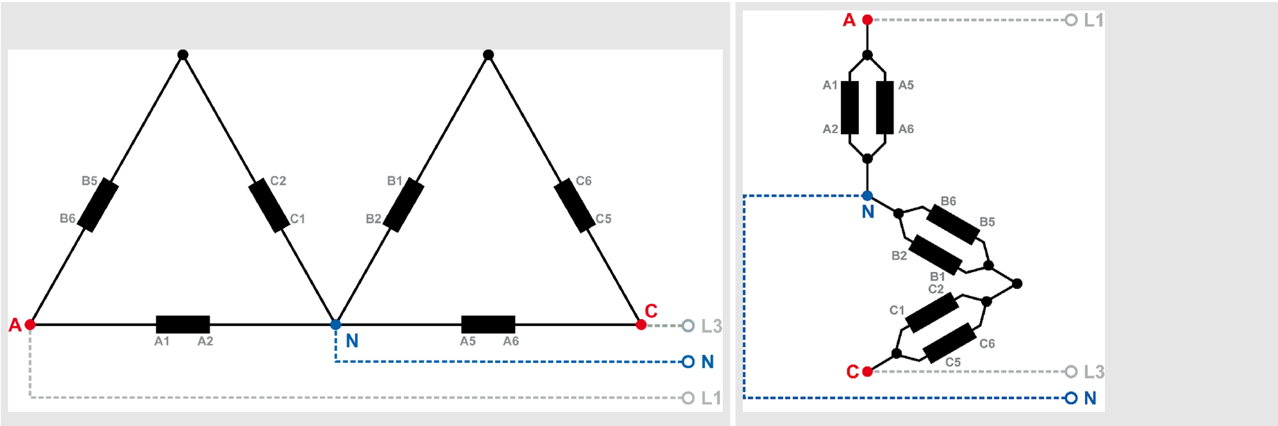


Table 9: Generator windings - 1Ph 3W

Measuring inputs

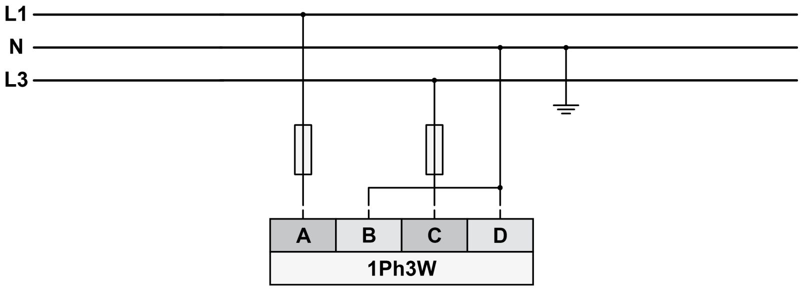


Fig. 14: Measuring inputs - 1Ph 3W

Terminal assignment

1Ph 3W	Wiring terminals							
Rated voltage (range)	120 V (50 to 130 $V_{eff.}$)				690 V (131 to 690 $V_{eff.}$)			
Measuring range (max.)	0 to 150 Vac				0 to 800 Vac			
Terminal	A	C	E	G	B	D	F	H
	21	19	17	15	21	19	17	15
Phase	L1	N	L3	N	L1	N	L3	N

3.2.4.4 Parameter Setting '1Ph 2W' (1-phase, 2-wire)

*The 1-phase, 2-wire measurement may be performed **phase-neutral** or **phase-phase**.*

– *Please note to configure and wire the device consistently.*

3.2.4.4.1 '1Ph 2W' Phase-Neutral Measuring

Generator windings

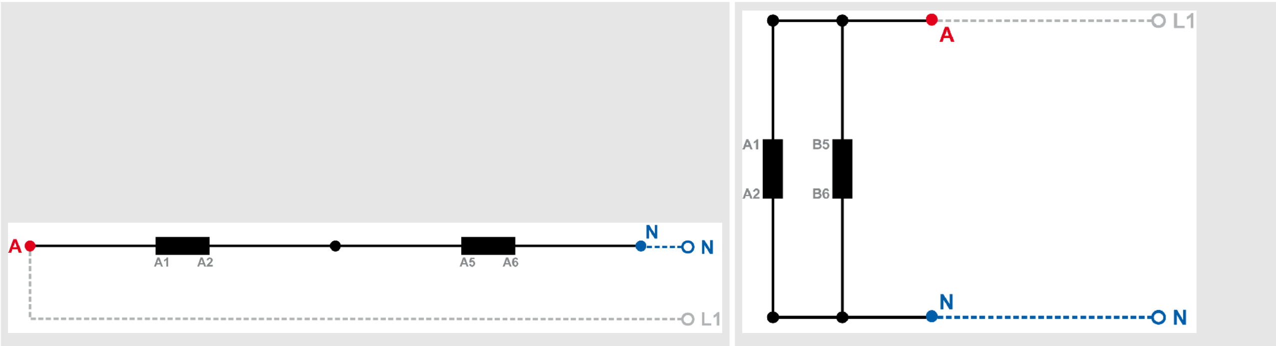


Table 10: Generator windings - 1Ph 2W (phase neutral)

Measuring inputs

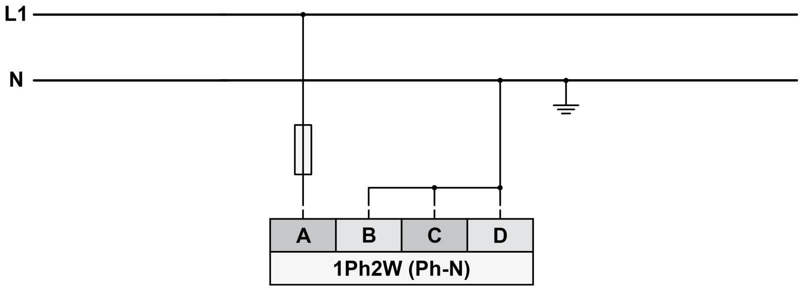


Fig. 15: Measuring inputs - 1Ph 2W (phase neutral)

Terminal assignment

1Ph 2W	**Wiring terminals**							
Rated voltage (range)	120 V (50 to 130 $V_{eff.}$)				690 V (131 to 690 $V_{eff.}$)			
Measuring range (max.)	0 to 150 Vac				0 to 800 Vac			
Terminal	A	C	E	G	B	D	F	H
	21	19	17	15	21	19	17	15
Phase	L1	N	N	N	L1	N	N	N

3.2.4.4.2 '1Ph 2W' Phase-Phase Measuring

Generator windings

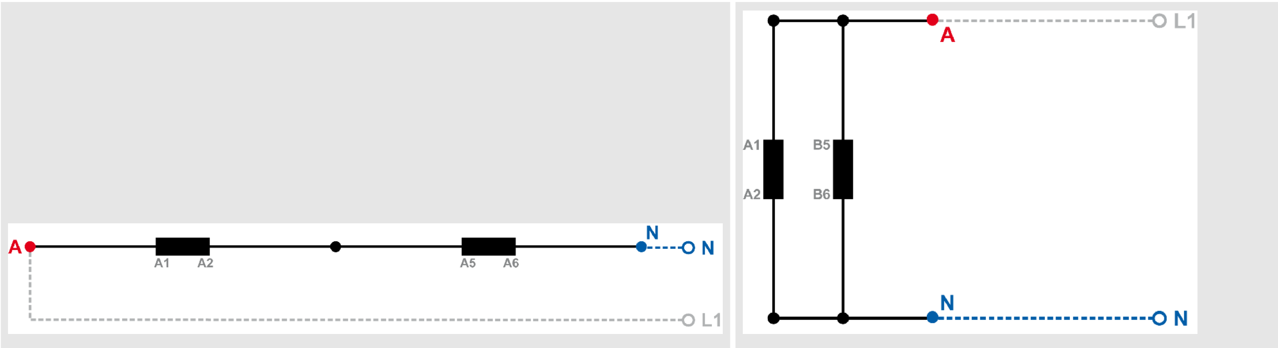


Table 11: Generator windings - 1Ph 2W (phase-phase)

Measuring inputs

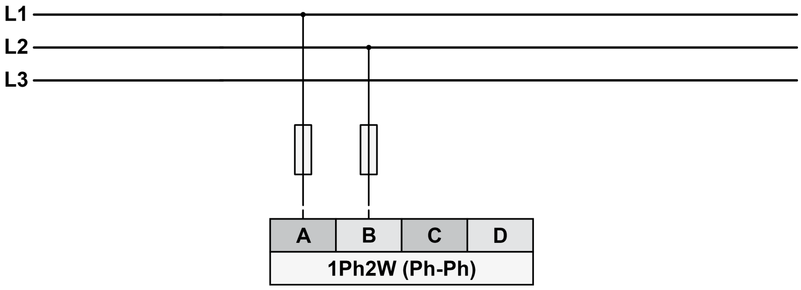


Fig. 16: Measuring inputs - 1Ph 2W (phase-phase)

Terminal assignment

1Ph 2W	Wiring terminals							
Rated voltage (range)	120 V (50 to 130 $V_{eff.}$)				690 V (131 to 690 $V_{eff.}$)			
Measuring range (max.)	0 to 150 Vac				0 to 800 Vac			
Terminal	A	C	E	G	B	D	F	H
	21	19	17	15	21	19	17	15
Phase	L1	L2	---	---	L1	L2	---	---

3.2.5 Current Measuring

General notes

> **NOTICE!**
> **Versions**
> The MFR 300 Series multifunction relays are available in different versions. Please make sure to use the description which is valid for your device.

> **WARNING!**
> **Dangerous voltages due to missing load**
> – Before disconnecting the device, ensure that the current transformer (CT) is short-circuited.

> *Generally, one line of the current transformers secondary must be grounded close to the CT.*

Schematic and terminals

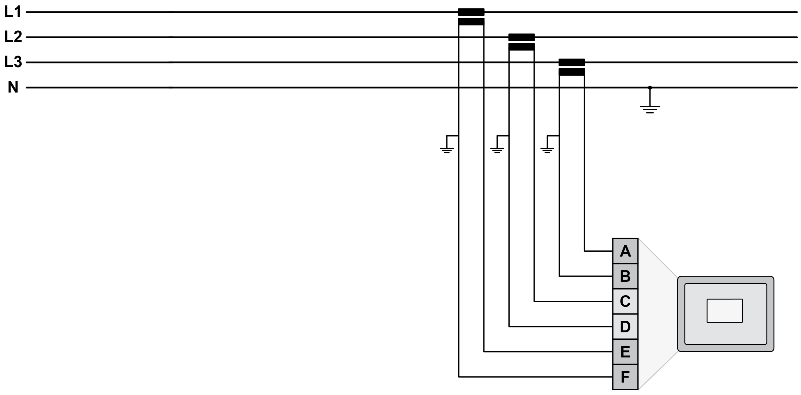


Fig. 17: Current measuring - wiring

Terminal		Description	A_{max}
A	23	Measuring current - L3 - transformer terminal s1 (k)	2.5 mm²
B	22	Measuring current - L3 - transformer terminal s2 (l)	2.5 mm²
C	25	Measuring current - L2 - transformer terminal s1 (k)	2.5 mm²
D	24	Measuring current - L2 - transformer terminal s2 (l)	2.5 mm²
E	27	Measuring current - L1 - transformer terminal s1 (k)	2.5 mm²
F	26	Measuring current - L1 - transformer terminal s2 (l)	2.5 mm²

Table 12: Current measuring - terminal assignment

3.2.5.1 Parameter Setting 'L1 L2 L3'

Schematic and terminals

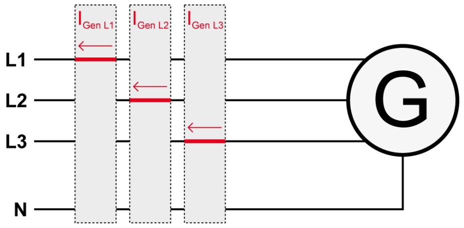


Fig. 18: Current measuring, L1 L2 L3

	Wiring terminals					
	F	E	D	C	B	A
L1 L2 L3						
Terminal	26	27	24	25	22	23
Phase	s2 (l) L1	s1 (k) L1	s2 (l) L2	s1 (k) L2	s2 (l) L3	s1 (k) L3
Phase L1 and L3						
Terminal	26	27	24	25	22	23
Phase	s2 (l) L1	s1 (k) L1	---	---	s2 (l) L3	s1 (k) L3

"Phase L1 and L3" applies if the voltage measurement is configured to 1Ph 3W (↪ Chapter 3.2.4.3 " Parameter Setting '1Ph 3W' (1-phase, 3-wire)" on page 31).

3.2.5.2 Parameter Setting 'Phase L1' 'Phase L2' 'Phase L3'

Schematic and terminals

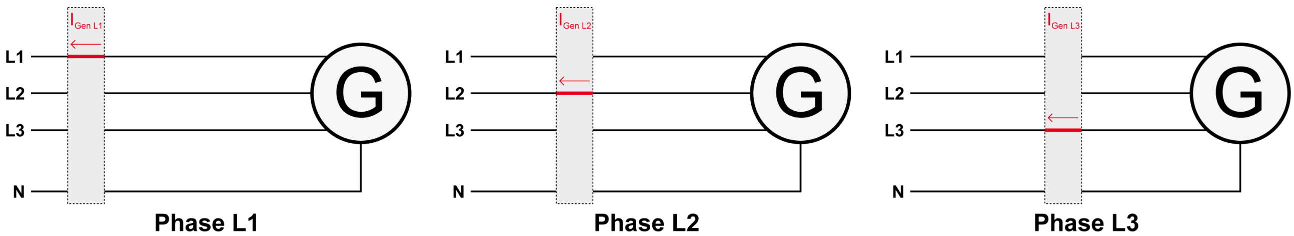


Fig. 19: Current measuring, 'Phase L1' 'Phase L2' 'Phase L3'

	Wiring terminals					
	F	E	D	C	B	A
Phase L1						
Terminal	26	27	24	25	22	23
Phase	s2 (l) L1	s1 (k) L1	---	---	---	---
Phase L2						
Terminal	26	27	24	25	22	23
Phase	---	---	s2 (l) L2	s1 (k) L2	---	---
Phase L3						
Terminal	26	27	24	25	22	23
Phase	---	---	---	---	s2 (l) L3	s1 (k) L3

3.2.6 Relay Outputs

General notes

CAUTION!
The discrete output "Ready for operation" may be wired in series with an emergency stop function and used in conjunction with an alarm function to ensure that the proper actions are initiated upon activation of this output, i.e. a failure of the unit.

Schematic and terminals

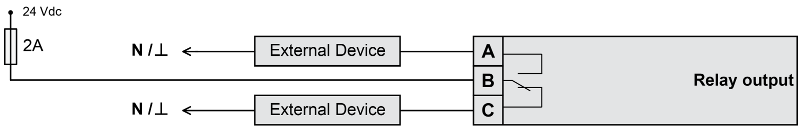


Fig. 20: Relay outputs - schematic

Terminal			Description		A_{max}
N.O.	**Common**	**N.C.**			
A	**B**	**C**	**Form C**		
28	29	30	Relay output [R 01]	---	2.5 mm²
31	32	33	Relay output [R 02]	---	2.5 mm²
34	35	36	Relay output [R 03]	---	2.5 mm²
37	38	39	Relay output [R 04]	---	2.5 mm²
40	41	42	Relay output [R 05]	Fixed to "Ready for operation"	2.5 mm²

Notes
N.O.: *normally open (make) contact*
N.C.: *normally closed (break) contact*

3.2.7 Serial Interface

3.2.7.1 RS-485 Interface

General notes

Please note that the RS-485 interface only operates in half-duplex mode.

Pin assignment

Terminal	Description	A_{max}
7	RS-485-A (TxD+)	N/A
8	RS-485-B (TxD-)	N/A

Table 13: Pin assignment

RS-485 half-duplex

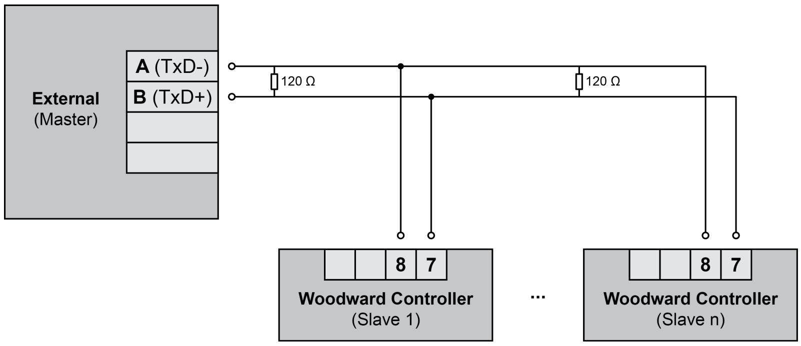


Fig. 21: RS-485 - connection for half-duplex operation

3.2.8 Service Port

Service port connector

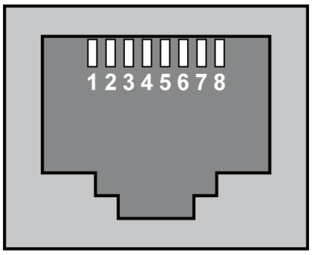


Fig. 22: Service port connector (RJ-45)

The Woodward specific service port is a connector (RJ-45) to extend the interfaces of the controller.

> *The service port can be **only** used in combination with an optional Woodward direct configuration cable (DPC).*

Direct configuration cable (DPC)

The DPC cable is used to configure the device with the ToolKit configuration software and external extensions/applications.

There are two versions available:

- DPC-USB direct configuration cable
- DPC-RS-232 direct configuration cable

DPC-USB direct configuration cable

Use the DPC-USB direct configuration cable if you want to connect the Woodward controller to an external device (master) which is equipped with an USB port.

Order item number:

- DPC-USB direct configuration cable – P/N 5417-1251

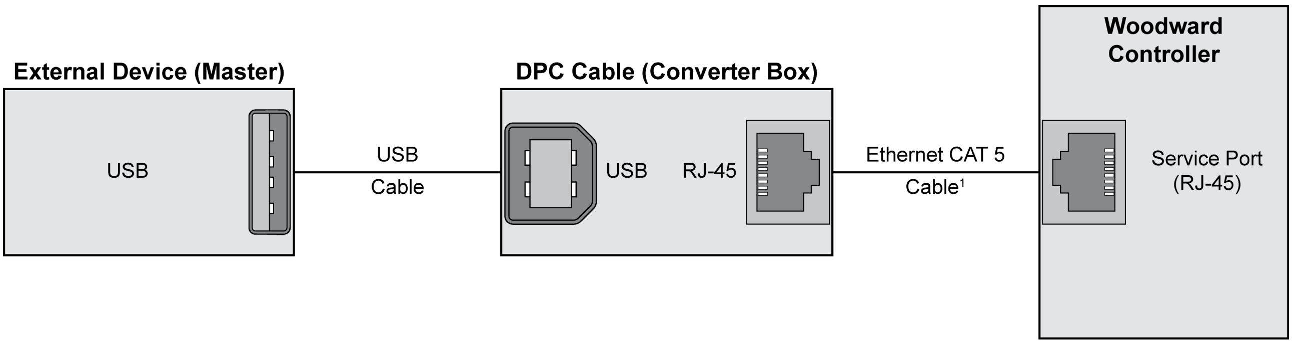


Fig. 23: DPC-USB wiring - schematic

[1] Use the Ethernet CAT 5 cable which is supplied with the DPC-USB converter. The maximum cable length must not exceed 0.5 m.

DPC-RS-232 direct configuration cable

Use the DPC-RS-232 direct configuration cable if you want to connect the Woodward controller to an external device (master) which is equipped with an RS-232 port.

Order item number:

- DPC-RS-232 direct configuration cable – P/N 5417-557

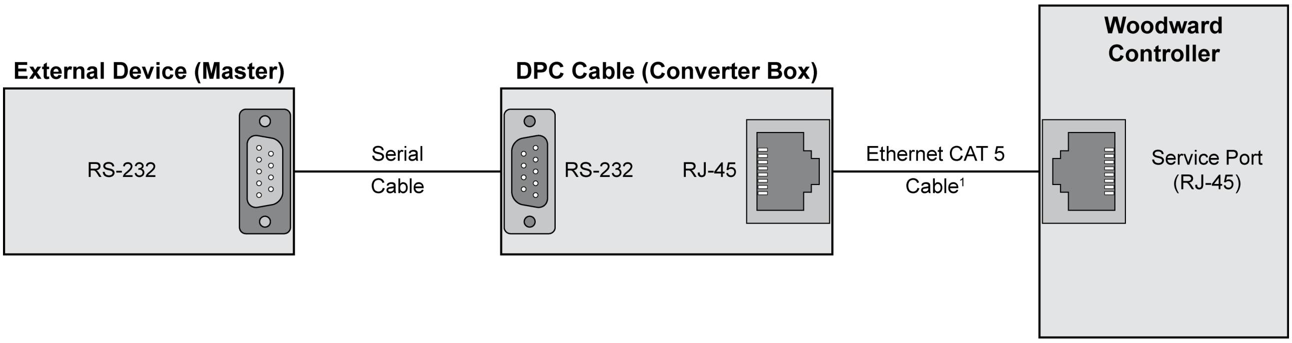


Fig. 24: DPC-RS-232 wiring - schematic

[1] Use the Ethernet CAT 5 cable which is supplied with the DPC-RS-232 converter. The maximum cable length must not exceed 0.5 m.

For a continuous operation with the direct configuration cable DPC-RS-232 (e.g. remote control of controller), it is required to use at least revision F (P/N 5417-557 Rev. F) of the DPC-RS-232. When using a DPC-RS-232 of an earlier revision, problems may occur in continuous operation. The shield connector (6.3 mm tab connector) at the DPC-RS-232 of revision F (P/N 5417-557 Rev. F) and above must be connected to ground.

3.3 CAN Bus Interface

Pin assignment

Terminal	Description	A_{max}
3	CAN-L	N/A
4	CAN-H	N/A

Table 14: Pin assignment

Topology

Please note that the CAN bus must be terminated with a resistor, which corresponds to the impedance of the cable (e.g. 120 Ohms, 1/4 W) at both ends.

The termination resistor is connected between CAN-H and CAN-L (Fig. 25).

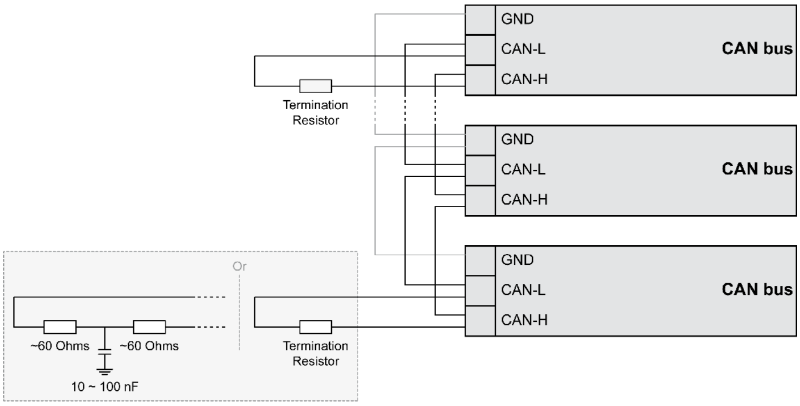


Fig. 25: CAN bus - termination

For very critical EMC conditions (many noise sources with high noise levels) and for high transmission rates we recommend to use the 'Split termination concept' as shown.

- Divide the termination resistance into 2x60 Ohms with a center tap connected to ground via a capacitor of 10 to 100 nF (Fig. 25).

Maximum CAN bus length

The maximum length of the communication bus wiring is dependent on the configured baud rate. Observe the maximum bus length.

(Source: CANopen; Holger Zeltwanger (Hrsg.); 2001 VDE VERLAG GMBH, Berlin und Offenbach; ISBN 3-8007-2448-0).

Baud rate	Max. length
1000 kbit/s	25 m
800 kbit/s	50 m
500 kbit/s	100 m
250 kbit/s	250 m
125 kbit/s	500 m
50 kbit/s	1000 m
20 kbit/s	2500 m

Bus shielding

The bus connection of the device is not internally grounded via an RC element. Therefore, it must be grounded via an external RC element.

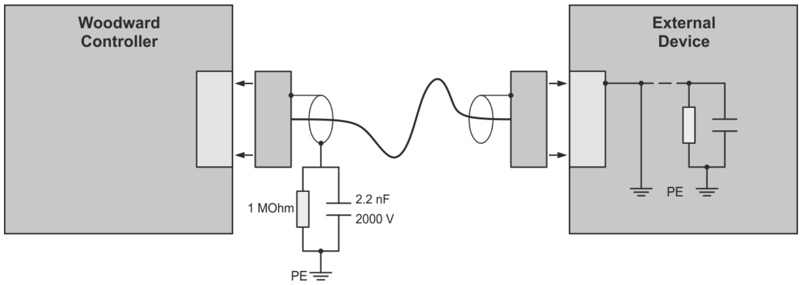


Fig. 26: Bus shielding

Troubleshooting

If data is not transmitting on the CAN bus, check the for the following common CAN bus communication problems:

- *A T-structure bus is utilized*
- *CAN-L and CAN-H are interchanged*
- *Not all devices on the bus are using identical baud rates*
- *Terminating resistor(s) are missing*
- *The configured baud rate is too high for wiring length*
- *The CAN bus cable is routed in close proximity with power cables*

Woodward recommends the use of shielded, twisted-pair cables for the CAN bus (see examples).

- *Lappkabel Unitronic LIYCY (TP) 2×2×0.25*
- *UNITRONIC-Bus LD 2×2×0.22*

4 Configuration

Parameter Numbers

All parameters are assigned a unique parameter identification number.

The parameter identification number may be used to reference individual parameters listed in this manual.

This parameter identification number is also displayed in the ToolKit configuration screens next to the respective parameter.

4.1 Homepage

General notes

The ToolKit “Homepage” gives an overview of all measured values, the state of the relays and the state of the monitoring.

The “Homepage” is only used to display values. The values cannot be adjusted here. The configuration of the parameters is done in the other menu sections on the left hand side. The following chapters describe all menus in detail.

Please refer to *Chapter 5.1 “Access Via PC (ToolKit)” on page 89* *for details about the operation of the device via ToolKit.*

Fig. 27: Homepage

4.2 Configuration

4.2.1 Measurement

General notes

The setpoints for specific parameters will differ depending upon the hardware version, indicated on the data plate.

- [1] MFR 300-x1x = Current transformer with ../1 A rated current
- [5] MFR 300-x5x = Current transformer with ../5 A rated current

Dependencies

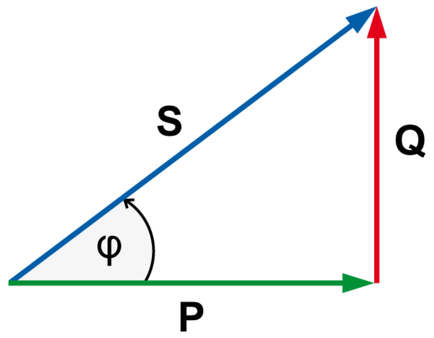


Fig. 28: AC power triangle

PF Power Factor
P Active Power [kW]
S Apparent power [kVA]
Q Reactive Power [kvar]

The AC power triangle illustrates the dependencies between active power, apparent power, reactive power and power factor.

- PF = P/S = cos Φ
- $Q = \sqrt{(S^2-P^2)}$
- $S = \sqrt{(P^2+Q^2)}$
- P = S * PF

ID	Parameter	CL	Setting range [Default]	Description
1750	**System rated frequency**	4	50 / 60 Hz **[50 Hz]**	The rated frequency of the system is used as a reference figure for all frequency related functions, which use a percentage value, like frequency monitoring.
1766	**Rated voltage**	4	50 to 650000 V **[690 V]**	This value refers to the rated voltage of the source and is the voltage measured on the potential transformer primary. The rated voltage is used as a reference figure for all voltage related functions, which use a percentage value, like voltage monitoring.
1754	**Rated current**	4	5 to 32000 A **[300 A]**	This value specifies the source rated current, which is used as a reference figure for related functions.
1752	**Rated active power [kW]**	4	0.5 to 200000.0 kW **[200.0 kW]**	This value specifies the source rated active power, which is used as a reference figure for related functions. The rated active power is the power factor multiplied by the apparent power.
1758	**Rated react. power [kvar]**	4	0.5 to 200000.0 kvar **[200.0 kvar]**	This value specifies the source rated reactive power, which is used as a reference figure for related functions.
1850	**Current measuring**	4	**[L1 L2 L3]**	All three phases are monitored. Measurement, display and protection are adjusted according to the rules for 3-phase measurement. Monitoring refers to the following currents: IL1, IL2, IL3
			Phase L{1/2/3}	Only one phase is monitored. Measurement, display and protection are adjusted according to the rules for single-phase measurement. Monitoring refers to the selected phase.
				Notes This parameter is only effective if the voltage measuring (parameter 1851 ➪ p. 43) is configured to "3Ph 4W" or "3Ph 3W". For information on measuring principles refer to ➪ *Chapter 3.2.5 "Current Measuring" on page 33.*

ID	Parameter	CL	Setting range [Default]	Description
1851	**Voltage measuring**	4	**[3Ph 4W]**	Measurement is performed Line-Neutral (WYE connected system) and Line-Line (Delta connected system). The protection depends on the setting of parameter 1770 ↳ p. 44. Phase voltages and the neutral must be connected for proper calculation. Measurement, display and protection are adjusted according to the rules for WYE connected systems. Monitoring refers to the following voltages: ■ VL12, VL23, and VL31 (parameter 1770 ↳ p. 44 configured to "Phase-phase") ■ VL1N, VL2N and VL3N (parameter 1770 ↳ p. 44 configured to "Phase-neutral") ■ VL12, VL23, VL31, VL1N, VL2N and VL3N (parameter 1770 ↳ p. 44 configured to "All")
			3Ph 3W	Measurement is performed Line-Line (Delta connected system). Phase voltages must be connected for proper calculation. Measurement, display and protection are adjusted according to the rules for Delta connected systems. Monitoring refers to the following voltages: ■ VL12, VL23, VL31
			1Ph 2W	Measurement is performed Line-Neutral (WYE connected system) if parameter 1858 ↳ p. 44 is configured to "Phase - neutral" and Line-Line (Delta connected system) if parameter 1858 ↳ p. 44 is configured to "Phase - phase". Measurement, display and protection are adjusted according to the rules for phase-phase systems. Monitoring refers to the following voltages: ■ VL1N, VL12
			1Ph 3W	Measurement is performed Line-Neutral (WYE connected system) and Line-Line (Delta connected system). The protection depends on the setting of parameter 1770 ↳ p. 44. Measurement, display, and protection are adjusted according to the rules for single-phase systems. Monitoring refers to the following voltages: ■ VL13 (parameter 1770 ↳ p. 44 configured to "Phase-phase") ■ VL1N, VL3N (parameter 1770 ↳ p. 44 configured to "Phase-neutral") ■ VL1N, VL3N (parameter 1770 ↳ p. 44 configured to "All")
				Notes If this parameter is configured to 1Ph 3W, the rated voltage (parameter 1766 ↳ p. 42) must be entered as Line-Line (Delta).
3954	**Phase rotation**	4	**[CW]**	The three-phase measured voltage is rotating CW (clock-wise; that means the voltage rotates in L1-L2-L3 direction; standard setting).
			CCW	The three-phase measured voltage is rotating CCW (counter clock-wise; that means the voltage rotates in L1-L3-L2 direction).
				Notes This parameter is important for a correct unbalanced load monitoring (refer to ↳ *Chapter 4.3.7 "Unbalanced Load (Level 1 & 2) ANSI# 46" on page 61* for details).

ID	Parameter	CL	Setting range [Default]	Description
1858	**1Ph2W voltage measuring**	4	**[Phase - phase]**	The unit is configured for measuring phase-phase voltages if 1Ph 2W measuring is selected.
			Phase - neutral	The unit is configured for measuring phase-neutral voltages if 1Ph 2W measuring is selected.
				Notes For information on measuring principles refer to *Chapter 3.2.4 "Voltage Measuring" on page 27*
1859	**1Ph2W phase rotation**	4	**[CW]**	A clockwise rotation field is considered for 1Ph 2W measuring .
			CCW	A counter-clockwise rotation field is considered for 1Ph 2W measuring.
				Notes For information on measuring principles refer to *Chapter 3.2.4 "Voltage Measuring" on page 27* This parameter is important for power factor and reactive power calculation.
1770	**Voltage monitoring**	4		The unit can either monitor the wye voltages (phase-neutral) or the delta voltages (phase-phase). The monitoring of the wye voltage is above all necessary to avoid earth-faults in a compensated or isolated network resulting in the tripping of the voltage protection.
			[Phase - phase]	The phase-phase voltage will be monitored and all subsequent parameters concerning voltage monitoring are referred to this value (VL-L).
			Phase - neutral	The phase-neutral voltage will be monitored and all subsequent parameters concerning voltage monitoring are referred to this value (VL-N).
			All	The phase-phase **and** phase-neutral voltage will be monitored and all subsequent parameters concerning voltage monitoring are referred to this value (VL-L & VL-N). This setting is only effective if "Voltage measuring" (parameter 1851 p. 43) is configured to "3Ph 4W".
				Notes WARNING: This parameter influences the protective functions. Please be aware that if "Voltage monitoring" (parameter 1770 p. 44) is configured to "All" and the function *Chapter 4.3.11 "Voltage Increase" on page 68* is used, that this function only monitors "Phase - neutral".
1788	**Disable underfrequency monitoring with low voltage**	4		Blocks the underfrequency monitoring, if the voltage is below 12.5% of nominal to avoid an alarm if the voltage drops to zero. This affects both underfrequency monitoring thresholds.
			Yes	Underfrequency monitoring with low voltage is disabled.
			[No]	Underfrequency monitoring with low voltage is enabled.
1801	**PT primary rated voltage** (Potential transformer primary voltage rating)	4	50 to 650000 V **[690 V]**	The primary source voltage in V. The control utilizes the value entered in this parameter along with the measured voltage of the PT secondaries to calculate the voltage.

ID	Parameter	CL	Setting range [Default]	Description
1800	**PT secondary rated volt.** (Potential transformer secondary voltage rating)	4	50 to 800 V **[690 V]**	The secondary source voltage in V, which is used as a reference figure for related functions.
1806	**CT primary rated current** (Current transformer primary rating)	4	1 to 32000 A/x **[500 A/x]**	The input of the current transformer ratio is necessary for the indication and control of the actual monitored value. The current transformers ratio should be selected so that at least 60 % of the secondary current rating can be measured when the monitored system is at 100 % of operating capacity (i.e. at 100 % of system capacity a 5 A CT should output 3 A). If the current transformers are sized so that the percentage of the output is lower, the loss of resolution may cause inaccuracies in the monitoring and control functions and affect the functionality of the control.
				Notes Current transformer ratio for the source.

4.2.2 Discrete Outputs

General notes

The discrete outputs of this control device have a "Normally Open" (N.O.) as well as a "Normally Closed" (N.C.) function.

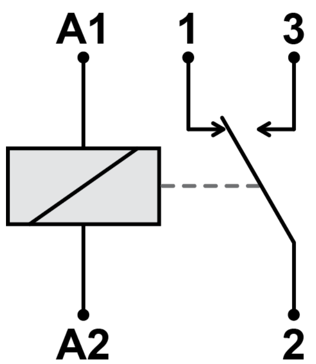


Fig. 29: Normally Open/Closed contacts - schematic

Normally Open (N.O.) contacts

– *The relay (discrete output) must be energized to close the contact.*

Normally Closed (N.C.) contacts

– *The relay (discrete output) must be de-energized to open the contact.*

ID	Parameter	CL	Setting range [Default]	Description
6920 6921 6922 6923	**Relay {x} function** [x = 1 to 4]	4	**[N.O.]**	The relay will be energized when an alarm occurs.
			N.C	The relay will be de-energized when an alarm occurs.
				Notes The fallback delay of the relays can be configured with parameter 8855 ↳ p. 48.

4.2.3 Serial Interface

ID	Parameter	CL	Setting range [Default]	Description
3170	**Baudrate**	2	2.4 / 4.8 / 9.6 / 14.4 / **[19.2]** / 38.4 / 56 / 115 kBaud	This parameter defines the baud rate for communications. Please note, that all participants on the bus must use the same baud rate.
3185	**ModBus slave ID**	2	0 to 255 **[1]**	The Modbus device address, which is used to identify the device via Modbus, is entered here. If "0" is configured here, the Modbus is disabled.
3186	**Reply delay time**	2	1.00 to 100.00 ms **[1.00 ms]**	This is the minimum delay time between a request from the Modbus master and the sent response of the slave. This time is also required if an external interface converter to RS-485 is used for example.

4.2.4 Counters

ToolKit display: Rounding (round-off) error

Please note that-from the left to the right-always seven numbers are displayed correctly. Further numbers might be not correct because of system related rounding errors.

This is just a display issue - the parameter values itself are not changed! They are correct e.g. transferred via CAN bus or RS-485.

Parameter 2536 Counter value preset [Giga]: Software version 1.0209 or higher

Earlier versions of the software come with parameter 2515 only which allows a max. preset value of 999,999.9. With software version 1.0209 or higher the preset value is exeedable for up to 213,999,999.9 by using parameter 2536 "on top" of parameter 2515.

ID	Parameter	CL	Setting range [Default]	Description
2515	**Counter value preset**	4	0 to 999,999.9 **[0]**	This value is utilized to set the following (part of the) counters: ■ kWh counter ■ kvarh counter The number entered into this parameter is the number that will be set to the parameters listed below when they are enabled. **Notes** For even larger values (GWh/Gvarh) the parameter "Counter value preset [Giga]" 2536 ⇘ p. 47 allows for giga-values 'on top' if used. With 2536 default "0" the device settings are backword compatible.

ID	Parameter	CL	Setting range [Default]	Description
2536	**Counter value preset [Giga]**	4	0 to 213 **[0]**	This value is utilized to set the 'Giga' value part of the counter value preset. The number entered into this parameter is the number that will be set as the 'Giga' part of the complete value to the parameters listed below when they are enabled.
				Notes The complete GWh/Gvarh value consits of the 'Giga' part of this parameter plus the 'kilo' part of parameter 2515. With its default "0" the device settings are still backword compatible.
2510	**Active energy [0.0 kWh]**	4	Yes	The current value of this counter is overwritten with the value configured in "Counter value preset" (parameter 2515 ⇘ p. 46). After the counter has been (re)set, this parameter changes back to "No" automatically.
			[No]	The value of this counter is not changed.
				Example ■ The counter value preset [Giga](parameter 2536 ⇘ p. 47) is configured to "123" and the counter value preset (parameter 2515 ⇘ p. 46) is configured to "45674567". ■ If this parameter is set to "Yes", the "Active energy" counter will be set to 123,456,456.7 kWh.
2512	**Active energy - [0.0 kWh]**	4	Yes	The current value of this counter is overwritten with the value configured in "Counter value preset" (parameter 2515 ⇘ p. 46). After the counter has been (re)set, this parameter changes back to "No" automatically.
			[No]	The value of this counter is not changed.
				Example ■ The counter value preset (parameter 2515 ⇘ p. 46) is configured to "3456". ■ If this parameter is set to "Yes", the "Active energy -" counter will be set to 345.6 kWh.
2511	**React.energy [0.0 kvarh]**	4	Yes	The current value of this counter is overwritten with the value configured in "Counter value preset" (parameter 2515 ⇘ p. 46). After the counter has been (re)set, this parameter changes back to "No" automatically.
			[No]	The value of this counter is not changed.
				Example ■ The counter value preset (parameter 2515 ⇘ p. 46) is configured to "123456". ■ If this parameter is set to "Yes", the "Reactive energy" counter will be set to 12,345.6 kvarh.
2513	**React.energy - [0.0 kvarh]**	4	Yes	The current value of this counter is overwritten with the value configured in "Counter value preset" (parameter 2515 ⇘ p. 46). After the counter has been (re)set, this parameter changes back to "No" automatically.
			[No]	The value of this counter is not changed.
				Example ■ The counter value preset (parameter 2515 ⇘ p. 46) is configured to "345". ■ If this parameter is set to "Yes", the "Reactive energy -" counter will be set to 34.5 kvarh.

ID	Parameter	CL	Setting range [Default]	Description
2520	**Pos. act. energy**	---	Info	Displays the accumulated positive energy (kWh).
2524	**Neg. act. energy**	---	Info	Displays the accumulated negative energy (kWh).
2522	**Pos. react. energy**	---	Info	Displays the accumulated positive reactive energy (kvarh).
2526	**Neg. react. energy**	---	Info	Displays the accumulated negative reactive energy (kvarh).

4.2.5 Monitoring

ID	Parameter	CL	Setting range [Default]	Description
8855	**Monitoring fall-back delay**	0	0.0 to 500.0 s **[0.2 s]**	This parameter defines the fallback time of all alarms and hence the fallback time of the relays.

4.2.6 CAN Interface

General notes

The CAN bus is a field bus and subject to various disturbances. Therefore, it cannot be guaranteed that every request will be answered. We recommend to repeat a request, which is not answered within reasonable time.

ID	Parameter	CL	Setting range [Default]	Description
3156	**Baudrate**	2	20 / 50 / 100 / 125 / 250 / 500 / 800 / 1000 kBaud **[1000 kBd]**	This parameter defines the used baud rate. Please note, that all participants on the CAN bus must use the same baud rate.
				Notes The baud rate can be configured via CAN interface. However, the configuring CANopen Master must change its baud rate to be able to reconnect. If the baud rate has been changed, the unit continues to operate with its current baud rate until it is shut down. The new baud rate will be enabled after a restart.
1702	**Device number**	2	1 to 32 **[1]**	A unique address is assigned to the control though this parameter. This unique address permits the controller to be correctly identified on the CAN bus. The address assigned to the controller may only be used once. All other bus addresses are calculated on the number entered in this parameter.

ID	Parameter	CL	Setting range [Default]	Description
				Notes The unit must be restarted after changing the device number to ensure proper operation.
9100	**COB-ID SYNC message**	3	0 to 2047 **[128]**	This parameter defines the COB-ID of the synchronization object (SYNC).
9117	**Producer heartbeat time**	3	1 to 65535 ms **[240 ms]**	Independent from the CANopen Master configuration, the unit transmits a heartbeat message with this configured heartbeat cycle time.
9600 9610 9620	**COB-ID**	3	1 to 2047 9600: **[385]** 9610: **[641]** 9620: **[897]**	This parameter contains the communication parameters for the PDOs the unit is able to transmit. The unit transmits data (i.e. visualization data) on the CAN ID configured here.
9602 9612 9622	**Transmission type**	3	0 to 255 9602: **[1]** 9612: **[240]** 9622: **[10]**	This parameter contains the communication parameters for the PDOs the unit is able to transmit. This parameter defines whether the unit broadcasts all data automatically (value 254 or 255) or only upon request with the configured address of the "COB-ID SYNC message" (parameter 9100 ➨ p. 49). A value between 1 and 240 means that the PDO is transferred synchronously and cyclically. Then the transmission type indicates the number of SYNC messages, which are necessary to trigger PDO transmissions.

4.3 Monitoring

4.3.1 Overvoltage (Level 1 & 2) ANSI# 59

General notes

Voltage is monitored according to how the parameter "Voltage measuring" (parameter 1851 ➨ p. 43) is configured. This controller provides the user with two alarm levels for overvoltage. Both alarms are definite time alarms.

Monitoring for overvoltage faults is performed in two steps.

The diagram listed below shows a frequency trend and the associated pickup times and length of the alarms.

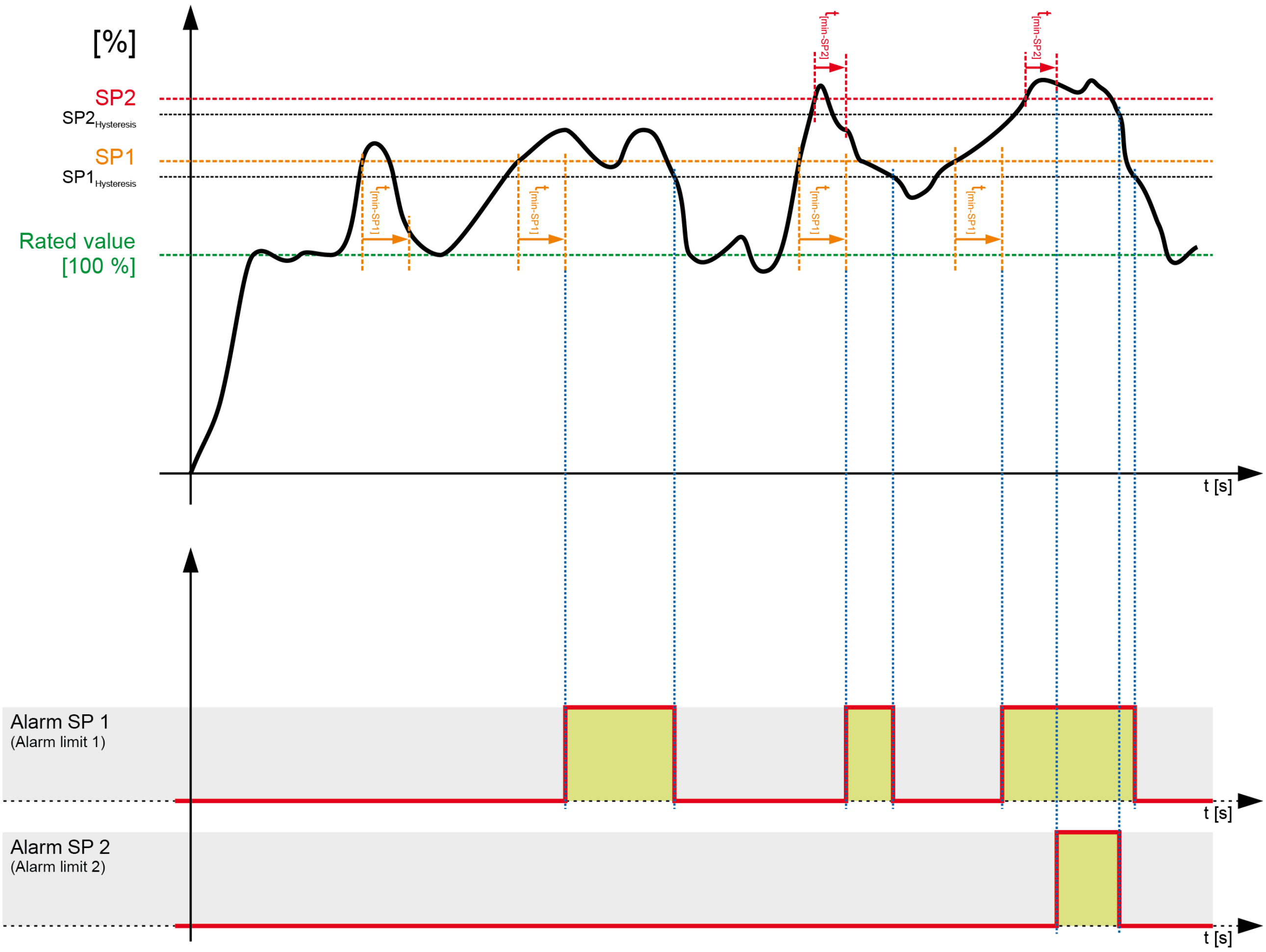


Fig. 30: Overvoltage monitoring

The hysteresis is depending on the voltage threshold.

The hysteresis is 0.7% of the primary transformer delta voltage.

The parameter limits listed below have identical setting ranges. Each parameter may be configured with different settings to create unique trip characteristics for specific thresholds.

ID	Parameter	CL	Setting range [Default]	Description
2000 2006	**Monitoring**	2	**[On]**	Overvoltage monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit < limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.

ID	Parameter	CL	Setting range [Default]	Description
2004 2010	**Limit**	2	50.0 to 150.0 % 2004: **[108.0 %]** 2010: **[112.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated voltage" (parameter 1766 ➡ p. 42).
2005 2011	**Delay**	2	0.02 to 300.00 s 2005: **[5.00 s]** 2011: **[0.30 s]**	If the monitored voltage exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored voltage falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
2014 2015	**AND characteristics**	2	On	Each phase has to be over the threshold for tripping.
			[Off]	At least one phase has to be over the threshold for tripping.
2001 2007	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2001: **[Relay 1]** 2007: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➡ p. 45 , 6921 ➡ p. 45, 6922 ➡ p. 45 and 6923 ➡ p. 45).

4.3.2 Undervoltage (Level 1 & 2) ANSI# 27

General notes

Voltage is monitored according to how the parameter "Voltage measuring" (parameter 1851 ➡ p. 43) is configured. This controller provides the user with two alarm levels for undervoltage. Both alarms are definite time alarms.

Monitoring for undervoltage faults is performed in two steps.

The diagram listed below shows a frequency trend and the associated pickup times and length of the alarms.

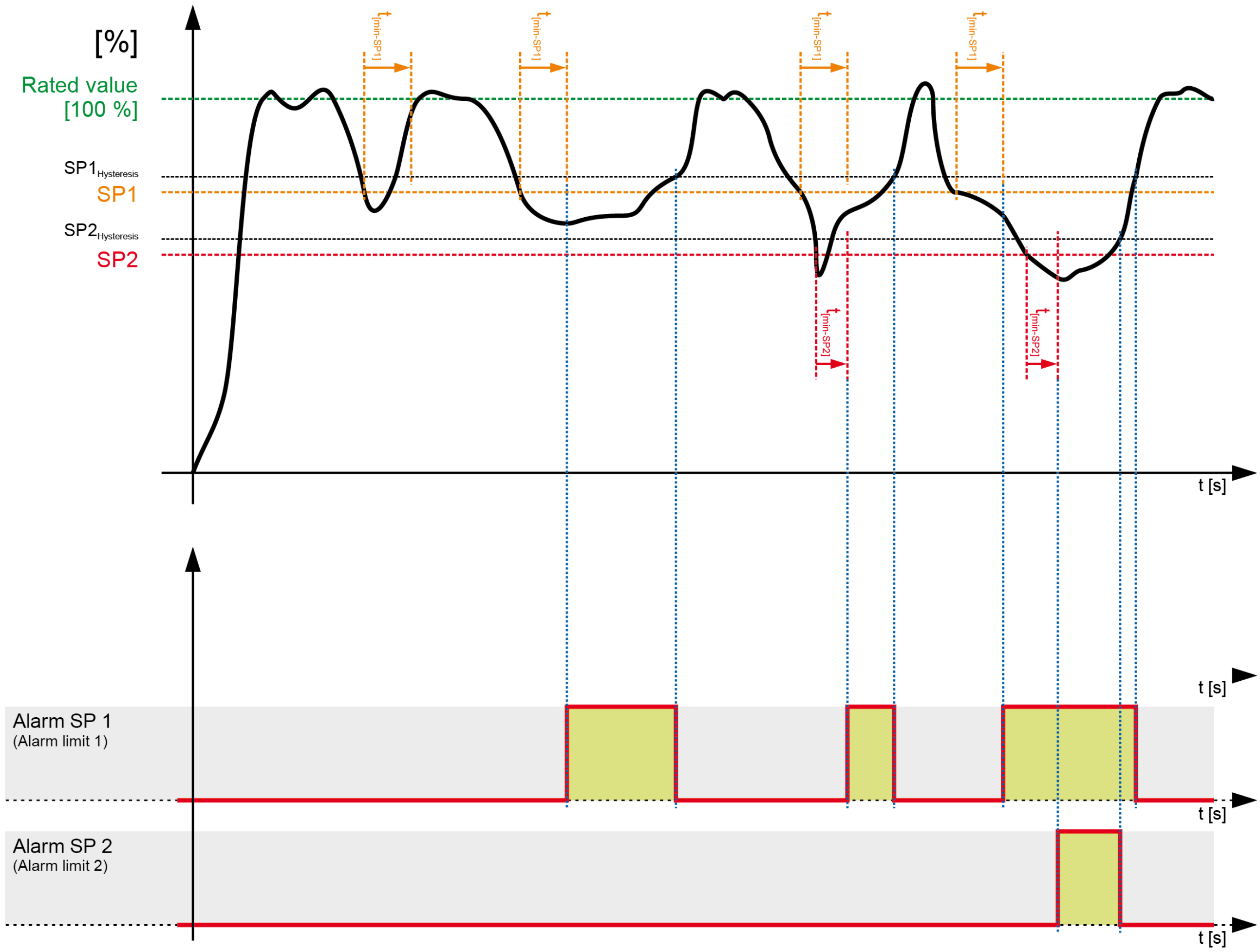


Fig. 31: Undervoltage monitoring

> *The hysteresis is depending on the voltage threshold.*
>
> *The hysteresis is ...*
>
> – *... 0.7% of the primary transformer delta voltage if the voltage threshold is higher than 35% or*
> – *... 0.4% of the primary transformer delta voltage if the voltage threshold is lower than 20%.*
> – *Between 20% and 35% the hysteresis increases linearly from 0.4% to 0.7%.*

> *The parameter limits listed below have identical setting ranges. Each parameter may be configured with different settings to create unique trip characteristics for specific thresholds.*

ID	Parameter	CL	Setting range [Default]	Description
2050 2056	**Monitoring**	2	**[On]**	Undervoltage monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit > limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.
2054 2060	**Limit**	2	5.0 to 150.0 % 2054: **[92.0 %]** 2060: **[88.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or fallen below for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated voltage" (parameter 1766 ➯ p. 42).
2055 2061	**Delay**	2	0.02 to 300.00 s 2055: **[5.00 s]** 2061: **[0.30 s]**	If the monitored voltage falls below the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored voltage exceeds the threshold (plus the hysteresis) again before the delay expires the time will be reset.
2064 2065	**AND characteristics**	2	On	Each phase has to be under the threshold for tripping.
			[Off]	At least one phase has to be under the threshold for tripping.
2051 2057	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2051: **[Relay 1]** 2057: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➯ p. 45 , 6921 ➯ p. 45, 6922 ➯ p. 45 and 6923 ➯ p. 45).

4.3.3 Overfrequency (Level 1 & 2) ANSI# 81O

General notes

This controller provides the user with two alarm levels for overfrequency. Both alarms are definite time alarms.

Monitoring for overfrequency faults is performed in two steps.

The diagram listed below shows a frequency trend and the associated pickup times and length of the alarms.

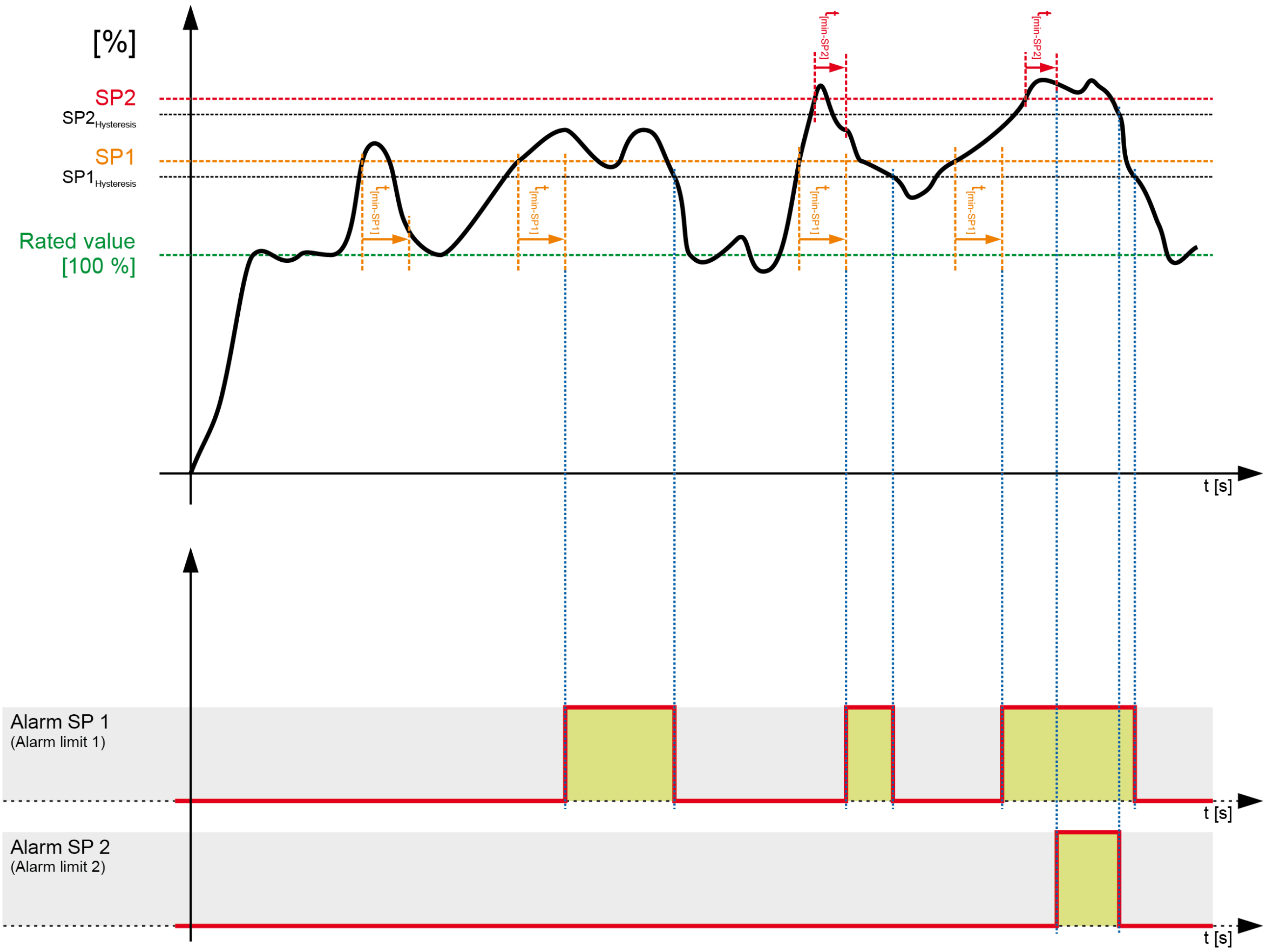


Fig. 32: Overfrequency monitoring

The hysteresis is 0.05 Hz.

The parameter limits listed below have identical setting ranges. Each parameter may be configured with different settings to create unique trip characteristics for specific thresholds.

ID	Parameter	CL	Setting range [Default]	Description
1900 1906	**Monitoring**	2	**[On]**	Overfrequency monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit < limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.

ID	Parameter	CL	Setting range [Default]	Description
1904 1910	**Limit**	2	50.0 to 140.0 % 1904: **[110.0 %]** 1910: **[115.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated system frequency" (parameter 1750 ➩ p. 42).
1905 1911	**Delay**	2	0.02 to 300.00 s 1905: **[1.50 s]** 1911: **[0.30 s]**	If the monitored frequency value exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored frequency falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
1901 1907	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 1901: **[Relay 1]** 1907: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➩ p. 45 , 6921 ➩ p. 45, 6922 ➩ p. 45 and 6923 ➩ p. 45).

4.3.4 Underfrequency (Level 1 & 2) ANSI# 81U

General notes

This controller provides the user with two alarm levels for underfrequency. Both alarms are definite time alarms.

Monitoring for underfrequency faults is performed in two steps.

The diagram listed below shows a frequency trend and the associated pickup times and length of the alarms.

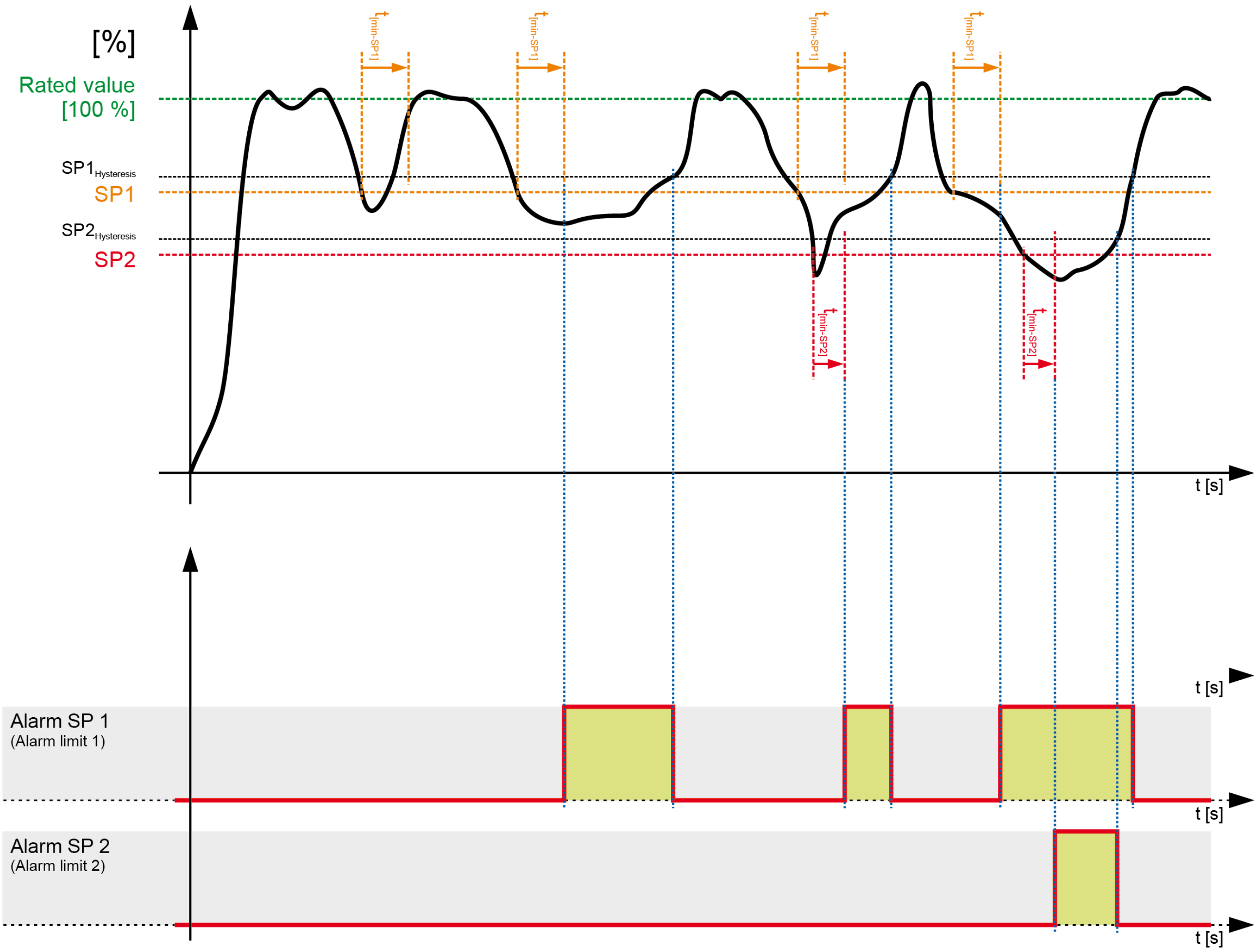


Fig. 33: Underfrequency monitoring

> *The hysteresis is 0.05 Hz.*

> *The parameter limits listed below have identical setting ranges. Each parameter may be configured with different settings to create unique trip characteristics for specific thresholds.*

ID	Parameter	CL	Setting range [Default]	Description
1950 1956	**Monitoring**	2	**[On]**	Underfrequency monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit > limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.

ID	Parameter	CL	Setting range [Default]	Description
1954 1960	**Limit**	2	50.0 to 140.0 % 1954: **[90.0 %]** 1960: **[84.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or fallen below for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated system frequency" (parameter 1750 ↳ p. 42).
1955 1961	**Delay**	2	0.02 to 300.00 s 1955: **[5.00 s]** 1961: **[0.30 s]**	If the monitored frequency value falls below the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored frequency exceeds the threshold (plus the hysteresis) again before the delay expires the time will be reset.
1951 1957	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 1951: **[Relay 1]** 1957: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ↳ p. 45 , 6921 ↳ p. 45, 6922 ↳ p. 45 and 6923 ↳ p. 45).

4.3.5 Positive Load (Level 1 & 2) ANSI# 32

General notes

The power is monitored depending on parameter "Voltage measuring" (parameter 1851 ↳ p. 43) and parameter "Current measuring" (parameter 1850 ↳ p. 42).

If the single- or three-phase measured real power exceeds the configured limit, the alarm will be issued.

Both alarm limits may either be positive or negative.

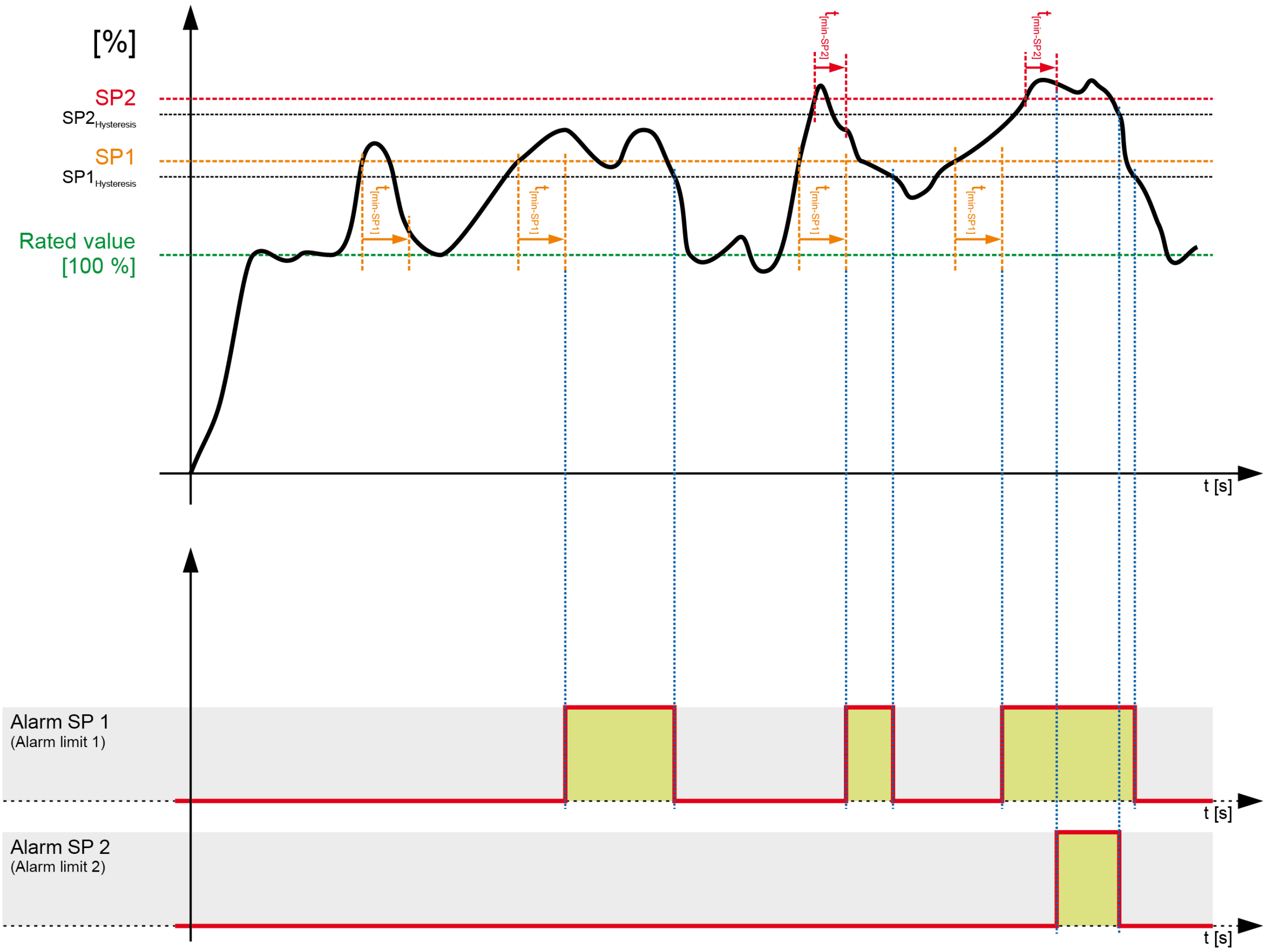


Fig. 34: Positive load monitoring

> *The hysteresis is 1.0 % of the power calculated from primary transformer delta voltage and primary CT current.*

ID	Parameter	CL	Setting range [Default]	Description
2300 2306	**Monitoring**	4	**[On]**	Positive load monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit < limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.
2304 2310	**Limit**	4	-300.0 to 300.0 % 2304: **[110.0 %]** 2310: **[120.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated active power" (parameter 1752 ➪ p. 42).

ID	Parameter	CL	Setting range [Default]	Description
2305 2311	**Delay**	4	0.02 to 300.00 s 2305: **[11.00 s]** 2311: **[0.10 s]**	If the monitored load exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored load falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
2301 2307	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2301: **[Relay 1]** 2307: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.6 Negative Load (Level 1 & 2) ANSI# 32R/F

General notes

The power is monitored depending on parameter "Voltage measuring" (parameter 1851 ➪ p. 43) and parameter "Current measuring" (parameter 1850 ➪ p. 42).

If the single- or three-phase measured real power is below the configured limit, the alarm will be issued.

Both alarm limits may either be positive or negative.

The negative load monitoring follows the same principle as the positive load monitoring, but triggers when the value falls below the threshold.

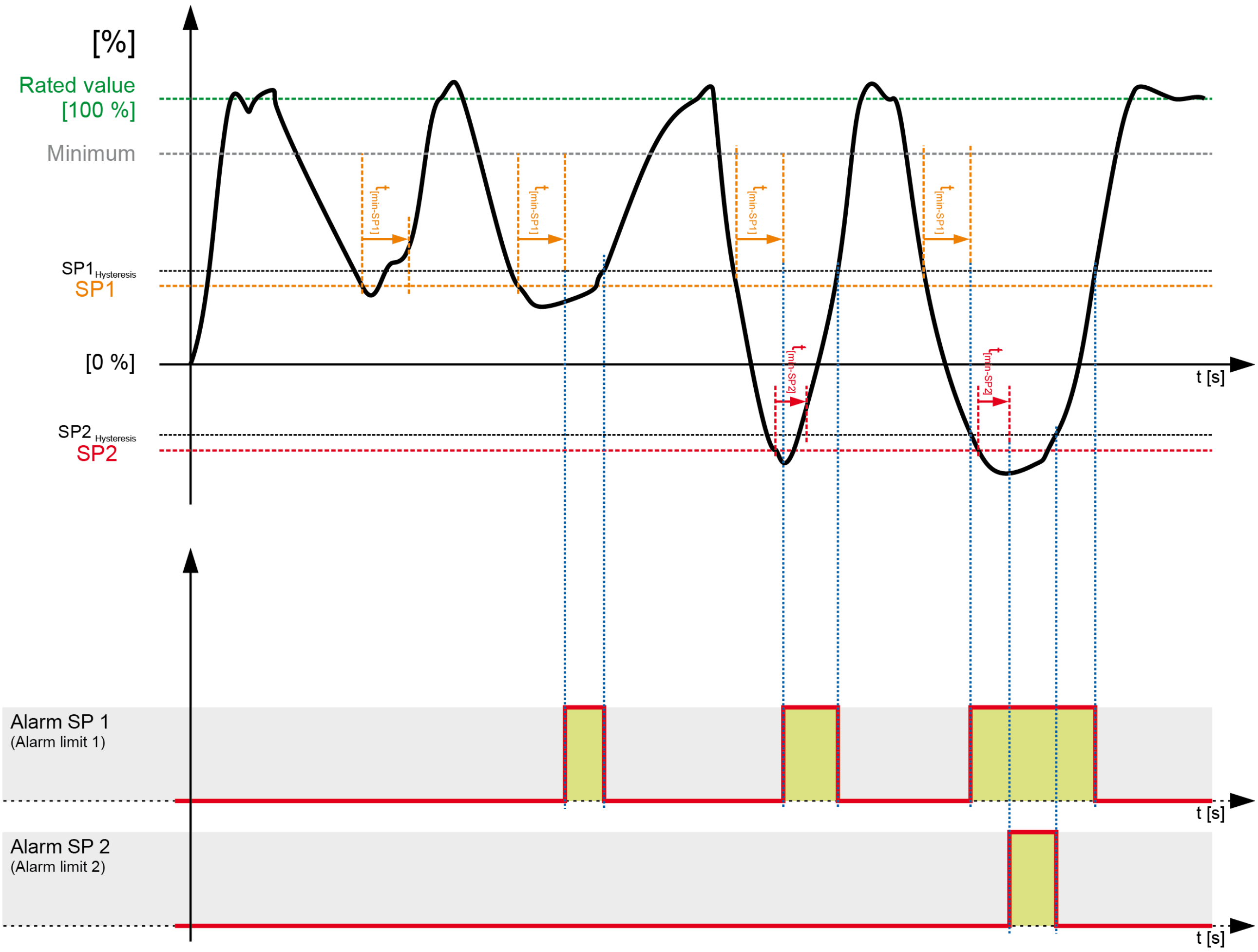


Fig. 35: Negative load monitoring

> *The hysteresis is 1.0 % of the power calculated from primary transformer delta voltage and primary CT current.*

ID	Parameter	CL	Setting range [Default]	Description
2250 2256	**Monitoring**	4	**[On]**	Negative load monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit > limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.
2254 2260	**Limit**	4	-300.0 to 300.0 % 2254: **[-3.0 %]** 2260: **[-5.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or fallen below for at least the delay time without interruption, the specified relay will be energized.

ID	Parameter	CL	Setting range [Default]	Description
				Notes This value refers to the "Rated active power" (parameter 1752 ➪ p. 42). A negative value refers to a negative load, i.e. reverse load and a positive load is considered as a reduced load.
2255 2261	**Delay**	4	0.02 to 300.00 s 2255: **[5.00 s]** 2261: **[3.00 s]**	If the monitored load falls below the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored load exceeds the threshold (plus the hysteresis) again before the delay expires the time will be reset.
2251 2257	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2251: **[Relay 1]** 2257: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.7 Unbalanced Load (Level 1 & 2) ANSI# 46

General notes

Unbalanced load is monitored according to how the parameters "Voltage measuring" (parameter 1851 ➪ p. 43), "Current measuring" (parameter 1850 ➪ p. 42) and "Phase rotation" (parameter 3954 ➪ p. 43) are configured.

The unbalanced load alarm is a phase imbalance alarm. Unbalanced load is determined by calculating the negative sequence component of a three phase system: The three current components and the angle between them. Parameter "Monitoring Modes" (parameter 2414 ➪ p. 62) defines how to calculate in detail accoring to typical standards.

Unbalanced load monitoring is only active if "Current measuring" (parameter 1850 ➪ p. 42) is configured to "L1 L2 L3" and "Voltage measuring" (parameter 1851 ➪ p. 43) is either configured to "3Ph 4W" or "3Ph 3W". The threshold is defined as the percentage of that value relative to the nominal current. The protective function is triggered if this percentage value is exceeded.

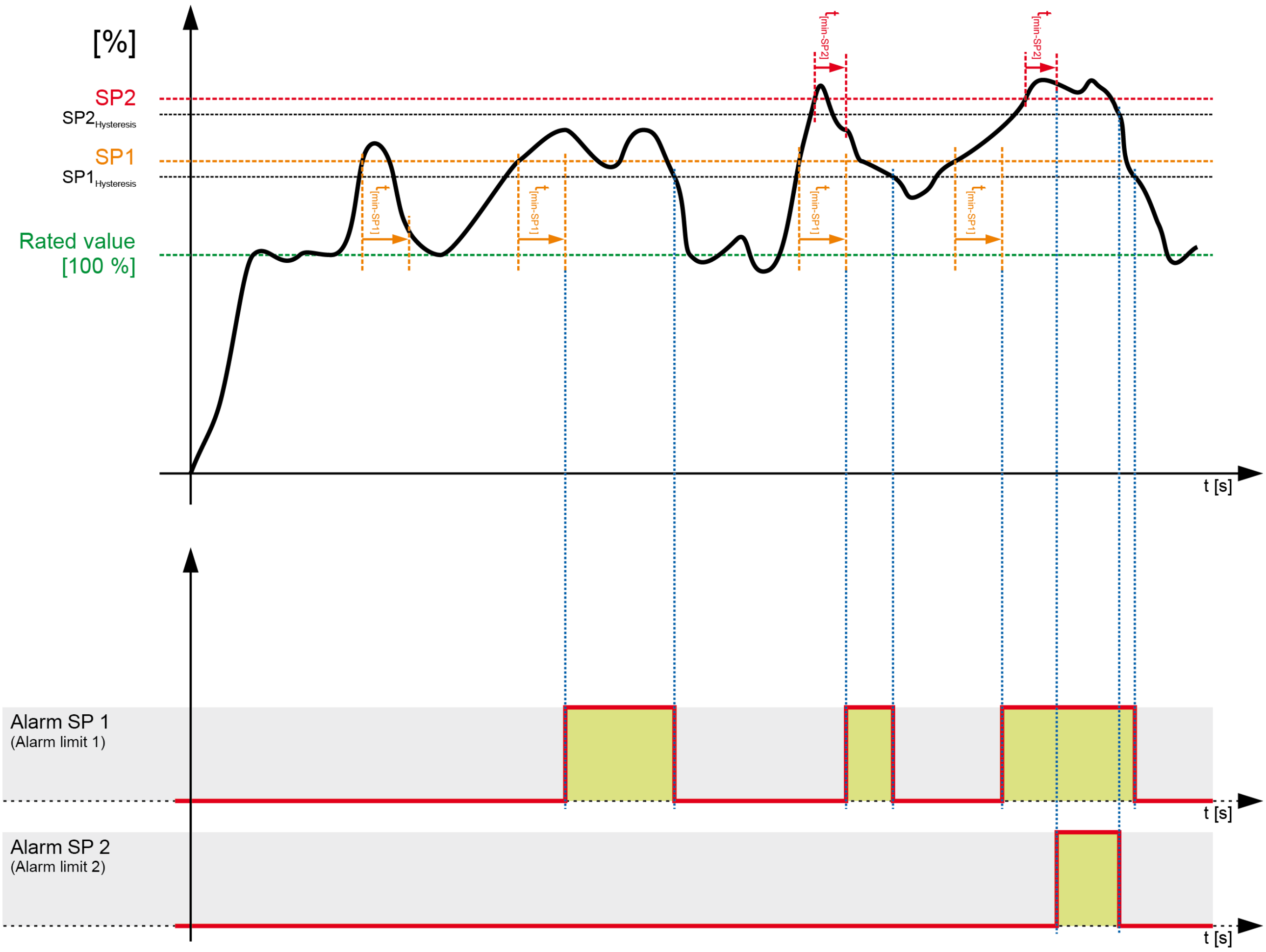


Fig. 36: Unbalanced load monitoring

> *The hysteresis is 0.5 % of the CT primary current.*

> *This monitoring function is only enabled when "Voltage measuring" (parameter 1851 ⇘ p. 43) is configured to "3Ph 4W" or "3Ph 3W" and "Current measuring" (parameter 1850 ⇘ p. 42) is configured to "L1 L2 L3".*
>
> *The "Phase rotation" (parameter 3954 ⇘ p. 43) must be configured correctly for a proper operation.*

ID	Parameter	CL	Setting range [Default]	Description
2414	**Monitoring Mode**	4	**[Neg. Seq.]**	**Absolute** current values and the angles between them are taken for account.
			NEMA	The maximum deviation from the **average** current value is taken for account.

ID	Parameter	CL	Setting range [Default]	Description
			Neg. Seq. 120°	**Absolute** curent values are taken for account. The angles between them are assumed to be 120°.
2400 2406	**Monitoring**	4	**[On]**	Unbalanced load monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 limit < limit 2).
			Off	Monitoring is disabled for Level 1 limit and/or Level 2 limit.
2404 2410	**Limit**	4	5.0 to 100.0 % 2404: **[10.0 %]** 2410: **[15.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated current" (parameter 1754 ➪ p. 42).
2405 2411	**Delay**	4	0.02 to 300.00 s 2405: **[10.00 s]** 2411: **[1.00 s]**	If the monitored load exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored load exceeds or falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
2401 2407	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2401: **[Relay 1]** 2407: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.8 Voltage Asymmetry (Level 1 & 2)

General notes

Voltage asymmetry is determined by calculating the negative sequence component of a three-phase system. This value is derived from the three delta voltages (phase-phase). Voltage asymmetry monitoring is only active if "Voltage measuring" (parameter 1851 ➪ p. 43) is configured to "3Ph 4W" or "3Ph 3W". The threshold is defined as the percentage of that value relative to the nominal delta voltage. The protective function is triggered if this percentage value is exceeded.

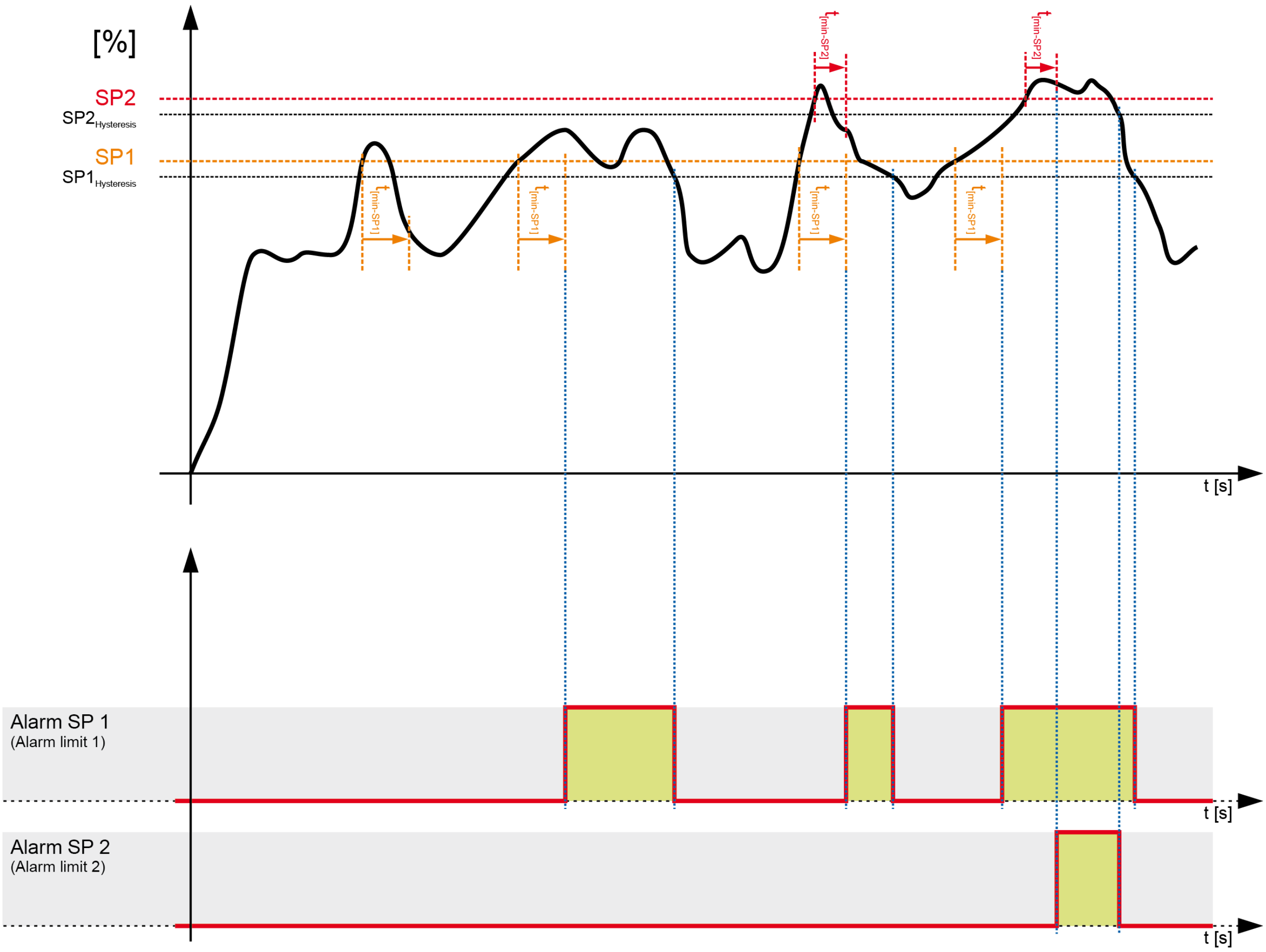


Fig. 37: Voltage asymmetry monitoring

> *The hysteresis is 0.5 % of the primary transformer delta voltage.*

> *This monitoring function is only enabled if "Voltage measuring" (parameter 1851 ✎ p. 43) is configured to "3Ph 4W" or "3Ph 3W".*

ID	Parameter	CL	Setting range [Default]	Description
3900 3931	**Monitoring**	2	3900: **[On]**	Voltage asymmetry monitoring is carried out according to the following parameters.
			3931: **[Off]**	No monitoring is carried out.

ID	Parameter	CL	Setting range [Default]	Description
3903 3934	**Limit**	2	0.5 to 99.9 % 3903: **[10.0 %]** 3934: **[15.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated voltage" (parameter 1766 ➪ p. 42).
3904 3935	**Delay**	2	0.02 to 300.00 s 3904: **[5.00 s]** 3935: **[3.00 s]**	If the monitored voltage asymmetry exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored voltage asymmetry falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
3901 3932	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 3901: **[Relay 1]** 3932: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.9 Phase Shift

General notes

A vector/phase shift is defined as the sudden variation of the voltage curve which may be caused by a major source load change.

The unit measures the duration of a cycle, where a new measurement is started with each voltage passing through zero. The measured cycle duration will be compared with an internal quartz-calibrated reference time to determine the cycle duration difference of the voltage signal.

A vector/phase shift as shown in Fig. 38 causes a premature or delayed zero passage. The determined cycle duration difference corresponds with the occurring phase shift angle.

The monitoring may be carried out three-phase or one/three-phase. The monitoring can be configured in different ways. The vector/phase shift monitor can also be used as an additional method to decouple from the grid. Vector/phase shift monitoring is only enabled after the monitored voltage exceeds 50% of the PT secondary rated voltage.

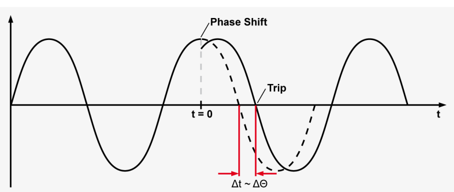


Fig. 38: Phase shift

> ***Function "Voltage cycle duration not within the permissible range"***
> *The voltage cycle duration exceeds the configured limit value for the phase/vector shift.*

> *3-phase - phase shift monitoring is only enabled if "Voltage measuring" (parameter 1851 ➪ p. 43) is configured to "3Ph 4W" or "3Ph 3W".*

ID	Parameter	CL	Setting range [Default]	Description
3050	**Monitoring**	4	**[On]**	Phase shift monitoring is carried out according to the following parameters.
			Off	No monitoring is carried out.
3053	**Monitoring**	4	**[1- and 3-phase]**	During single-phase voltage phase/vector shift monitoring, tripping occurs if the phase/vector shift exceeds the configured threshold value (parameter 3054 ➪ p. 66) in at least one of the three phases.
			3-phase	During three-phase voltage phase/vector shift monitoring, tripping occurs only if the phase/vector shift exceeds the specified threshold value (parameter 3055 ➪ p. 66) in all three phases within 2 cycles.
				Notes If a phase/vector shift occurs in one or two phases, the single-phase threshold value (parameter 3054 ➪ p. 66) is taken into consideration; if a phase/vector shift occurs in all three phases, the three-phase threshold value (parameter 3055 ➪ p. 66) is taken into consideration. Single phase monitoring is very sensitive and may lead to nuisance tripping if the selected phase angle settings are too small.
3054	**Limit 1-phase**	4	3 to 30° **[20°]**	If the electrical angle of the voltage shifts more than this configured value in any single phase, the relay configured in parameter 3051 ➪ p. 66 energizes.
				Notes This parameter is only active, if phase shift "Monitoring" (parameter 3053 ➪ p. 66) is configured to "1- and 3-phase". Since one phase monitoring is more sensible than three phase monitoring, it should be always be configured to a significantly higher threshold than phase shift "Limit 3-phase" (parameter 3055 ➪ p. 66).
3055	**Limit 3-phase**	4	3 to 30° **[8°]**	If the electrical angle of the voltage shifts more than this configured value in all three phases, the relay configured in parameter 3051 ➪ p. 66 energizes.
3051	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 1]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.10 df/dt (ROCOF)

General notes

df/dt (rate of change of frequency) monitoring measures the stability of the frequency. The frequency of a source will vary due to changing loads and other effects. The rate of these frequency changes due to the load variances is relatively high compared to those of a large network.

> ***Function "Rate of change of frequency not within permissible limits"***
>
> *The control unit calculates the unit of measure per unit of time. The df/dt is measured over 4 sine waves to ensure that it is differentiated from a phase shift. This results in a minimum response time of approximately 100ms (at 50 Hz).*

> *The hysteresis is 0.1 Hz/s.*

ID	Parameter	CL	Setting range [Default]	Description
3100	**Monitoring**	4	On	df/dt monitoring is carried out according to the following parameters.
			[Off]	No monitoring is carried out.
3104	**Limit**	4	0.1 to 9.9 Hz/s **[2.6 Hz/s]**	The df/dt threshold is defined here. If this value is reached or exceeded for at least the delay time without interruption, the relay configured in parameter 3101 ↳ p. 67 will be energized.
3105	**Delay**	4	0.10 to 2.00 s **[0.10 s]**	If the monitored rate of df/dt exceeds the threshold value for the delay time configured here, the relay configured in parameter 3101 ↳ p. 67 will be energized. If the monitored df/dt falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
3101	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 1]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ↳ p. 45 , 6921 ↳ p. 45, 6922 ↳ p. 45 and 6923 ↳ p. 45).

4.3.11 Voltage Increase

General notes

Voltage is monitored depending on parameter "Monitoring" (parameter 8806 ➾ p. 68). This function allows the monitoring of the voltage quality over a longer time period. It is realized as a 10 minute moving average. The function is only active, if the frequency is larger than 60 % of the nominal frequency. If "Voltage measuring" (parameter 1851 ➾ p. 43) is configured to a three-phase measurement, the slow voltage increase alarm is monitoring the individual three-phase voltages according to parameter “AND characteristics” (parameter 8849 ➾ p. 69).

If this protective function is triggered, the configured relay is energized (parameter 8831 ➾ p. 69).

The average is set to "Rated voltage" (parameter 1766 ➾ p. 42) if:

- *Frequency is smaller than 60 % nominal frequency OR*
- *Monitoring (parameter 8806 ➾ p. 68) is "Off" OR*
- *Monitoring is tripped AND the measured voltage is again below the limit*

The relay is de-energized, if:

- *The 10 minute average value is smaller than the defined limit AND*
- *The actual measured value frequency is smaller than 60 % of nominal frequency*
- *After a tripping has occurred AND the voltage falls below the threshold*

The hysteresis is 0.7 % of the primary transformer delta voltage.

Please be aware that if "Voltage monitoring" (parameter 1770 ➾ p. 44) is configured to "All" and the voltage increase monitoring (parameter 8806 ➾ p. 68) is used, that this function only monitors "Phase - neutral".

ID	Parameter	CL	Setting range [Default]	Description
8806	**Monitoring**	4	On	Voltage increase monitoring is carried out according to the following parameters.
			[Off]	No monitoring is carried out.
8807	**Limit**	4	100 to 150 % **[110 %]**	The percentage voltage value that is to be monitored is defined here. If the average voltage over 10 minutes is higher, the specified relay will be energized.

ID	Parameter	CL	Setting range [Default]	Description
				Notes This value refers to the "Rated voltage" (parameter 1766 ➪ p. 42).
8849	**AND characteristics**	4	On	If the 10 minute voltage averages of **all** phases exceed the limit, the monitoring is tripping.
			[Off]	If the 10 minute voltage average of **at least one** phase exceeds the limit, the monitoring is tripping.
8831	**Relay**	4	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 1]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.12 QV Monitoring

General notes

In case of undervoltage some grid codes require a special monitoring function to avoid the import of inductive reactive power at the interchange point. The QV monitoring is a function of voltage and reactive power. To prevent malfunction, a "Minimum current" (parameter 3287 ➪ p. 71) must be configured.

QV monitoring is triggered if the following conditions are fulfilled: (Refer to Fig. 39 for details)

- QV monitoring is configured to "On" (parameter 3292 ➪ p. 71)
- Measured reactive power is higher than the configured “Reactive power threshold” (parameter 3291 ➪ p. 71)
- Measured average current is higher than the configured “Minimum current” (parameter 3287 ➪ p. 71)
- Measured voltages are below the configured “Limit undervoltage” (parameter 3285 ➪ p. 71)

As a result Timer 1 and Timer 2 are starting. If the delay time "Delay step 1" (parameter 3283 ➪ p. 71) has exceeded, the specified relay for step 1 is energized. If the delay time "Delay step 2" (parameter 3284 ➪ p. 71) has exceeded, the specified relay for step 2 is energized.

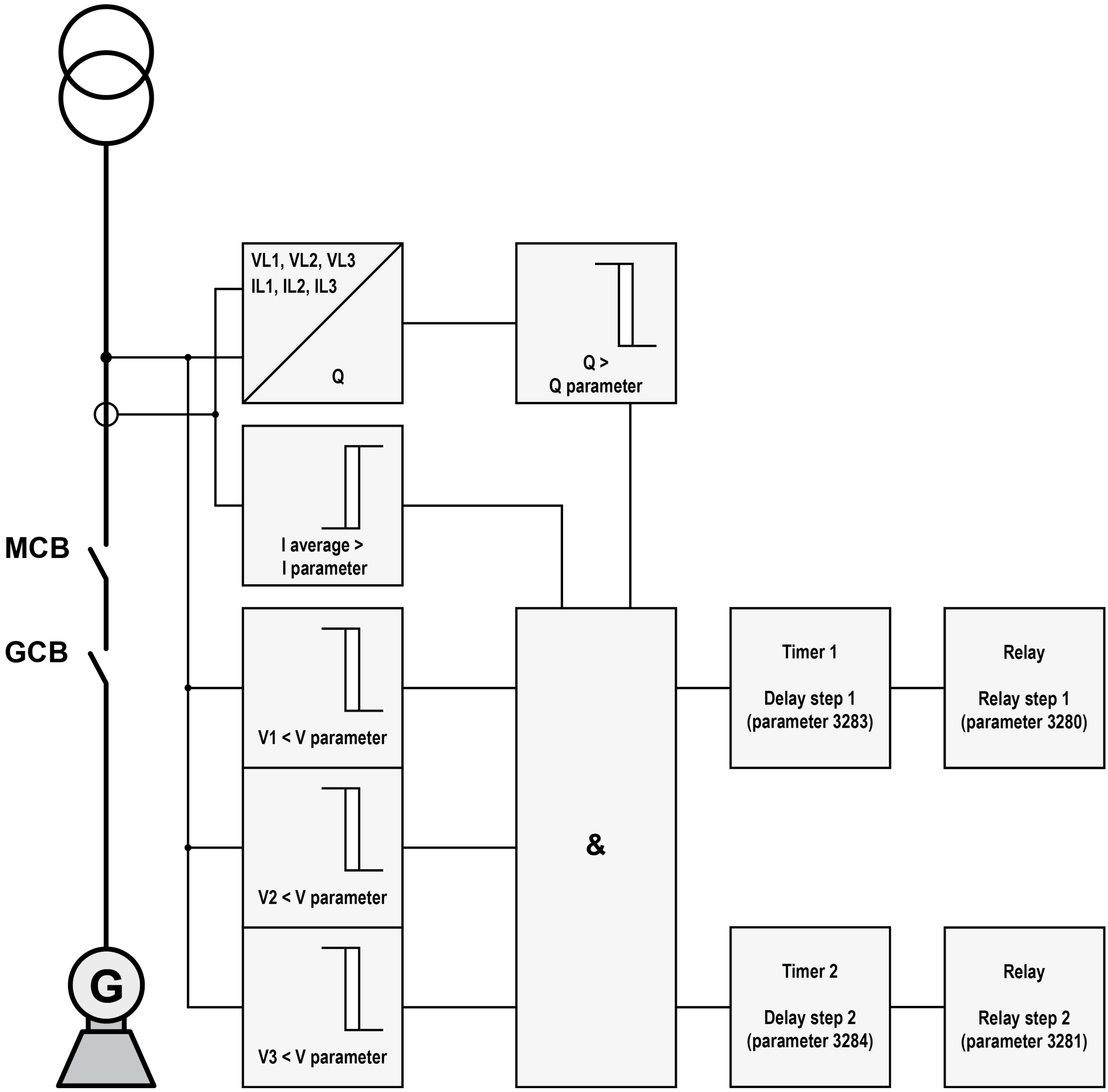


Fig. 39: QV monitoring - schematic

As QV monitoring is a combined protection function the following hystereses are included:

- *Voltage: 0.7 % of primary transformer delta voltage*
- *Current: 1.0 % of CT primary current*
- *Reactive power: 1.0 % of power calculated from primary transformer delta voltage and primary CT current*

ID	Parameter	CL	Setting range [Default]	Description
3292	**Monitoring**	2	On	QV monitoring is carried out according to the following parameters.
			[Off]	No monitoring is carried out.
3285	**Limit under-voltage**	2	45 to 150 % **[85 %]**	The percentage voltage value that is to be monitored is defined here. If the voltages of all phases (one phase in 1Ph 2W system) are below this limit, the voltage condition for tripping the monitoring function is TRUE.
				Notes This value refers to the "Rated voltage" (parameter 1766 ➾ p. 42).
3291	**Reactive power threshold**	2	2 to 100 % **[5 %]**	The percentage reactive value that is to be monitored is defined here. If the absolute value of reactive power Q is higher than this threshold, the reactive power condition for tripping the monitoring function is TRUE.
				Notes This value refers to the "Rated react. power [kvar]" (parameter 1758 ➾ p. 42).
3287	**Minimum cur-rent**	2	0 to 100 % **[10 %]**	The percentage current value that is to be monitored is defined here. If the average current has been exceeded this limit, the current condition for tripping the monitoring function is TRUE.
				Notes This value refers to the "Rated current" (parameter 1754 ➾ p. 42).
3283 3284	**Delay step {x}** [x = 1 to 2]	2	0.10 to 99.99 s 3283: **[0.50 s]** 3284: **[1.50 s]**	If the QV monitoring conditions are met, for the delay time configured here, the specified relay will be energized.
3280 3281	**Relay step {x}** [x = 1 to 2]	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 3280: **[Relay 1]** 3281: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➾ p. 45 , 6921 ➾ p. 45, 6922 ➾ p. 45 and 6923 ➾ p. 45).

4.3.13 Overcurrent (Level 1, 2 & 3) ANSI# 50/51

General notes

Current is monitored according to how the parameter "Current measuring" (parameter 1850 ➾ p. 42) is configured. This controller provides the user with three definite time alarm levels for overcurrent faults.

Monitoring of the maximum phase current is performed in three steps. Every step can be provided with a delay time independent of the other steps.

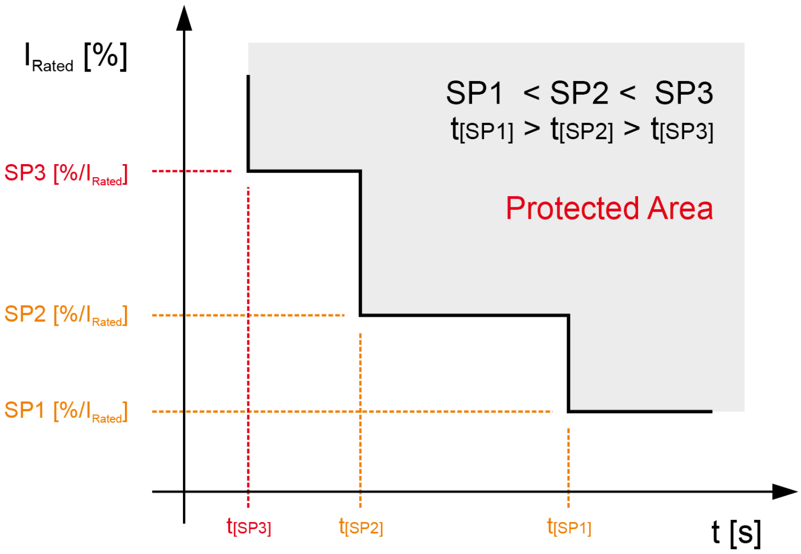


Fig. 40: Overcurrent monitoring

The hysteresis is 1.0 % of the primary CT current.

If this protective function is triggered, the relays configured to "Overcurrent level 1", "Overcurrent level 2", or "Overcurrent level 3" are energized.

ID	Parameter	CL	Setting range [Default]	Description
2200 2206 2212	**Monitoring**	2	On	Overcurrent monitoring is carried out according to the following parameters. Monitoring is performed at three levels. All three values may be configured independent from each other (prerequisite: Level 1 < Level 2 < Level 3).
			[Off]	Monitoring is disabled for Level 1 limit, Level 2 limit, and/or Level 3 limit.
2204 2210 2216	**Limit**	2	50.0 to 300.0 % 2204: **[110.0 %]** 2210: **[150.0 %]** 2216: **[250.0 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.
				Notes This value refers to the "Rated current" (parameter 1754 ➜ p. 42).
2205 2211 2217	**Delay**	2	0.02 to 300.00 s 2205: **[30.00 s]** 2211: **[1.00 s]** 2217: **[0.40 s]**	If the monitored current exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored current falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.

ID	Parameter	CL	Setting range [Default]	Description
2201 2207 2213	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 2201: **[Relay 1]** 2207: **[Relay 2]** 2213: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ⤷ p. 45 , 6921 ⤷ p. 45, 6922 ⤷ p. 45 and 6923 ⤷ p. 45).

4.3.14 Ground Fault (Level 1 & 2)

Calculated ground fault

The current is monitored depending on how parameter "Current measuring" (parameter 1850 ⤷ p. 42) is configured. The measured three conductor currents IL1, IL2 and IL3 are vectorially totaled (IS = IL1 + IL2 + IL3) and compared with the configured fault limit (the calculated actual value is indicated in the configuration software). If the measured value exceeds the fault threshold limit, the configured relay is energized.

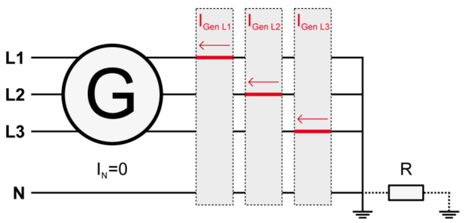


Fig. 41: Ground fault - schematic

> *The ground fault protection zone is determined by the location where current transformers are physically installed.*

Test

➜ Short-circuit one of the three current transformers under load.

⇨ The measured current should read 100 % of rated on the two phases that do not have their current transformers short-circuited.

The ground current calculation does not take current on the neutral conductor into consideration. In order for the controller to be able to perform calculated ground fault current protection accurately, the neutral conductor must not conduct current.

The fault threshold value is configured as a percentage. This percentage threshold refers to the "Rated current" (parameter 1754 ⤷ p. 42). Due to accuracy restrictions the system will always calculate a ground current of about 3 % of the nominal current. The threshold has to be sufficiently higher than that.

Calculation

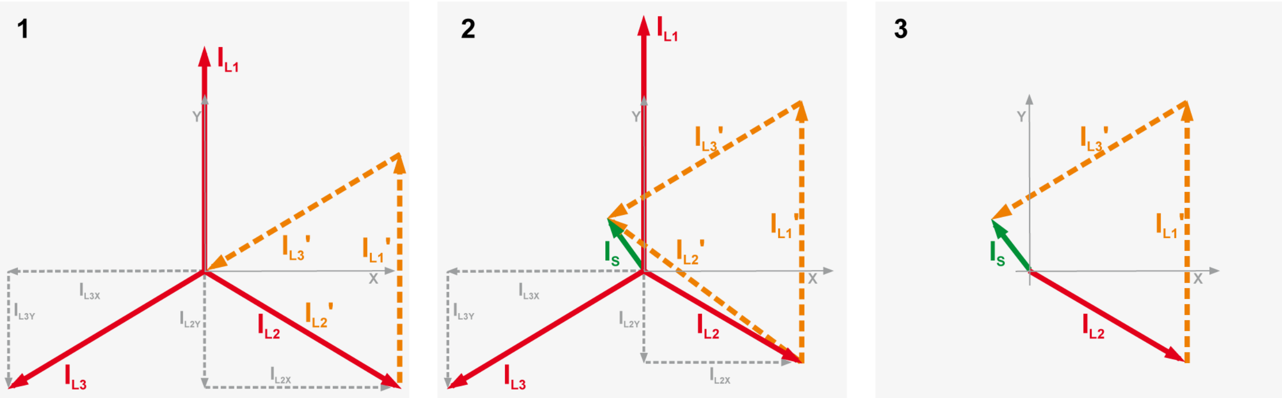


Fig. 42: Generator ground fault - calculation

1 No ground fault
2 Ground fault (with vectorial calculation)
3 Ground fault (I_S = ground fault current)

The ground current I_S is calculated geometrically/vectorially. The pointers for phase currents IL1 and IL2 are parallel shifted and lined up as shown in (Fig. 42/1).

The pointer between the neutral point and the point of the shifted pointer I_{L2}' results is the sum current I_S as shown in (Fig. 42/2).

In order to be able to add the pointers vectorially, these must be divided into their X- and Y-coordinates (IL2X, IL2Y, IL3X and IL3Y).

The ground fault current may be calculated using the following formula:

- $(I_{L1rated} + I_{L2rated} + I_{L3rated}) - (I_{L1measured} + I_{L2measured} + I_{L3measured}) / 1.73 = I_S$
- (7 A + 7 A + 7 A) – (7A + 6.5 A + 6 A) / 1.73 = 0.866 A

Results of a calculation example:

- Phase current $I_{L1} = I_{Rated}$ = 7 A
- Phase current I_{L2} = 6.5 A
- Phase current I_{L3} = 6 A

The hysteresis is 1.0 % of the primary CT current.

ID	Parameter	CL	Setting range [Default]	Description
3250 3256	**Monitoring**	2	On	Ground current monitoring is carried out according to the following parameters. Monitoring is performed at two levels. Both values may be configured independent from each other (prerequisite: Level 1 < Level 2).
			[Off]	Monitoring is disabled for Level 1 limit and/or Level 2 limit.
3254 3260	**Limit**	2	0 to 300 % 3254: **[10 %]** 3260: **[30 %]**	The percentage values that are to be monitored for each threshold limit are defined here. If this value is reached or exceeded for at least the delay time without interruption, the specified relay will be energized.

ID	Parameter	CL	Setting range [Default]	Description
				Notes This value refers to the "Rated current" (parameter 1754 ➪ p. 42). The ground fault threshold shall not exceed the current measuring range (approx. 1.5 × I_{rated}; ➪ *Chapter 8.1 "Technical Data" on page 109*).
3255 3261	**Delay**	2	0.02 to 300.00 s 3255: **[0.20 s]** 3261: **[0.10 s]**	If the monitored ground fault exceeds the threshold value for the delay time configured here, an alarm will be issued.
				Notes If the monitored ground fault falls below the threshold (minus the hysteresis) before the delay expires the time will be reset.
3251 3257	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 3251: **[Relay 1]** 3257: **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.15 Time-Dependent Voltage 1

General notes

Voltage is monitored depending on parameter "Voltage measuring" (parameter 1851 ➪ p. 43). It can be configured either as undervoltage or overvoltage monitoring (parameter 4953 ➪ p. 76). If the measured voltage of at least one phase falls below/exceeds the configured "Initial threshold" (parameter 4970 ➪ p. 76), the time-dependent voltage monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 4978 ➪ p. 77) for at least the configured "Fallback time" (parameter 4968 ➪ p. 77), the time-dependent voltage monitoring sequence will be reset.

The threshold curve results from seven configurable points and a linear interpolation between these points. Fig. 43 shows a threshold curve with standard values for time-dependent voltage monitoring 1. These standard values form an FRT (fault ride-through) monitoring function according to the grid code requirements for wind turbines. The time points should always have an ascending order. The fallback threshold should always be configured to a value higher/lower than the init threshold.

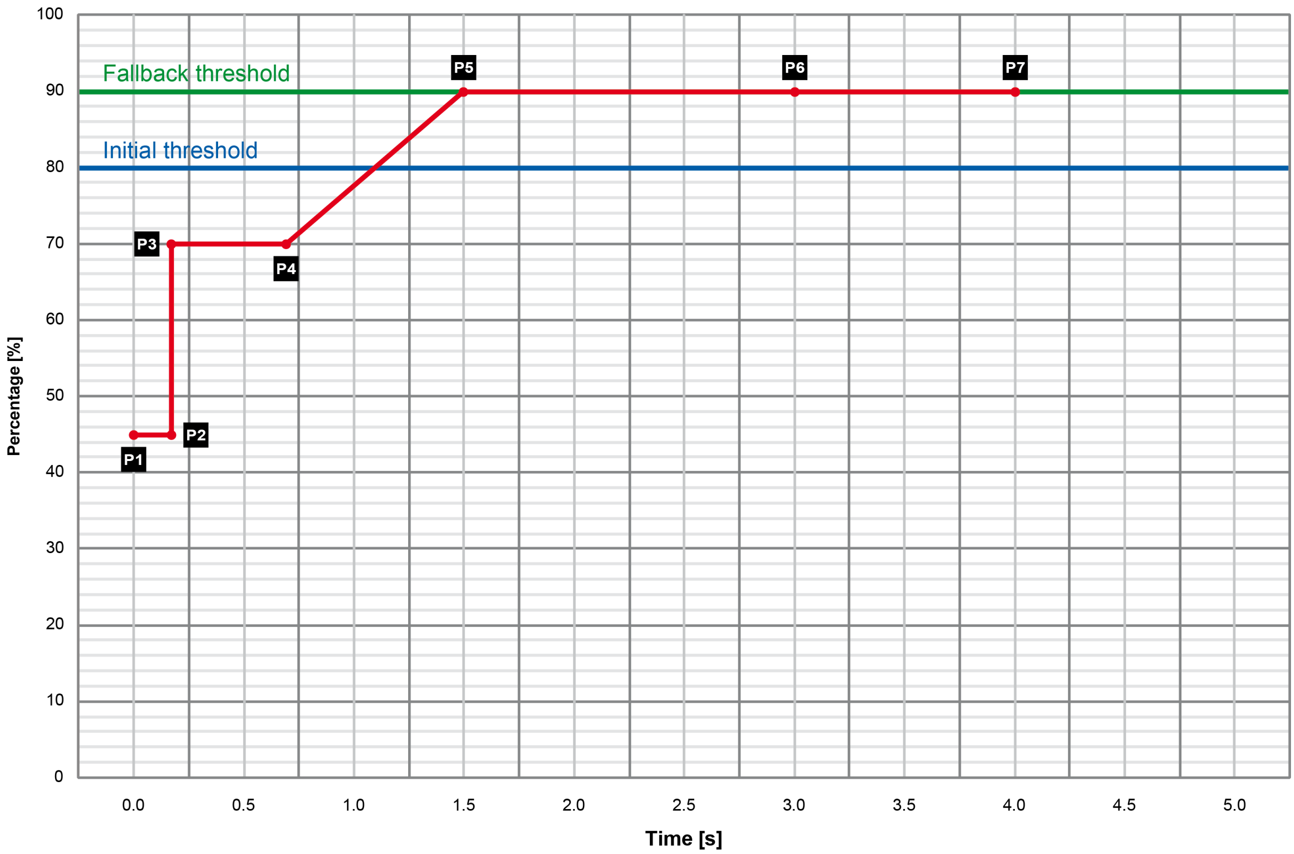


Fig. 43: Time-dependent voltage monitoring 1

P1	0.00 s → 45.0 %	P6	3.00 s → 90.0 %
P2	0.15 s → 45.0 %	P7	4.00 s → 90.0 %
P3	0.15 s → 70.0 %	Fallback voltage	90.0 %
P4	0.70 s → 70.0 %	Initial threshold	80.0 %
P5	1.50 s → 90.0 %	Fallback time	1.00 s

ID	Parameter	CL	Setting range [Default]	Description
4950	**Monitoring**	2	**[On]**	Time-dependent voltage monitoring 1 is carried out according to the following parameters.
			Off	No monitoring is carried out.
4952	**AND characteristics**	2	On	Each phase falls below/exceeds the threshold for tripping.
			[Off]	At least one phase falls below/exceeds the threshold for tripping.
4953	**Monitoring at**	2		Selects whether the system shall do over- or undervoltage monitoring.
			[Underrun]	The undervoltage monitoring is carried out.
			Overrun	The overvoltage monitoring is carried out.
4970	**Init threshold**	2	0.0 to 200.0 % **[80.0 %]**	The time-dependent voltage monitoring initial threshold is configured here. If the measured voltage of at least one phase falls below/exceeds this threshold, the monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize.

ID	Parameter	CL	Setting range [Default]	Description
4968	**Fallback time**	2	0.00 to 320.00 s **[1.00 s]**	The time-dependent voltage monitoring fallback time is configured here. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 4978 ➡ p. 77) for at least the time configured here, the monitoring sequence will be reset.
4978	**Fallback threshold**	2	0.0 to 200.0 % **[90.0 %]**	The time-dependent voltage monitoring fallback voltage is configured here. If the measured voltage falls below/exceeds the voltage configured here for at least the configured "Fallback time" (parameter 4968 ➡ p. 77), the monitoring sequence will be reset.
				Notes This parameter should always be configured to a value higher/lower than the "Init threshold" (parameter 4970 ➡ p. 76) for proper operation.
4961 4962 4963 4964 4965 4966 4967	**Time point {x}** [x = 1 to 7]	2	0.00 to 320.00 s 4961: **[0.00 s]** 4962: **[0.15 s]** 4963: **[0.15 s]** 4964: **[0.70 s]** 4965: **[1.50 s]** 4966: **[3.00 s]** 4967: **[4.00 s]**	The time values of time-dependent voltage monitoring time points are configured here.
4971 4972 4973 4974 4975 4976 4977	**Voltage point {x}** [x = 1 to 7]	2	0.0 to 200.0 % 4971: **[45.0 %]** 4972: **[45.0 %]** 4973: **[70.0 %]** 4974: **[70.0 %]** 4975: **[90.0 %]** 4976: **[90.0 %]** 4977: **[90.0 %]**	The voltage values of time-dependent voltage monitoring voltage points are configured here.
4951	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 1]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➡ p. 45 , 6921 ➡ p. 45, 6922 ➡ p. 45 and 6923 ➡ p. 45).

4.3.16 Time-Dependent Voltage 2

General notes

Voltage is monitored depending on parameter "Voltage measuring" (parameter 1851 ➡ p. 43). It can be configured either as undervoltage or overvoltage monitoring (parameter 4957 ➡ p. 79). If the measured voltage of at least one phase falls below/exceeds the configured "Initial threshold" (parameter 4990 ➡ p. 79), the time-dependent voltage monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 4998 ↬ p. 79) for at least the configured "Fallback time" (parameter 4988 ↬ p. 79), the time-dependent voltage monitoring sequence will be reset.

The threshold curve results from seven configurable points and a linear interpolation between these points. Fig. 44 shows a threshold curve with standard values for time-dependent voltage monitoring 2. These standard values form an STI (short-term interruption) monitoring function according to the grid code requirements for wind turbines. The time points should always have an ascending order. The fallback threshold should always be configured to a value higher/lower than the init threshold.

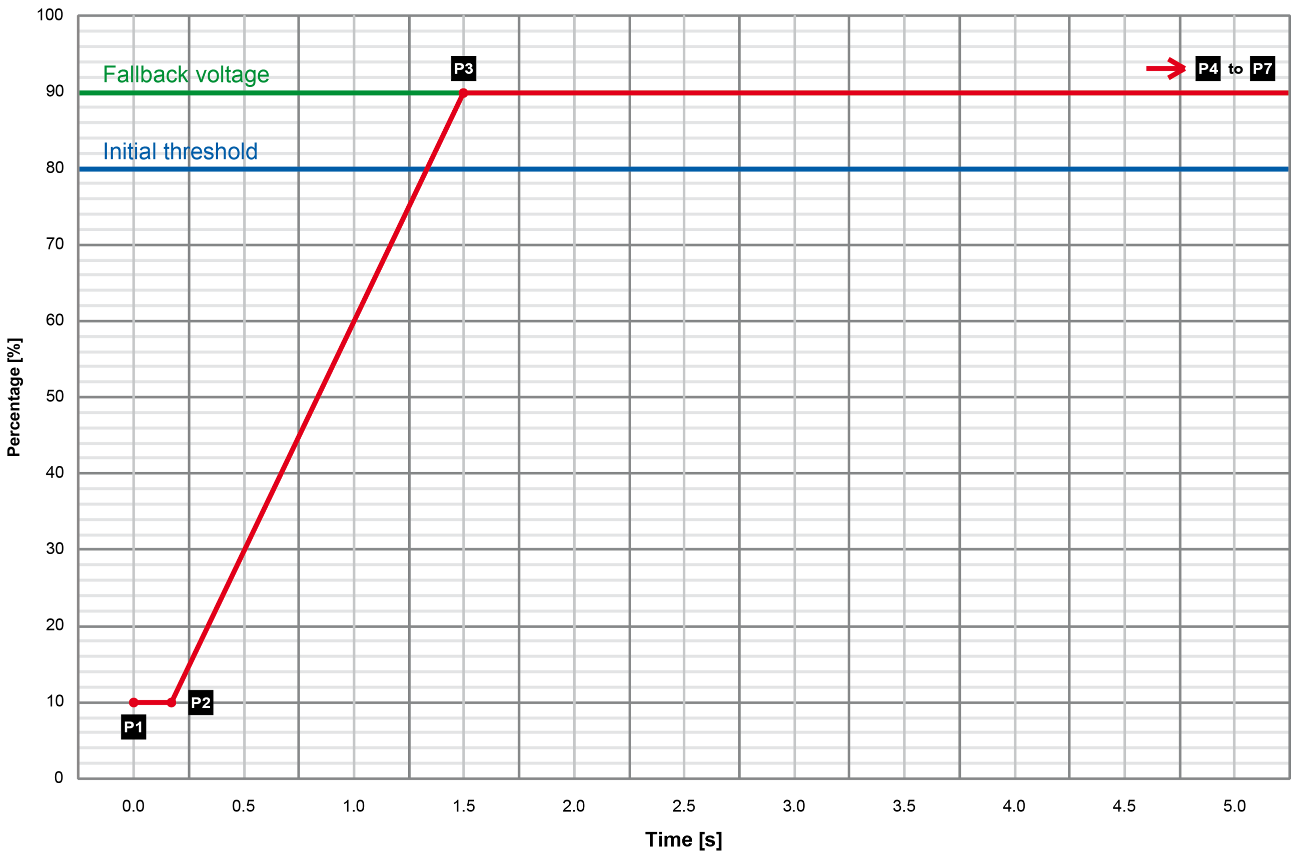


Fig. 44: Time-dependent voltage monitoring 2

P1	0.00 s → 10.0 %	P6	30.00 s → 90.0 %
P2	0.15 s → 10.0 %	P7	40.00 s → 90.0 %
P3	1.50 s → 90.0 %	Fallback voltage	90.0 %
P4	10.00 s → 90.0 %	Initial threshold	80.0 %
P5	20.00 s → 90.0 %	Fallback time	1.00 s

ID	Parameter	CL	Setting range [Default]	Description
4954	**Monitoring**	2	**[On]**	Time-dependent voltage monitoring 2 is carried out according to the following parameters.
			Off	No monitoring is carried out.
4956	**AND characteristics**	2	On	Each phase falls below/exceeds the threshold for tripping.
			[Off]	At least one phase falls below/exceeds the threshold for tripping.

ID	Parameter	CL	Setting range [Default]	Description
4957	**Monitoring at**	2		Selects whether the system shall do over- or undervoltage monitoring.
			[Underrun]	The undervoltage monitoring is carried out.
			Overrun	The overvoltage monitoring is carried out.
4990	**Init threshold**	2	0.0 to 200.0 % **[80.0 %]**	The time-dependent voltage monitoring initial threshold is configured here. If the measured voltage of at least one phase falls below/exceeds this threshold, the monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize.
4988	**Fallback time**	2	0.00 to 320.00 s **[1.00 s]**	The time-dependent voltage monitoring fallback time is configured here. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 4998 ➪ p. 79) for at least the time configured here, the monitoring sequence will be reset.
4998	**Fallback threshold**	2	0.0 to 200.0 % **[90.0 %]**	The time-dependent voltage monitoring fallback voltage is configured here. If the measured voltage falls below/exceeds the voltage configured here for at least the configured "Fallback time" (parameter 4988 ➪ p. 79), the monitoring sequence will be reset.
				Notes This parameter should always be configured to a value higher/lower than the "Init threshold" (parameter 4990 ➪ p. 79) for proper operation.
4981 4982 4983 4984 4985 4986 4987	**Time point {x}** [x = 1 to 7]	2	0.00 to 320.00 s 4981: **[0.00 s]** 4982: **[0.15 s]** 4983: **[1.50 s]** 4984: **[10.00 s]** 4985: **[20.00 s]** 4986: **[30.00 s]** 4987: **[40.00 s]**	The time values of time-dependent voltage monitoring time points are configured here.
4991 4992 4993 4994 4995 4996 4997	**Voltage point {x}** [x = 1 to 7]	2	0.0 to 200.0 % 4991: **[10.0 %]** 4992: **[10.0 %]** 4993: **[90.0 %]** 4994: **[90.0 %]** 4995: **[90.0 %]** 4996: **[90.0 %]** 4997: **[90.0 %]**	The voltage values of time-dependent voltage monitoring voltage points are configured here.
4955	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.17 Time-Dependent Voltage 3

General notes

Voltage is monitored depending on parameter "Voltage measuring" (parameter 1851 ↬ p. 43). It can be configured either as undervoltage or overvoltage monitoring (parameter 9133 ↬ p. 81). If the measured voltage of at least one phase falls below/exceeds the configured "Initial threshold" (parameter 9148 ↬ p. 81), the time-dependent voltage monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 9156 ↬ p. 81) for at least the configured "Fallback time" (parameter 9147 ↬ p. 81), the time-dependent voltage monitoring sequence will be reset.

The threshold curve results from seven configurable points and a linear interpolation between these points. Fig. 45 shows a threshold curve with standard values for time-dependent voltage monitoring 3. These standard values form an FRT (fault ride-through) monitoring function according to the grid code requirements for wind turbines. The time points should always have an ascending order. The fallback threshold should always be configured to a value higher/lower than the init threshold.

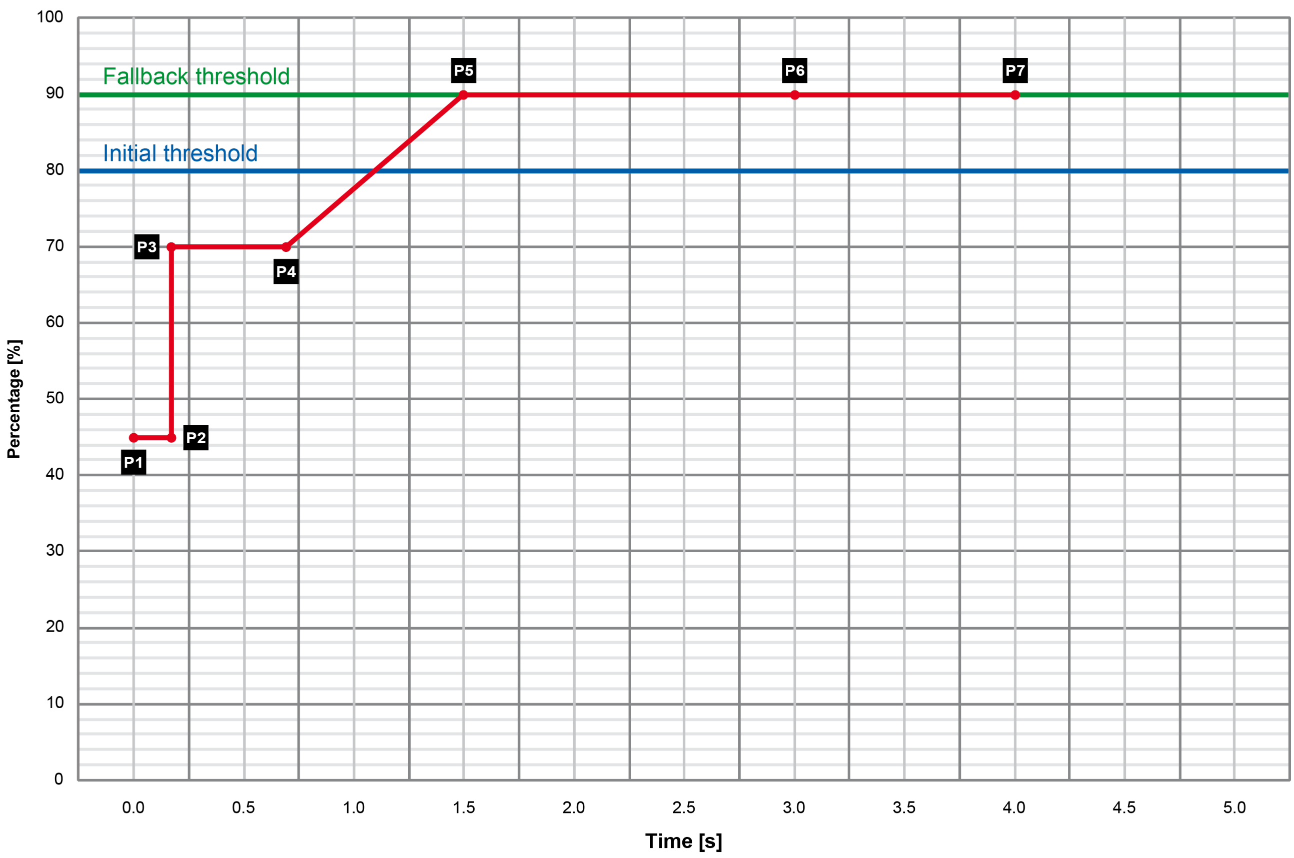


Fig. 45: Time-dependent voltage monitoring 3

P1	0.00 s → 45.0 %	P6	3.00 s → 90.0 %
P2	0.15 s → 45.0 %	P7	4.00 s → 90.0 %
P3	0.15 s → 70.0 %	Fallback voltage	90.0 %
P4	0.70 s → 70.0 %	Initial threshold	80.0 %
P5	1.50 s → 90.0 %	Fallback time	1.00 s

ID	Parameter	CL	Setting range [Default]	Description
9130	**Monitoring**	2	On	Time-dependent voltage monitoring 3 is carried out according to the following parameters.
			[Off]	No monitoring is carried out.
9132	**AND characteristics**	2	On	Each phase falls below/exceeds the threshold for tripping.
			[Off]	At least one phase falls below/exceeds the threshold for tripping.
9133	**Monitoring at**	2		Selects whether the system shall do over- or undervoltage monitoring.
			[Underrun]	The undervoltage monitoring is carried out.
			Overrun	The overvoltage monitoring is carried out.
9148	**Init threshold**	2	0.0 to 200.0 % **[80.0 %]**	The time-dependent voltage monitoring initial threshold is configured here. If the measured voltage of at least one phase falls below/exceeds this threshold, the monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize.
9147	**Fallback time**	2	0.00 to 320.00 s **[1.00 s]**	The time-dependent voltage monitoring fallback time is configured here. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 9156 ➪ p. 81) for at least the time configured here, the monitoring sequence will be reset.
9156	**Fallback threshold**	2	0.0 to 200.0 % **[90.0 %]**	The time-dependent voltage monitoring fallback voltage is configured here. If the measured voltage falls below/exceeds the voltage configured here for at least the configured "Fallback time" (parameter 9147 ➪ p. 81), the monitoring sequence will be reset.
				Notes This parameter should always be configured to a value higher/lower than the "Init threshold" (parameter 9148 ➪ p. 81) for proper operation.
9140 9141 9142 9143 9144 9145 9146	**Time point {x}** [x = 1 to 7]	2	0.00 to 320.00 s 9140: **[0.00 s]** 9141: **[0.15 s]** 9142: **[0.15 s]** 9143: **[0.70 s]** 9144: **[1.50 s]** 9145: **[3.00 s]** 9146: **[4.00 s]**	The time values of time-dependent voltage monitoring time points are configured here.
9149 9150 9151 9152 9153 9154 9155	**Voltage point {x}** [x = 1 to 7]	2	0.0 to 200.0 % 9149: **[45.0 %]** 9150: **[45.0 %]** 9151: **[70.0 %]** 9152: **[70.0 %]** 9153: **[90.0 %]** 9154: **[90.0 %]** 9155: **[90.0 %]**	The voltage values of time-dependent voltage monitoring voltage points are configured here.

ID	Parameter	CL	Setting range [Default]	Description
9131	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 1]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ➪ p. 45 , 6921 ➪ p. 45, 6922 ➪ p. 45 and 6923 ➪ p. 45).

4.3.18 Time-Dependent Voltage 4

General notes

Voltage is monitored depending on parameter "Voltage measuring" (parameter 1851 ➪ p. 43). It can be configured either as undervoltage or overvoltage monitoring (parameter 9137 ➪ p. 83). If the measured voltage of at least one phase falls below/exceeds the configured "Initial threshold" (parameter 9165 ➪ p. 83), the time-dependent voltage monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 9173 ➪ p. 84) for at least the configured "Fallback time" (parameter 9164 ➪ p. 84), the time-dependent voltage monitoring sequence will be reset.

The threshold curve results from seven configurable points and a linear interpolation between these points. Fig. 46 shows a threshold curve with standard values for time-dependent voltage monitoring 4. These standard values form an STI (short-term interruption) monitoring function according to the grid code requirements for wind turbines. The time points should always have an ascending order. The fallback threshold should always be configured to a value higher/lower than the init threshold.

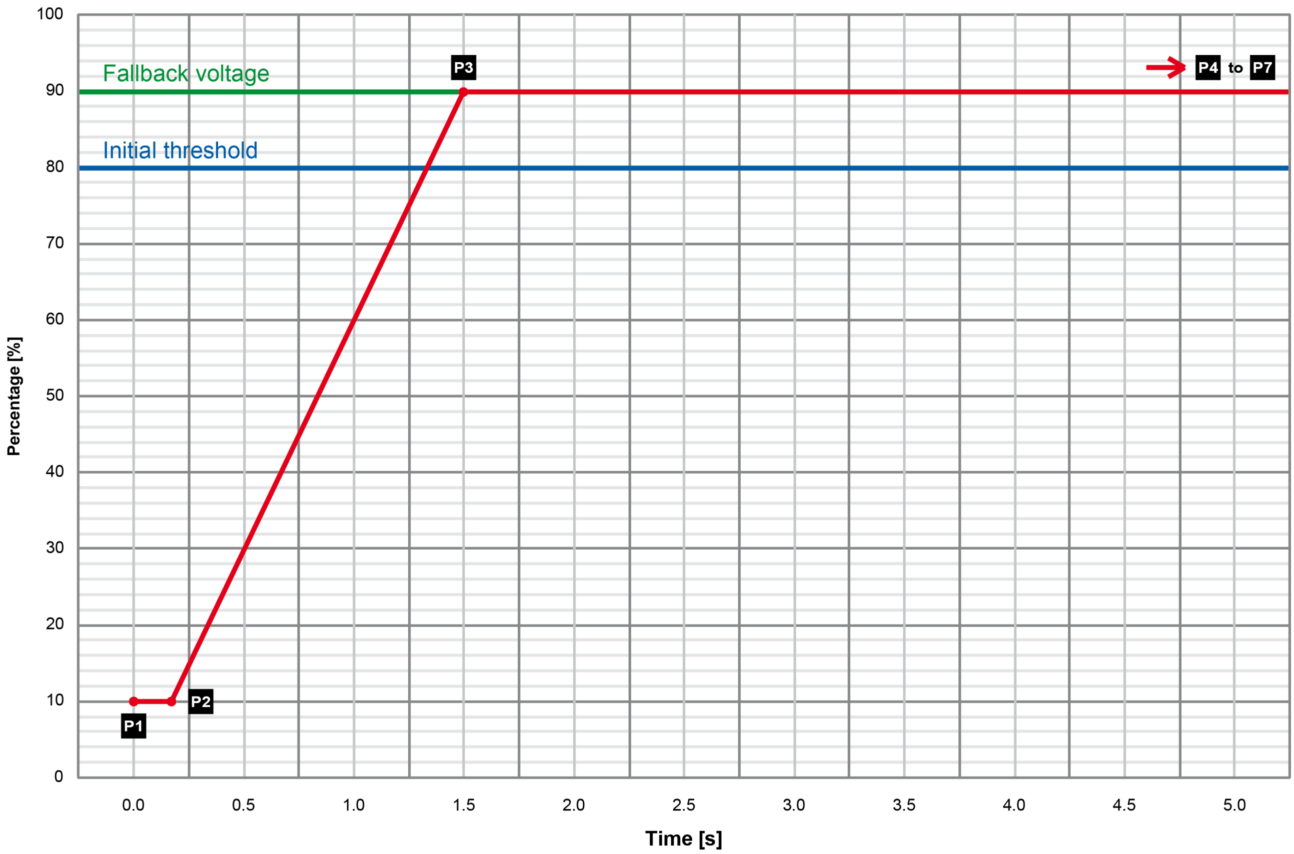


Fig. 46: Time-dependent voltage monitoring 4

P1	0.00 s → 10.0 %	P6	30.00 s → 90.0 %
P2	0.15 s → 10.0 %	P7	40.00 s → 90.0 %
P3	1.50 s → 90.0 %	Fallback voltage	90.0 %
P4	10.00 s → 90.0 %	Initial threshold	80.0 %
P5	20.00 s → 90.0 %	Fallback time	1.00 s

ID	Parameter	CL	Setting range [Default]	Description
9134	**Monitoring**	2	On	Time-dependent voltage monitoring 4 is carried out according to the following parameters.
			[Off]	No monitoring is carried out.
9136	**AND character-istics**	2	On	Each phase falls below/exceeds the threshold for tripping.
			[Off]	At least one phase falls below/exceeds the threshold for tripping.
9137	**Monitoring at**	2		Selects whether the system shall do over- or undervoltage monitoring.
			[Underrun]	The undervoltage monitoring is carried out.
			Overrun	The overvoltage monitoring is carried out.
9165	**Init threshold**	2	0.0 to 200.0 % **[80.0 %]**	The time-dependent voltage monitoring initial threshold is configured here. If the measured voltage of at least one phase falls below/exceeds this threshold, the monitoring sequence starts and the voltage threshold will change in time according to the configured threshold curve points. If the measured voltage falls below/exceeds this curve, the monitoring function triggers and the configured relay will energize.

ID	Parameter	CL	Setting range [Default]	Description
9164	**Fallback time**	2	0.00 to 320.00 s **[1.00 s]**	The time-dependent voltage monitoring fallback time is configured here. If the measured voltage falls below/exceeds the configured "Fallback threshold" (parameter 9173 ↳ p. 84) for at least the time configured here, the monitoring sequence will be reset.
9173	**Fallback threshold**	2	0.0 to 200.0 % **[90.0 %]**	The time-dependent voltage monitoring fallback voltage is configured here. If the measured voltage falls below/exceeds the voltage configured here for at least the configured "Fallback time" (parameter 9164 ↳ p. 84), the monitoring sequence will be reset.
				Notes This parameter should always be configured to a value higher/lower than the "Init threshold" (parameter 9165 ↳ p. 83) for proper operation.
9157 9158 9159 9160 9161 9162 9163	**Time point {x}** [x = 1 to 7]	2	0.00 to 320.00 s 9157: **[0.00 s]** 9158: **[0.15 s]** 9159: **[1.50 s]** 9160: **[10.00 s]** 9161: **[20.00 s]** 9162: **[30.00 s]** 9163: **[40.00 s]**	The time values of time-dependent voltage monitoring time points are configured here.
9166 9167 9168 9169 9170 9171 9172	**Voltage point {x}** [x = 1 to 7]	2	0.0 to 200.0 % 9166: **[10.0 %]** 9167: **[10.0 %]** 9168: **[90.0 %]** 9169: **[90.0 %]** 9170: **[90.0 %]** 9171: **[90.0 %]** 9172: **[90.0 %]**	The voltage values of time-dependent voltage monitoring voltage points are configured here.
9135	**Relay**	2	None / Relay 1 / Relay 2 / Relay 3 / Relay 4 **[Relay 2]**	The relay configured here is activated if the respective monitoring functions triggers. If "None" is configured here, no relay is activated in this case.
				Notes Whether the relay is energized or de-energized depends on the configuration of the relay function (parameter 6920 ↳ p. 45 , 6921 ↳ p. 45, 6922 ↳ p. 45 and 6923 ↳ p. 45).

4.4 System Management

4.4.1 Factory Settings

ID	Parameter	CL	Setting range [Default]	Description
1704	**Factory default settings**	0	Yes	Enables the parameter "Reset factory default values" (parameter 1701 ➪ p. 85).
			[No]	Disables the parameter "Reset factory default values" (parameter 1701 ➪ p. 85).
1701	**Reset factory default values**	0	Yes	All parameters, which the enabled access code grants privileges to, will be restored to factory default values.
			[No]	All parameters will remain as currently configured.
				Notes The function will only be executed if parameter 1704 ➪ p. 85 is configured to “Yes”. It will reset itself automatically.

4.4.2 Password System

General notes

The controller utilizes a password protected multi-level configuration access hierarchy. This permits varying degrees of access to the parameters being granted by assigning unique passwords to designated personnel.

A distinction is made between the access levels as follows:

Code level	
Code level CL0 (User Level) Standard password = none	This code level permits for monitoring of the system. Configuration of the control is not permitted. The unit powers up in this code level.
Code level CL1 (Service Level) Standard password = "0 0 0 1"	This code level entitles the user to change selected non-critical parameters. The user may also change the password for level CL1. Access granted by this password expires two hours after the password has been entered and the user is returned to the CL0 level.

Code level	
Code level CL2 (Temporary Commissioning Level) No standard password available	This code level grants temporary access to most of the parameters. The password is calculated from the random number generated when the password is initially accessed. It is designed to grant a user one-time access to a parameter without having to give him a reusable password. The user may also change the password for level CL1. Access granted by this password expires two hours after the password has been entered and the user is returned to the CL0 level. The password for the temporary commissioning level may be obtained from the vendor.
Code level CL3 (Commissioning Level) Standard password = "0 0 0 3"	This code level grants complete and total access to most of the parameters. In addition, the user may also change the passwords for levels CL1, CL2 and CL3. Access granted by this password expires two hours after the password has been entered and the user is returned to the CL0 level.

Once the code level is entered, access to the configuration menus will be permitted for two hours or until another password is entered into the control. If a user needs to exit a code level then code level, CL0 should be entered. This will block unauthorized configuration of the control.

A user may return to CL0 by allowing the entered password to expire after two hours or by changing any one digit on the random number generated on the password screen and entering it into the unit.

4.4.3 Password Entry

ID	Parameter	CL	Setting range [Default]	Description
10418	**Password system**	4	On	The standard password system is used.
			[Off]	The password system is set permanently to code level CL5 (Supercommissioning level).
10406	**Actual code level**	---	Info **[-]**	This value displays the code level which is currently enabled for the access via ToolKit.
10401	**Password**	0	0 to 9999 **[0]**	The password to configure the device needs to be entered here.

4.4.4 Passwords

General notes

The following passwords grant varying levels of access to the parameters.

Each individual password can be used to access the appropriate configuration level through multiple access methods and communication protocols (via serial RS-232/485 interface, and via the CAN bus).

The values from parameter 10411 ⇨ p. 87 to parameter 10415 ⇨ p. 87 are not readable in ToolKit if the actual code level is lower than the parameters code level.

ID	Parameter	CL	Setting range [Default]	Description
10415	**Basic code level**	1	0 to 9999 **[-]**	The password for the code level "Service" is defined in this parameter. Refer to ⇨ *Chapter 4.4.2 "Password System" on page 85* for default values.
10414	**Temp. commissioning code level**	3	0 to 9999 **[-]**	The algorithm for calculating the password for the code level "Temporary Commissioning" is defined in this parameter.
10413	**Commissioning code level**	3	0 to 9999 **[-]**	The password for the code level "Commission" is defined in this parameter. Refer to ⇨ *Chapter 4.4.2 "Password System" on page 85* for default values.
10412	**Temp. supercomm. level code**	5	0 to 9999 **[-]**	The algorithm for calculating the password for the code level "Temporary Supercommissioning" is defined in this parameter.
10411	**Supercommissioning level code**	5	0 to 9999 **[-]**	The password for the code level "Supercommissioning" is defined in this parameter. Refer to ⇨ *Chapter 4.4.2 "Password System" on page 85* for default values.

5 Operation

The MFR 300 can be operated, monitored and configured using the following access methods:

- External access with a PC using the ToolKit configuration software.
  ↳ *Chapter 5.1.1 "Install ToolKit" on page 89*
- External command access using Modbus/CANopen
  ↳ *Chapter 7 "Interfaces And Protocols" on page 101*

5.1 Access Via PC (ToolKit)

Version

> *Woodward's ToolKit software is required to access the unit via PC*
>
> – *Required version: 5.0.2 or higher*
> – *Please use the latest available version!*
> – *For information on how to obtain the latest version see ↳ "Load from the website" on page 90.*

5.1.1 Install ToolKit

Load from CD

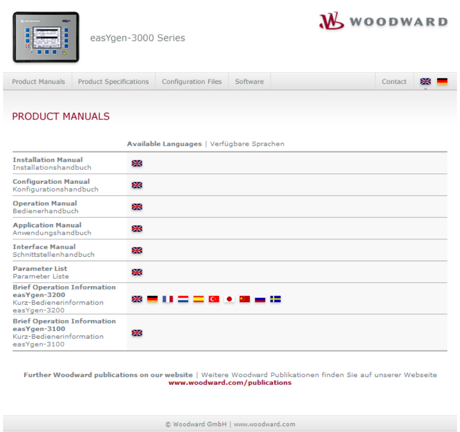


Fig. 47: Product CD - HTML menu

1. Insert the product CD (as supplied with the unit) in the CD-ROM drive of your computer.
   ⇨ The HTML menu is opened automatically in a browser.

> *The 'autostart' function of your operating system needs to be activated.*
>
> *Alternately open the document "start.html" in the root directory of the CD in a browser.*

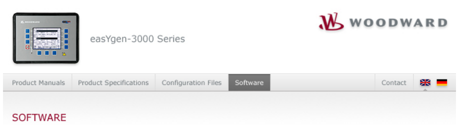


Fig. 48: HTML menu section 'Software'

2. Go to section *"Software"* and follow the instructions described there.

Load from the website

> *The latest version of the ToolKit software (5.0.2 or higher) can be obtained from our website.*
>
> *The latest version of Microsoft .NET Framework (4.6.1 or higher) can be obtained from Microsoft website.*

To get the software from the website:

1. Go to *http://www.woodward.com/software*
2. Select ToolKit in the list and click the *"Go"* button.
3. Click *"More Info"* to get further information about ToolKit.
4. Choose the preferred software version and click *"Download"*.
5. Login with your e-mail address or register first.
   ⇨ The download will start immediately.

Minimum system requirements

- Microsoft Windows® 8.1, 7, Vista (32- & 64-bit)
- Microsoft .NET Framework Ver. 4.6.1
- 1 GHz or faster x86 or x64 processor
- 512 MB of RAM
- Screen
  - Resolution: 800 by 600 pixels
  - Colors: 256
- Serial Port
- Serial Extension Cable
- (CD-ROM drive)

> *Microsoft .NET Framework must be installed on your computer to be able to install ToolKit.*
>
> - *If not already installed, Microsoft .NET Framework will be installed automatically (internet connection required).*
> - *Alternatively use the .NET Framework installer found on the Product CD.*

Installation

To install ToolKit:

- Run the self-extracting installation package and follow the on-screen steps to install.

5.1.2 Install ToolKit Configuration Files

Load from CD

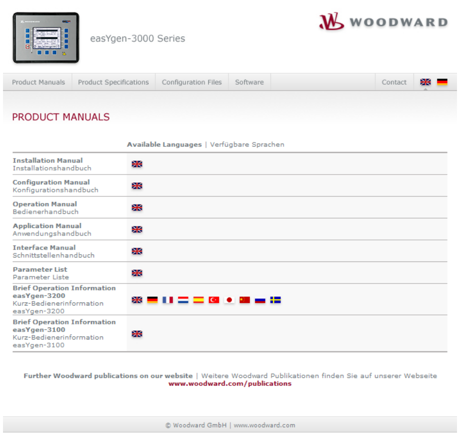


Fig. 49: Product CD - HTML menu

1. Insert the product CD (as supplied with the unit) in the CD-ROM drive of your computer.
   ⇨ The HTML menu is opened automatically in a browser.

> *The 'autostart' function of your operating system needs to be activated.*
>
> *Alternately open the document "start.html" in the root directory of the CD in a browser.*
>
> *Details of your current product CD menu may differ because of updates.*

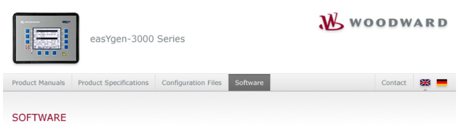


Fig. 50: HTML menu section 'Software'

2. Go to section *"Configuration Files"* and follow the instructions described there.

Load from the website

> *The latest version of the ToolKit software can be obtained from our website.*

To get the software from the website:

1. Go to *http://www.woodward.com/software/configfiles*
2. Insert the part number (P/N) and revision of your device into the corresponding fields.
3. Select "ToolKit" in the *"application type"* list.
4. Click *"Search"*.
5. Download the file displayed in the search result.
   ⇨ The file is a ZIP archive which must be extracted for use in ToolKit.

ToolKit files

*.WTOOL	
File name composition:	[P/N1][1]-[Revision]_[Language ID]_[P/N2][2]-[Revision]_[# of visualized gens].WTOOL
Example file name:	8440-1234-NEW_US_5418-1234-NEW.WTOOL
File content:	Display screens and pages for online configuration, which are associated with the respective *.SID file.

*.SID	
File name composition:	[P/N2][2]-[Revision].SID
Example file name:	5418-1234-NEW.SID
File content:	All display and configuration parameters available in ToolKit.

*.WSET	
File name composition:	[user defined].WSET
Example file name:	device_settings.WSET
File content:	Default settings of the ToolKit configuration parameters provided by the SID file or user-defined settings read from the unit.

- [1] P/N1 = Part number of the unit
- [2] P/N2 = Part number of the software in the unit

5.1.3 Configure ToolKit

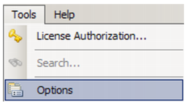


Fig. 51: Tools menu

To change ToolKit settings:

1. Select *"Tools ➔ Options"*.

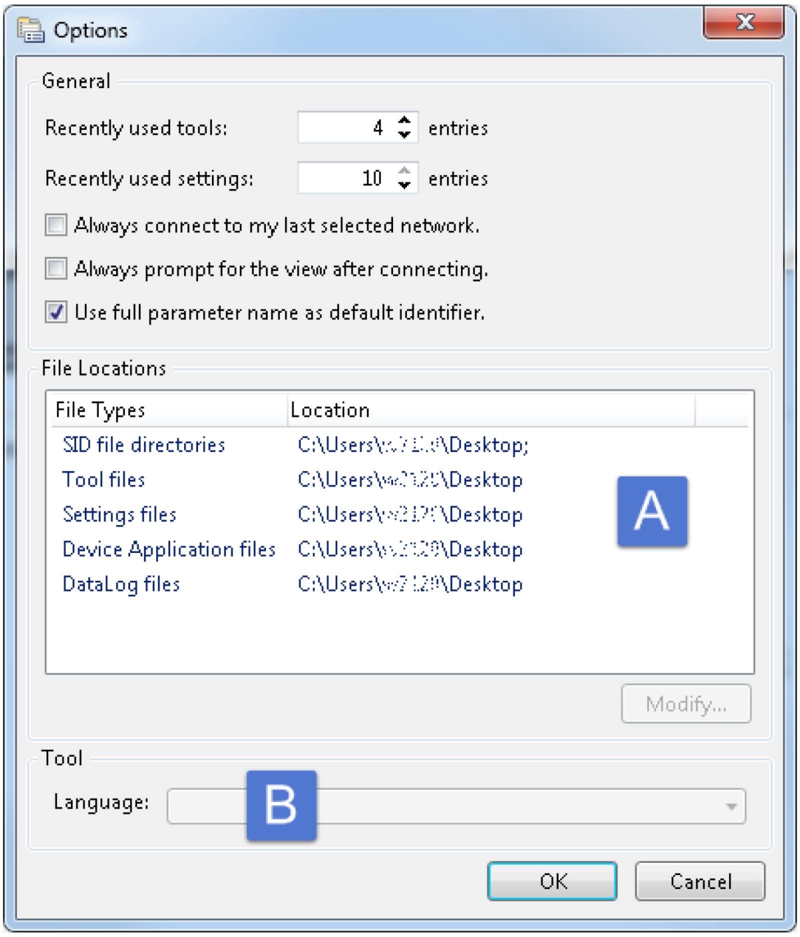


Fig. 52: ToolKit Options window

A File locations
B Language setting for tools

⇨ The *"Options"* windows is displayed.

2. Adjust settings as required.

> *For more information on the individual settings refer to the ToolKit help.*

⇨ Changes take effect after clicking *"OK"*.

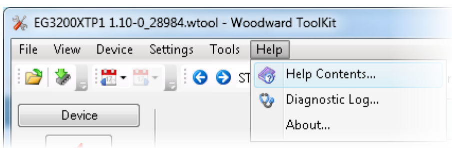


Fig. 53: Help

> *Please do not change the default installation folder! Otherwise the language selection will not work properly.*

5.1.4 Connect ToolKit

Standard connection

To connect ToolKit and the MFR unit:

1. *The USB/RS-232 serial interface is only provided via the optional Woodward DPC (direct configuration cable), which must be connected to the service port.*

   – *For additional information refer to* *Chapter 3.2.8 "Service Port" on page 37.*

   Plug the DPC cable into the service port. Use a USB cable/ null modem cable to connect the USB/RS-232 serial port of the DPC to a serial USB/COM port of the PC with.

   If the PC does not have a serial port to connect the null modem cable to, use a USB to serial adapter.

2. Open ToolKit from the Windows Start Menu path *"Programs ➔ Woodward ➔ ToolKit X.x"*.
3. From the main ToolKit window, select *"File ➔ Open Tool..."* click the *"Open Tool"* icon on the tool bar.
4. Locate and select the desired tool file (`*.WTOOL`) in the ToolKit data file directory and click *"Open"*.
5. From the main ToolKit window, click Device then click "Connect", or select the Connect icon on the toolbar.

   ⇨ The connect dialog will open if the option is enabled.

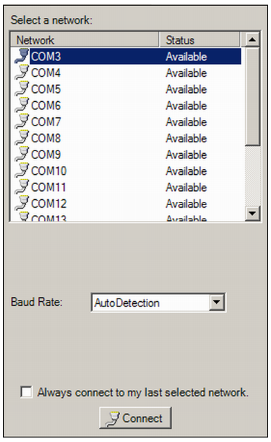


Fig. 54: Connect dialog

6. Select the COM port that is connected to the communication cable.
7. Click the *"Connect"* button.

   ⇨ The identifier of the device that ToolKit is connected to, will display in the status bar.

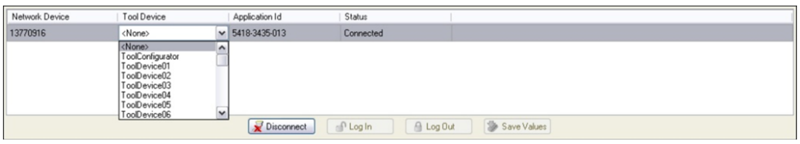


Fig. 55: Communications window

8. If the communications window opens, select *"ToolConfigurator"* from the *"Tool Device"* list and close the communications window.

   ⇨ If the device is security enabled, the login dialog will appear.

9. Enter the login data if required.

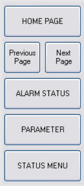
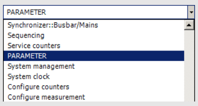
⇨ Now you are able to edit the device parameters in the main window.

> *Any changes are written automatically to the control unit's memory after pressing [Enter] to confirm them..*

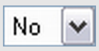
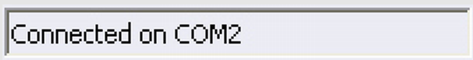
5.1.5 View And Set Values In ToolKit

Basic navigation

ToolKit offers the following graphical elements for basic navigation:

Graphical element	Caption	Description
	Navigation buttons	Select main and subordinate configura-tion pages
	Navigaton list	To directly select a configuration page based on its name
	Buttons *"Previous page"* and *"Next page"*	To go to the previous/next configuration page (as ordered in the list)

Value and status fields

Graphical element	Caption	Description
	Value field	To directly input (alpha)numeric values
	Option field	To select from a preset list of options
	Connection status field	Displays active port and unit connection status

To change the value of a value or option field:

1. Enter the value or select an option from the drop-down list.

2. Press *[Enter]* to confirm.

⇨ The new value is written directly to the unit.

Visualization

> *Values displayed by visualization graphical elements cannot be changed.*

Graphical element	Caption	Description
	Status indicator	Displays status [**on**/off]
	Error indicator	Displays error [**on**/off]

Search

To find specific parameters, settings and monitoring values more easily, ToolKit includes a full-text search function.

To find a parameter/setting/monitoring value:

1. Select *"Tools ➔ Search"* from the menu.
   ⇨ The *"Search"* dialog opens.
2. Enter a search term and press *[Enter]*.
   ⇨ The results are displayed in the table.
3. Double-click a table entry to go to the visualization/configuration page that includes this parameter/setting/monitoring value.

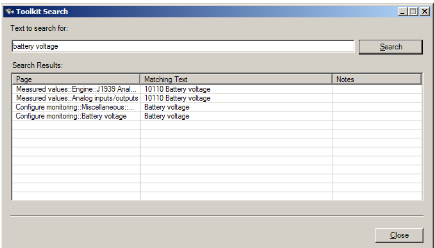


Fig. 56: Search dialog

Value trending

The value trending view can chart up to eight values over time.

To select values for trending screen:

1. Right-click an analog value field on any configuration/visualisation page and select *"Add to trend"* from the context-menu.
2. Select *"Tools ➔ Trending"* from the menu.
   ⇨ The trending screen opens.
3. Click the *"Start"* button to initiate charting.
4. Click the *"Stop"* button to stop charting the values.

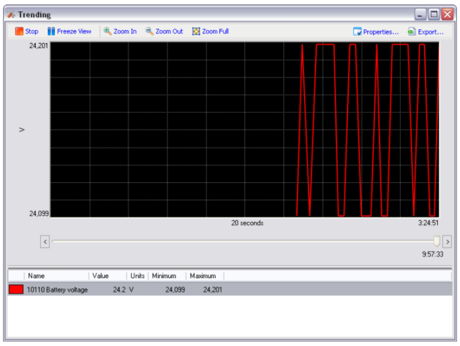
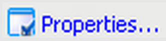


Fig. 57: Trending screen

5. To store the tracked data select *"Export"*

⇨ The tracked data is exported to a `.CSV` (comma separated values) file which can be viewed/edited/analysed in external applications (e.g. MS Excel/OpenOffice.org Calc).

Graphical element	Caption	Description
	*"Start"*	Start value charting
	*"Stop"*	Stop value charting
	Zoom controls	Adjust detail of value chart
	*"Export"*	Export to `.CSV`
	*"Properties"*	Change scale limits, sample rate, time span, colors

6 Application

6.1 General Application

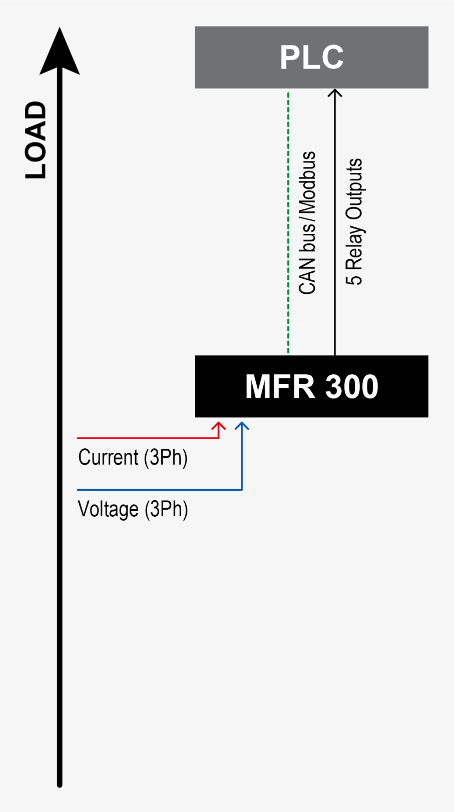


Fig. 58: General application

In this general application the device is used as a transducer with monitoring functions. The control does not operate any breaker.

- PLC measuring data V, f, I, P_{act}, P_{react}
- Monitoring V, f, I, P_{act}, P_{react}

6.2 Generator Application

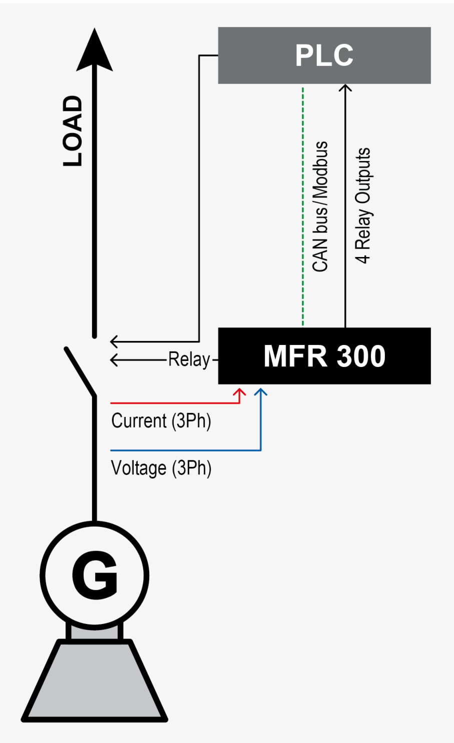


Fig. 59: Generator application

In this generator related application the device is used as a transducer with monitoring functions. The control can be used to open a breaker.

- Generator measuring data V, f, I, P_{act}, P_{react}
- Monitoring V, f, I, P_{act}, P_{react}

6.3 Mains Application

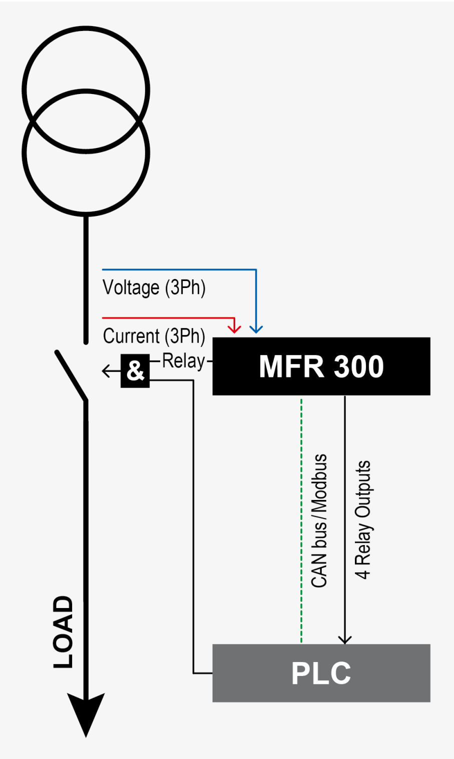


Fig. 60: Mains application

In this mains related application the device is used as a transducer with monitoring functions. The control can be used to open a breaker.

- Mains measuring data V, f, I, P_{act}, P_{react}
- Monitoring V, f, I, P_{act}, P_{react}

7 Interfaces And Protocols

7.1 Interfaces Overview

Interfaces and protocols

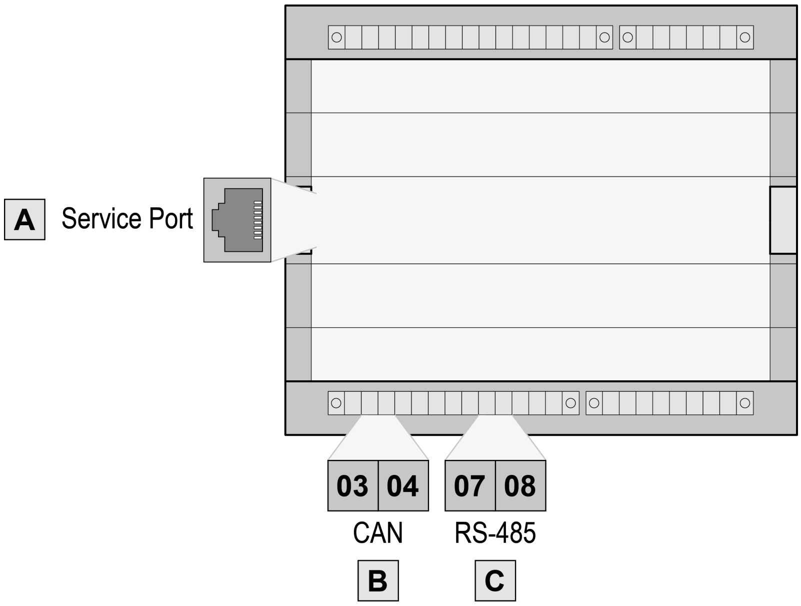


Fig. 61: MFR 300 interfaces

The MFR 300 (Fig. 61) provides the following interfaces, which are supporting different protocols.

Figure	Interface	Protocol
A	Service Port (USB/RS-232)[1]	ToolKit
B	CAN bus	CANopen
C	RS-485	Modbus

[1] Please refer to *Chapter 3.2.8 "Service Port" on page 37.*

7.2 CAN Interface

The CAN interface is a CANopen interface with 3 TPDOs (send boxes) and 1 Server SDO.

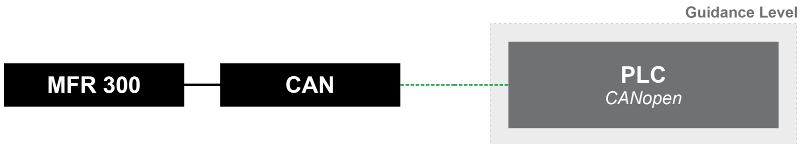


Fig. 62: CAN interface

7.3 Serial Interfaces

7.3.1 Service Port (RS-232/USB)

The Woodward specific service port can be used to extend the interfaces of the controller.

In conjunction with the direct configuration cable the service port allows service access for configuring the unit and visualize measured data.

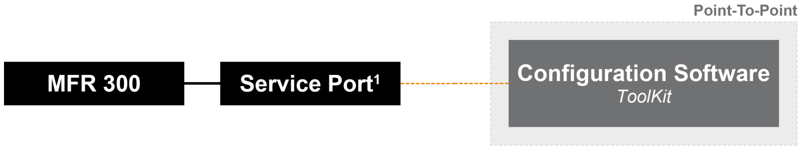


Fig. 63: Service Port

> *[1] The service port can be **only** used in combination with an optional Woodward direct configuration cable (DPC), which inclucdes a converter box to provide either an USB or a RS-232 interface.*
>
> – *For additional information refer to* *↳ Chapter 3.2.8 "Service Port" on page 37.*

7.3.2 RS-485 Interface

A freely configurable RS-485 Modbus RTU Slave interface is provided to add PLC connectivity. It is also possible to configure the unit, visualize measured data and alarm messages.

Fig. 64: RS-485 interface

7.4 CANopen Protocol

CANopen is a communication protocol and device profile specification for embedded systems used in automation. The CANopen standard consists of an addressing scheme, several small communication protocols and an application layer defined by a device profile. The communication protocols have support for network management, device monitoring and communication between nodes, including a simple transport layer for message segmentation/desegmentation.

Protocol description

If a data protocol is used, a CAN message looks like this:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
MUX	Data byte	Data byte	Data byte	Data byte	Data byte	Data byte	Internal

The MUX byte is counted up, the meaning of the data byte changes according to the value of the MUX byte.

In the protocol tables is listed which parameter at which MUX on which position is transmitted. The meaning of the parameter can be taken by means of the number of the parameter description ("CANopen Mapping parameter").

Example

MUX	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
1	144		171				Internal

In MUX 1 (byte 1 has got value 1) the value of parameter 144 is included in the byte 2 up to byte 3 (frequency). In byte 4 up to byte 7 the value of parameter 171 is included (average delta voltage). Byte 8 includes internal definitions and can be ignored.

Data format "Unsigned Integer"

UNSIGNED type data has positive integers as values. The range is between 0 and 2n-1. The data is shown by the bit sequence of length n.

- Bit sequence:
  $b = b_0$ to b_{n-1}
- Value shown:
  $UNSIGNEDn(b) = b_{n-1} * 2^{n-1} + ... + b_1 * 2^1 + b_0 * 2^0$

Please note that the bit sequence starts on the left with the least significant byte.

Example: Value 266 = 10A hex of type UNSIGNED16 is transmitted on the bus in two octets, first 0A hex and then 01 hex.

The following UNSIGNED data types are transmitted as follows:

Octet Number	1.	2.	3.	4.	5.	6.	7.	8.
UNSIGNED8	b_7 to b_0							
UNSIGNED16	b_7 to b_0	b_{15} to b_8						
UNSIGNED24	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}					
UNSIGNED32	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}				
UNSIGNED40	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}			
UNSIGNED48	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}		
UNSIGNED56	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}	b_{55} to b_{48}	
UNSIGNED64	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}	b_{55} to b_{48}	b_{63} to b_{56}

Table 15: Transfer syntax for data type UNSIGNEDn

Data format "Signed Integer"

SIGNED type data has integers as values. The range is between 0 and 2^{n-1}. The data is shown by the bit sequence of length n.

- Bit sequence:
  $b = b_0$ to b_{n-1}
- Value shown:
  $SIGNEDn(b) = b_{n-2} * 2^{n-2} + ... + b_1 * 2^1 + b_0 * 2^0$
  if $b_{n-1} = 0$
- And with two's complement:
  SIGNEDn(b) = SIGNEDn(^b)-1
  if $b_{n-1} = 1$

Please note that the bit sequence starts on the left with the least significant byte.

Example: The value -266 = FEF6 hex of type SIGNED16 is transmitted in two octets, first F6 hex and then FE hex.

Octet Number	1.	2.	3.	4.	5.	6.	7.	8.
SIGNED8	b_7 to b_0							
SIGNED16	b_7 to b_0	b_{15} to b_8						
SIGNED24	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}					
SIGNED32	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}				
SIGNED40	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}			
SIGNED48	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}		
SIGNED56	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}	b_{55} to b_{48}	
SIGNED64	b_7 to b_0	b_{15} to b_8	b_{23} to b_{16}	b_{31} to b_{24}	b_{39} to b_{32}	b_{47} to b_{40}	b_{55} to b_{48}	b_{63} to b_{56}

Table 16: Transfer syntax for data type INTEGER

7.5 Modbus Protocol

Modbus is a serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a de facto standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices. The Woodward controller supports a Modbus RTU Slave module. This means that a Master node needs to poll the controller slave node. Modbus RTU can also be multi-dropped, or in other words, multiple Slave devices can exist on one Modbus RTU network, assuming that the serial interface is a RS-485.

Detailed information about the Modbus protocol is available on the following website:

- *http://www.modbus.org/specs.php*

There are also various tools available on the internet. We recommend using ModScan32 which is a Windows application designed to operate as a Modbus Master device for accessing data points in a connected Modbus Slave device. It is designed primarily as a testing device for verification of correct protocol operation in new or existing systems.

A trial version download is available from the following website:

- http://www.win-tech.com/html/modscan32.htm

Address range

The controller Modbus Slave module distinguishes between visualization data and configuration & remote control data. The different data is accessible over a split address range and can be read via the "Read Holding Register" function.

Furthermore, controller parameters and remote control data can be written with the "Preset Single Registers" function or "Preset Multiple Registers" (Fig. 65)

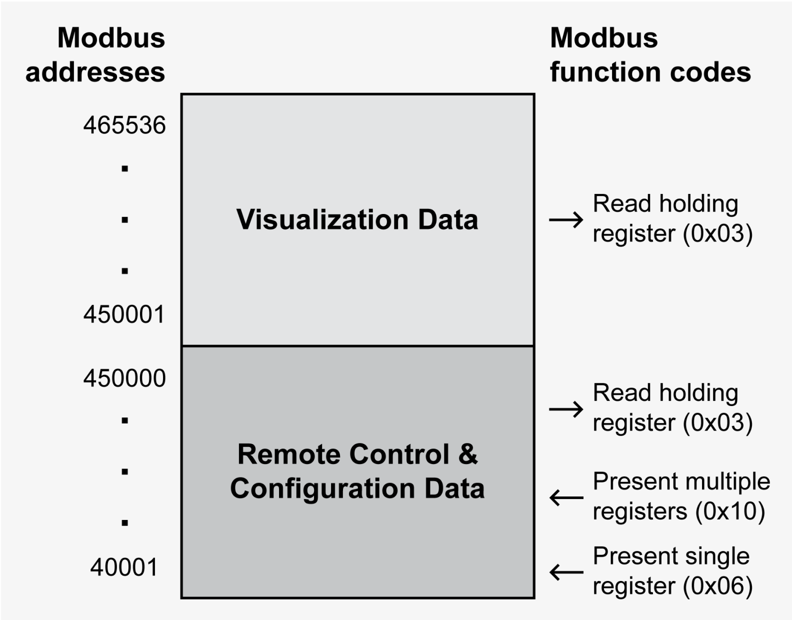


Fig. 65: Address range

All addresses in this document comply with the Modicon address convention. Some PLCs or PC programs use different address conventions depending on their implementation. Then the address must be increased and the leading 4 may be omitted.

Please refer to your PLC or program manual for more information. This determines the address sent over the bus in the Modbus telegram. The Modbus starting address 450001 of the visualization data may become bus address 50000 for example.

Visualization

The visualization over Modbus is provided in a very fast data protocol where important system data like alarm states, AC measurement data, switch states and various other informations may be polled.

According to the Modbus addressing range, the visualization protocol can be reached on addresses starting at 450001. On this address range it is possible to do block reads from 1 up to 128 Modbus registers at a time.

Modbus read addresses	Description	Multiplier	Units
450001	Protocol-ID, always 4610		--
450002	Active power phase 1	PT Primary voltage * CT primary current / 1616.58	W
....	....	.....	.....
....	....	.....	.....
....	....	.....	.....
....	....	.....	.....
450045	Monitor flags 4	--	--

Table 17: Address range block read

> *↳ "Address range block read" on page 106 is only an excerpt of the data protocol. It conforms to the data protocol 4610.*
>
> *Refer to ↳ Chapter 9.1.2.1 "Protocol 4610 (Basic Visualization)" on page 123 for the complete protocol.*

The following ModScan32 screenshot shows the configurations made to read the visualization protocol with a block read of 128 registers.

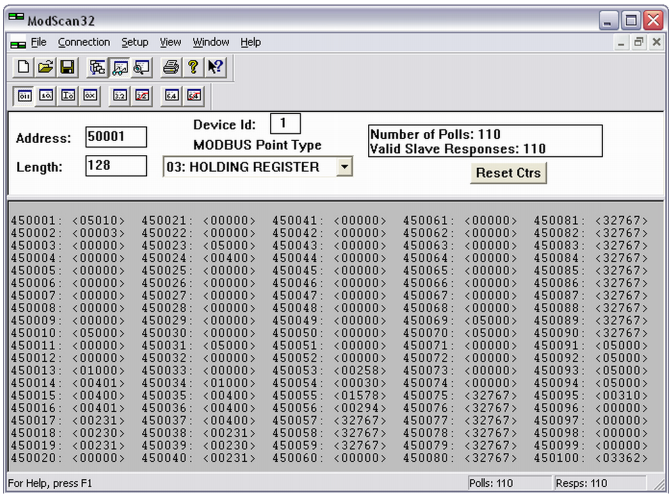


Fig. 66: Visualization configurations

Configuration

The Modbus interface can be used to read/write parameters. According the Modbus addressing range for the configuration addresses, the range starts at 40001 and ends at 450000. You can always access only one parameter of the system in this address range. The Modbus address can be calculated depending on the parameter ID as illustrated below:

	Parameter ID < 10000	Parameter ID >= 10000
Modbus address =	40000 + (Par. ID+1)	400000 + (Par. ID+1)

Table 18: Address calculation

Block reads in this address range depend on the data type of the parameter. This makes it important to set the correct length in Modbus registers which depends on the data type (UNSIGNED 8, INTEGER 16, etc.).

Refer to ↳ *“Data types” on page 107* for more information.

Types	Modbus registers
UNSIGNED 8	1
UNSIGNED 16	1
INTEGER 16	1
UNSIGNED 32	2
INTEGER 32	2
LOGMAN	7
TEXT/X	X/2

Table 19: Data types

Woodward recommends to make a break time of 10 ms after receiving the data of the last Modbus request.

8 Technical Specifications

8.1 Technical Data

Product label

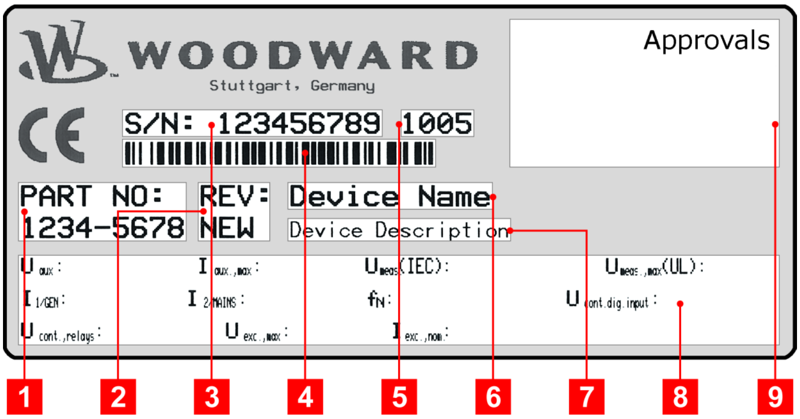


Fig. 67: Product label

1	P/N	Item number
2	REV	Item revision number
3	S/N	Serial number (numerical)
4	S/N	Serial number (barcode)
5	S/N	Date of production (year-month)
6	Type	Description (short)
7	Type	Description (long)
8	Details	Technical data
9	Approval	Approvals

8.1.1 Measuring Values

Voltages

Measuring voltage ⅄ / △	**120 V**	
Rated value (V_{rated})		69/120 Vac
Maximum value (V_{max})		max. 86/150 Vac
Rated voltage phase – ground		150 Vac
Rated surge voltage (V_{surge})		2.5 kV
Measuring voltage ⅄ / △	**690 V**	
Rated value (V_{rated})		400/690 Vac
Maximum value (V_{max})		max. 500/862 Vac
Rated value UL (V_{rated})		600/600 Vac
Rated voltage phase – ground		600 Vac
Rated surge voltage (V_{surge})		6.0 kV
Linear measuring range		1.25 × V_{rated}

Measuring frequency		50/60 Hz (45.0 to 65.0 Hz)
Accuracy		Class 0.5
Input resistance per path	**120 V**	0.522 MΩ
	690V	2.0 MΩ
Maximum power consumption per path		< 0.15 W

Currents

Measuring inputs		Isolated
Measuring current	[1] Rated value (I_{rated})	../1 A
	[5] Rated value (I_{rated})	../5 A
Accuracy	Class 0.5	
Linear measuring range		3.0 × I_{rated}
Maximum power consumption per path	< 0.15 VA	
Rated short-time current (1 s)	[1]	50.0 × I_{rated}
	[5]	10.0 × I_{rated}

8.1.2 Ambient Variables

Power supply	12/24 Vdc (8 to 32.0 Vdc)
Intrinsic consumption	max. 5 W
Degree of pollution	2
Maximum elevation	2,000 m ASL
Reverse voltage protection	Fully supply range
Input capacitance	440 uF

8.1.3 Inputs/Outputs

Discrete outputs

Discrete outputs		Potential free
Contact material		AgCdO
General purpose (GP) ($V_{cont, relays}$)	DC	2.00 Adc@24 Vdc
Pilot duty (PD) ($V_{cont, relays}$)	DC	1.00 Adc@24 Vdc

8.1.4 Interface

Service Port interface

Service Port interface	Not isolated
Proprietary interface	Connect only with Woodward DPC cable

RS-485 interface

RS-485 interface	Isolated
Insulation voltage (continuously)	100 Vac
Insulation test voltage (≤ 5 s)	1000 Vac
Version	RS-485 Standard
Operation	Half-duplex

CAN bus interface

CAN bus interface	Isolated
Insulation voltage (continuously)	100 Vac
Insulation test voltage (1 s)	500 Vac
Version	CAN bus
Internal line termination	Not available

8.1.5 Housing

Housing type

Type		Extrusion Profile UM122 Plastic - DIN rail mounting
Dimensions (W × H × D)		146 × 128 × 50 mm
Wiring	Screw-plug-terminals	2.5 mm²
Recommended locked torque	4 inch pounds / 0.5 Nm Use 60/75 °C copper wire only Use class 1 wire only or equivalent	
Weight		approx. 300 g

Protection

Protection system		IP20

8.1.6 Approvals

EMC test (CE)	Tested according to applicable EN guidelines
Listings	CE marking UL / cUL, Ordinary Locations, File No.: 231544

8.1.7 Generic Note

Accuracy	Referred to full scale value

8.2 Environmental Data

Vibration

Frequency range - sine sweep	5 Hz to 100 Hz
Acceleration	4 G
Standards	EN 60255-21-1 (EN 60068-2-6, Fc)
	Lloyd's Register, Vibration Test2
Frequency range - random	10 Hz to 500 Hz
Power intensity	0.015 G^2/Hz
RMS value	1.04 Grms
Standards	MIL-STD 810F, M514.5A, Cat.4,
	Truck/Trailer tracked-restrained
	Cargo, Fig. 514.5-C1

Shock

Shock	40 G, Saw tooth pulse, 11 ms
Standards	EN 60255-21-2
	MIL-STD 810F, M516.5, Procedure 1

Temperature

Cold, Dry Heat (storage)	-40 °C (-40 °F) / 85 °C (185 °F)
Cold, Dry Heat (operating)	-20 °C (-4 °F) / 70 °C (158 °F)
Standards	IEC 60068-2-2, Test Bb and Bd
	IEC 60068-2-1, Test Ab and Ad

Humidity

Humidity	95 %, not condensing
Standards	IEC 60068-2-30, Test Db

8.3 Accuracy

Measuring value	Range	Accuracy	Measuring start	Notes
Frequency	40.0 to 80.0 Hz	0.1 % (of 80 Hz)	5 % (of PT secondary voltage setting)[1]	
Voltage				
Wye generator / mains / busbar	0 to 650 kV	0.5 % (of 150/600 V)[2]	1.5 % (of PT secondary voltage setting)[1]	
Delta generator / mains / busbar			2 % (of PT secondary voltage setting)[1]	

Measuring value	Range	Accuracy	Measuring start	Notes
Current				
Generator	0 to 32,000 A	0.5 % (of 1.3/6.5 A)[3]	1 % (of 1.3/6.5 A)[3]	
Max. value				
Mains/ground current				
Real power				
Actual total real power value	-2 to 2 GW	1 % (of 150/600 V * 1.3/6.5 A)[2/3]	Measuring starts when voltage is recognized	
Reactive power				
Actual value in L1, L2, L3	-2 to 2 Gvar	1 % (of 150/600 V * 1.3/6.5 A)[2/3]	Measuring starts when voltage is recognized	
Power factor				
Actual value power factor L1	lagging 0.00 to 1.00 to leading 0.00	2 %	2 % (of 1.3/6.5 A)[3]	1.00 is calculated for measuring values below the measuring start
Miscellaneous				
Real energy	0 to 42,000 GWh			Not calibrated
Reactive energy	0 to 42,000 Gvarh			Not calibrated
Phase angle	-180 to 180°		2.00 % (of PT secondary volt. setting)	180° is displayed for measuring values below measuring start

[1] Setting of the parameter for the PT secondary rated voltage

[2] Depending on the used measuring inputs (120/690 V)

[3] Depending on the CT input hardware (1/5 A) of the respective unit

Reference conditions

The reference conditions for measuring the accuracy are listed below.

Input voltage	Sinusoidal rated voltage
Input current	Sinusoidal rated current
Frequency	Rated frequency +/- 2 %

Power supply	Rated voltage +/- 2 %
Power factor (cos φ)	1.00
Ambient temperature	23 °C +/- 2 K
Warm-up period	20 minutes

9 Appendix

9.1 Data Protocols

9.1.1 CANopen

9.1.1.1 Introduction

General notes

The multifunction relay transmits measuring data via CAN interface. The protocol utilized is CANopen.

PDOs

The measuring data is transmitted via synchronized PDOs. A SYNC message can be sent by the CANopen Master every 500 µsec, upon which the measuring transducer sends the synchronized PDOs back within a defined time window. A multiple of the SYNC pulse is adjustable for each PDO, i.e. for which SYNC message a reply is expected. There are three PDOs in all. These PDOs are multiplexed.

The PDOs are assigned as follows:

- *PDO 1 - ➪ Chapter 9.1.1.3 "Protocol 4600 (Unformatted Data)" on page 120*
- *PDO 2 - Reserved for future enhancements*
- *PDO 3 - ➪ Chapter 9.1.1.2 "Protocol 4500 (Formatted Data)" on page 116*

Power factor scaling

The power factor is transmitted in the PDOs with a value range between -999 and 1000, where a value of -999 corresponds with a power factor of 0.999 leading, a value of 999 corresponds with a power factor of 0.999 lagging, and a value of 1000 corresponds with a power factor of 1.0.

Examples:

- *-850 corresponds with 0.85 leading*
- *900 corresponds with 0.90 lagging*

SDOs

The configuration and resetting of counters is performed via SDOs. The CAN ID of the receive SDO is 0x600 + "Node-ID". The CAN ID of the response SDO is 0x5800 + "Node-ID". Here, "Node ID" is the value of the respective parameter 1702 ➪ p. 48 (Device number/Node-ID).

If the SDOs are addressed via CAN interface. An offset of 2000 hex (8192 decimal) must be added to the parameter ID.

Example

If parameter "Phase rotation" (parameter 3954 ➪ p. 43) is accessed using a CANopen SDO, the number "8192" must added to the parameter ID "3954".

3954 + 8192 = 12146

Do not configure the "Baudrate" (parameter 3156 ⇨ p. 48) via CANopen to avoid communication problems. However, if the baud rate has to be configured via the CAN interface, the configuring CAN Master must change it's baud rate to be able to reconnect.

Heartbeat message

A heartbeat message will be sent cyclically. This is all 240 msec by default. The CAN ID of the heartbeat message is 0x700 + "Node-ID". Here, "Node-ID" is the value of the respective parameter 1702 ⇨ p. 48 (Device number/Node-ID).

9.1.1.2 Protocol 4500 (Formatted Data)

This protocol is transmitted on CANopen interface PDO 3.

A factor of 10 for the SYNC object is set by default here. This means that this PDO is sent back upon each tenth SYNC pulse. The messages of Mux = 0 to Mux = 26 are sent cyclically.

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
0	1,2		Protocol-ID, always 4500		--
0	3,4,5,6	170	Average wye voltage	0.1	V
1	1,2	144	Frequency	0.01	Hz
1	3,4,5,6	171	Average delta voltage	0.1	V
2	1,2	162	Angle wye voltage L1-L2	0.1	°
2	3,4,5,6	135	Total power	1	W
3	1,2	163	Angle wye voltage L2-L3	0.1	°
3	3,4,5,6	136	Total reactive power	1	var
4	1,2	164	Angle wye voltage L3-L1	0.1	°
4	3,4,5,6	137	Total apparent power	1	VA
5	1,2	139	Power factor L1	0.001	
5	3,4,5,6	108	Voltage L1-L2	0.1	V
6	1,2	203	Power factor L2	0.001	

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
6	3,4,5,6	109	Voltage L2-L3	0.1	V
7	1,2	204	Power factor L3	0.001	
7	3,4,5,6	110	Voltage L3-L1	0.1	V
8	1,2	10107	Digital outputs and LEDs		
			Relay 1	Mask: 8000h	Bit
			Relay 2	Mask: 4000h	Bit
			Relay 3	Mask: 2000h	Bit
			Relay 4	Mask: 1000h	Bit
			Relay 5	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
			internal	Mask: 0200h	Bit
			internal	Mask: 0100h	Bit
			internal	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
			internal	Mask: 0020h	Bit
			internal	Mask: 0010h	Bit
			internal	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			LED 2	Mask: 0002h	Bit
			LED 1	Mask: 0001h	Bit
8	3,4,5,6	114	Voltage L1-N	0.1	V
9	1,2	1912	Overfrequency 1 triggered	Mask: 8000h	Bit
		1913	Overfrequency. 2 triggered	Mask: 4000h	Bit
		1962	Underfrequency 1 triggered	Mask: 2000h	Bit
		1963	Underfrequency 2 triggered	Mask: 1000h	Bit
		2012	Overvoltage 1 triggered	Mask: 0800h	Bit
		2013	Overvoltage 2 triggered	Mask: 0400h	Bit
		2062	Undervoltage 1 triggered	Mask: 0200h	Bit
		2063	Undervoltage 2 triggered	Mask: 0100h	Bit
		2218	Overcurrent 1 triggered	Mask: 0080h	Bit
		2219	Overcurrent 2 triggered	Mask: 0040h	Bit
		2220	Overcurrent 3 triggered	Mask: 0020h	Bit
		2262	Negative load 1 triggered	Mask: 0010h	Bit
		2263	Negative load 2 triggered	Mask: 0008h	Bit
		2314	Positive load 1 triggered	Mask: 0004h	Bit

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
		2315	Positive load 2 triggered	Mask: 0002h	Bit
			internal	Mask: 0001h	Bit
9	3,4,5,6	115	Voltage L2-N	0.1	V
10	1,2	2412	Unbalanced load 1 triggered	Mask: 8000h	Bit
		2413	Unbalanced load 2 triggered	Mask: 4000h	Bit
		3907	Voltage asymmetry 1 triggered	Mask: 2000h	Bit
		3263	Ground fault 1 triggered	Mask: 1000h	Bit
		3264	Ground fault 2 triggered	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
			internal	Mask: 0200h	Bit
			internal	Mask: 0100h	Bit
			internal	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
			internal	Mask: 0020h	Bit
			internal	Mask: 0010h	Bit
			internal	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			internal	Mask: 0002h	Bit
			internal	Mask: 0001h	Bit
10	3,4,5,6	116	Voltage L3-N	0.1	V
11	1,2		internal	Mask: 8000h	Bit
			internal	Mask: 4000h	Bit
			internal	Mask: 2000h	Bit
			internal	Mask: 1000h	Bit
			internal	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
			internal	Mask: 0200h	Bit
			internal	Mask: 0100h	Bit
		3057	Phase shift triggered	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
		3288	QV monitoring 1 triggered	Mask: 0020h	Bit
		3289	QV monitoring 2 triggered	Mask: 0010h	Bit
		3936	Voltage asymmetry 2 triggered	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			internal	Mask: 0002h	Bit

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	**Data byte**				
			internal	Mask: 0001h	Bit
11	3,4,5,6	111	Current L1	0.001	A
12	1,2		internal	Mask: 8000h	Bit
			internal	Mask: 4000h	Bit
			internal	Mask: 2000h	Bit
			internal	Mask: 1000h	Bit
			internal	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
		9138	Time-dependent voltage monitoring 3 triggered	Mask: 0200h	Bit
		9139	Time-dependent voltage monitoring 4 triggered	Mask: 0100h	Bit
		3106	df/dt (ROCOF) triggered	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
		4958	Time-dependent voltage monitoring 1 triggered	Mask: 0020h	Bit
		4959	Time-dependent voltage monitoring 2 triggered	Mask: 0010h	Bit
		8834	Voltage increase monitoring triggered	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			Status voltage CW	Mask: 0002h	Bit
			Status voltage CCW	Mask: 0001h	Bit
12	3,4,5,6	112	Current L2	0.001	A
13	1,2	160	Power factor	0.001	
13	3,4,5,6	113	Current L3	0.001	A
14	1,2	8850	Voltage increase monitoring value	0.001	%
14	3,4,5,6	2520	Positive energy	0.1	MWh
15	1,2		reserved		
15	3,4,5,6	2524	Negative energy	0.1	MWh
16	1,2		reserved		
16	3,4,5,6	2522	Positive reactive energy	0.1	Mvarh
17	1,2		reserved		
17	3,4,5,6	2526	Negative reactive energy	0.1	Mvarh
18	1,2		reserved		
18	3,4,5,6	125	Power L1	1	W
19	1,2		reserved		
19	3,4,5,6	126	Power L2	1	W
20	1,2		reserved		
20	3,4,5,6	127	Power L3	1	W

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
21	1,2		reserved		
21	3,4,5,6	128	Reactive power L1	1	var
22	1,2		reserved		
22	3,4,5,6	129	Reactive power L2	1	var
23	1,2		reserved		
23	3,4,5,6	130	Reactive power L3	1	var
24	1,2		reserved		
24	3,4,5,6	131	Apparent power L1	1	VA
25	1,2		reserved		
25	3,4,5,6	132	Apparent power L2	1	VA
26	1,2		reserved		
26	3,4,5,6	133	Apparent power L3	1	VA

9.1.1.3 Protocol 4600 (Unformatted Data)

This protocol is transmitted on CANopen interface PDO 1.

By default, this PDO is sent back upon each SYNC pulse.

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
0	1,2		Protocol-ID, always 4600		--
0	3,4		Total active power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	W

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
0	5,6		Total reactive power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the reactive power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	var
1	1,2		Voltage L1-L2 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
1	3,4		Voltage L2-L3 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
1	5,6		Voltage L3-L1 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
2	1,2		Current L1 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A
2	3,4		Current L2 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A
2	5,6		Current L3 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A
3	1,2		Frequency	0.01	Hz
3	3,4		Power factor	0.001	
3	5,6	1912	Overfrequency 1 triggered	Mask: 8000h	Bit
		1913	Overfrequency. 2 triggered	Mask: 4000h	Bit
		1962	Underfrequency 1 triggered	Mask: 2000h	Bit
		1963	Underfrequency 2 triggered	Mask: 1000h	Bit
		2012	Overvoltage 1 triggered	Mask: 0800h	Bit
		2013	Overvoltage 2 triggered	Mask: 0400h	Bit
		2062	Undervoltage 1 triggered	Mask: 0200h	Bit
		2063	Undervoltage 2 triggered	Mask: 0100h	Bit
		2218	Overcurrent 1 triggered	Mask: 0080h	Bit
		2219	Overcurrent 2 triggered	Mask: 0040h	Bit
		2220	Overcurrent 3 triggered	Mask: 0020h	Bit
		2262	Negative load 1 triggered	Mask: 0010h	Bit

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
		2263	Negative load 2 triggered	Mask: 0008h	Bit
		2314	Positive load 1 triggered	Mask: 0004h	Bit
		2315	Positive load 2 triggered	Mask: 0002h	Bit
			internal	Mask: 0001h	Bit
4	1,2	2412	Unbalanced load 1 triggered	Mask: 8000h	Bit
		2413	Unbalanced load 2 triggered	Mask: 4000h	Bit
		3907	Voltage asymmetry 1 triggered	Mask: 2000h	Bit
		3263	Ground fault 1 triggered	Mask: 1000h	Bit
		3264	Ground fault 2 triggered	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
			internal	Mask: 0200h	Bit
			internal	Mask: 0100h	Bit
			internal	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
			internal	Mask: 0020h	Bit
			internal	Mask: 0010h	Bit
			internal	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			internal	Mask: 0002h	Bit
			internal	Mask: 0001h	Bit
4	3,4		internal	Mask: 8000h	Bit
			internal	Mask: 4000h	Bit
			internal	Mask: 2000h	Bit
			internal	Mask: 1000h	Bit
			internal	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
			internal	Mask: 0200h	Bit
			internal	Mask: 0100h	Bit
		3057	Phase shift triggered	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
		3288	QV monitoring 1 triggered	Mask: 0020h	Bit
		3289	QV monitoring 2 triggered	Mask: 0010h	Bit
		3936	Voltage asymmetry 2 triggered	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			internal	Mask: 0002h	Bit

CAN		Parameter ID	Description	Multiplier	Units
Data byte 0 (Mux)	Data byte				
			internal	Mask: 0001h	Bit
4	5,6		internal	Mask: 8000h	Bit
			internal	Mask: 4000h	Bit
			internal	Mask: 2000h	Bit
			internal	Mask: 1000h	Bit
			internal	Mask: 0800h	Bit
			internal	Mask: 0400h	Bit
		9138	Time-dependent voltage monitoring 3 triggered	Mask: 0200h	Bit
		9139	Time-dependent voltage monitoring 4 triggered	Mask: 0100h	Bit
		3106	df/dt (ROCOF) triggered	Mask: 0080h	Bit
			internal	Mask: 0040h	Bit
		4958	Time-dependent voltage monitoring 1 triggered	Mask: 0020h	Bit
		4959	Time-dependent voltage monitoring 2 triggered	Mask: 0010h	Bit
			internal	Mask: 0008h	Bit
			internal	Mask: 0004h	Bit
			Status voltage CW	Mask: 0002h	Bit
			Status voltage CCW	Mask: 0001h	Bit

9.1.2 Modbus

9.1.2.1 Protocol 4610 (Basic Visualization)

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
50001	50000		Protocoll-ID, always 4610		--
50002	50001		Active power phase 1 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	W
50003	50002		Active power phase 2 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	W

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
50004	50003		Active power phase 3 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	W
50005	50004		Reactive power phase 1 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	var
50006	50005		Reactive power phase 2 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	var
50007	50006		Reactive power phase 3 This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	var
50008	50007		Frequency	0.01	Hz
50009	50008		Power factor 1000: pure leading. Positive values: lagging, Negative values: leading.	0.001	--
50010	50009		Voltage L1-L2 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50011	50010		Voltage L2-L3 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50012	50011		Voltage L3-L1 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50013	50012		Current L1 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A
50014	50013		Current L2 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
50015	50014		Current L3 This value is calculated new after every voltage cycle. It is not filtered.	CT primary current / 5000	A
50016	50015	2520	Positive energy (32 bit value; 50015 & 50016)	0.1	MWh
50017	50016		reserved		
50018	50017		reserved		
50019	50018	2524	Negative energy (32 bit value; 50018 & 50019)	0.1	MWh
50020	50019		reserved		
50021	50020		reserved		
50022	50021	2522	Positive reactive energy (32 bit value; 50021 & 50022)	0.1	Mvarh
50023	50022		reserved		
50024	50023		reserved		
50025	50024	2526	Negative reactive energy (32 bit value; 50024 & 50025)	0.1	Mvarh
50026	50025		reserved		
50027	50026		reserved		
50028	50027		Voltage L1-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50029	50028		Voltage L2-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50030	50029		Voltage L3-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary voltage / 4000	V
50031	50030		Total active power This value is the sum of the active power in all phases. It is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	W
50032	50031		Total reactive power This value is the sum of the active power in all phases. It is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the value has to be considered as zero. This is a two's complement value and may be positive or negative.	PT Primary voltage * CT primary current / 1616.58	var

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
50033	50032		Total apparent power This value is the sum of the apparent power in all phases. It is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the value has to be considered as zero.	PT Primary voltage * CT primary current / 1616.58	VA
50034	50033	162	Angle between L1-N and L2-N	0.1	°
50035	50034	163	Angle between L2-N and L3-N	0.1	°
50036	50035	164	Angle between L3-N and L1-N	0.1	°
50037	50036	139	Power factor Phase 1 1000: pure leading. Positive values: lagging, Negative values: leading	1	--
50038	50037	203	Power factor Phase 2 1000: pure leading. Positive values: lagging, Negative values: leading	1	--
50039	50038	204	Power factor Phase 3 1000: pure leading. Positive values: lagging, Negative values: leading	1	--
50040	50039	10107	State Digital outputs and LEDs		
			Relay 1 active	Mask: 8000h	
			Relay 2 active	Mask: 4000h	
			Relay 3 active	Mask: 2000h	
			Relay 4 active	Mask: 1000h	
			Relay 5 active	Mask: 0800h	
			internal	Mask: 0400h	
			internal	Mask: 0200h	
			internal	Mask: 0100h	
			internal	Mask: 0080h	
			internal	Mask: 0040h	
			internal	Mask: 0020h	
			internal	Mask: 0010h	
			internal	Mask: 0008h	
			internal	Mask: 0004h	
			LED 2 active	Mask: 0002h	
			LED 1 active	Mask: 0001h	
50041	50040		reserved		
50042	50041	10134	Monitor flags 1		
			Overfreq. 1 triggered	Mask: 8000h	

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
			Overfreq. 2 triggered	Mask: 4000h	
			Underfreq. 1 triggered	Mask: 2000h	
			Underfreq. 2 triggered	Mask: 1000h	
			Overvolt. 1 triggered	Mask: 0800h	
			Overvolt. 2 triggered	Mask: 0400h	
			Undervolt. 1 triggered	Mask: 0200h	
			Undervolt. 2 triggered	Mask: 0100h	
			Overcurrent 1 triggered	Mask: 0080h	
			Overcurrent 2 triggered	Mask: 0040h	
			Overcurrent 3 triggered	Mask: 0020h	
			Negative load 1 triggered	Mask: 0010h	
			Negative load 2 triggered	Mask: 0008h	
			Positive load 1 triggered	Mask: 0004h	
			Positive load 2 triggered	Mask: 0002h	
			internal	Mask: 0001h	
50043	50042	10138	Monitor flags 2		
			Unbalanced load 1 triggered	Mask: 8000h	
			Unbalanced load 2 triggered	Mask: 4000h	
			Voltage asymmetry 1 triggered	Mask: 2000h	
			Ground fault 1 triggered	Mask: 1000h	
			Ground fault 2 triggered	Mask: 0800h	
			internal	Mask: 0400h	
			internal	Mask: 0200h	
			internal	Mask: 0100h	
			internal	Mask: 0080h	
			internal	Mask: 0040h	
			internal	Mask: 0020h	
			internal	Mask: 0010h	
			internal	Mask: 0008h	
			internal	Mask: 0004h	
			internal	Mask: 0002h	
			internal	Mask: 0001h	
50044	50043	10135	Monitor flags 3		
			internal	Mask: 8000h	
			internal	Mask: 4000h	

Modbus		Param-eter ID	Description	Multiplier	Units
Modicon start addr.	Start addr. (*1)				
			internal	Mask: 2000h	
			internal	Mask: 1000h	
			internal	Mask: 0800h	
			internal	Mask: 0400h	
			internal	Mask: 0200h	
			internal	Mask: 0100h	
			Phase shift triggered	Mask: 0080h	
			internal	Mask: 0040h	
			QV monitoring 1 triggered	Mask: 0020h	
			QV monitoring 2 triggered	Mask: 0010h	
			Voltage asymmetry 2 triggered	Mask: 0008h	
			internal	Mask: 0004h	
			internal	Mask: 0002h	
			internal	Mask: 0001h	
50045	50044	10126	Monitor flags 4		
			internal	Mask: 8000h	
			internal	Mask: 4000h	
			internal	Mask: 2000h	
			internal	Mask: 1000h	
			internal	Mask: 0800h	
			internal	Mask: 0400h	
			Time-dependent voltage monitoring 3 triggered	Mask: 0200h	
			Time-dependent voltage monitoring 4 triggered	Mask: 0100h	
			df/dt (ROCOF) triggered	Mask: 0080h	
			internal	Mask: 0040h	
			Time-dependent voltage monitoring 1 triggered	Mask: 0020h	
			Time-dependent voltage monitoring 2 triggered	Mask: 0010h	
			Voltage increase monitoring triggered	Mask: 0008h	
			internal	Mask: 0004h	
			Voltage turns CW	Mask: 0002h	
			Voltage turns CCW	Mask: 0001h	

9.2 Options

9.2.1 MFR 300 Profibus/CAN Coupler (Option K28)

General notes

To establish an easy conversion from CAN bus to Profibus via an external converter, a special data protocol was implemented.

The MFR 300 Profibus/CAN Coupler (Option K28) controllers have some additional features compared to the standard MFR 300 controllers. The differences are listed below.

- The CAN protocols (↪ *Chapter 9.1.1.2 "Protocol 4500 (Formatted Data)" on page 116* and ↪ *Chapter 9.1.1.3 "Protocol 4600 (Unformatted Data)" on page 120*) are no longer supported.
- The protocols are replaced by 20 cyclical CAN messages on the CAN IDs 385 to 404 (↪ *Chapter 9.2.1.2 "Data Protocol 4650 (Profibus)" on page 129*).
- Some parameter default values are different compared to the standard MFR 300 (↪ *Chapter 9.2.1.4 "Parameter Default Values" on page 134*).

This CAN arrangement was developed for every CAN layer 2 converter, but was especially tested with Helmholz DP/CAN Coupler (Profibus DP to CAN-Bus Coupler - 700-651-CAN01). The following descriptions relate to the Helmholz DP/CAN Coupler.

The CAN default settings of the MFR 300 Profibus/CAN Coupler (Option K28) are already adapted to the Helmholz converter.

9.2.1.1 Data Mapping

General notes

Fig. 68 shows an application example which can be implemented with an MFR 300 Profibus/CAN Coupler (Option K28).

Fig. 68: Application example

The MFR 300 sends out the data on 20 different IDs. Each ID contains 8 byte data and has a cycle time of 100 ms.

9.2.1.2 Data Protocol 4650 (Profibus)

General notes

The content of the CAN messages is described in the following table. This data will be mirrored on the Profibus memory space by the Helmholz DP/CAN Coupler.

Offset in Profibus (bytes)	Data type	Description	Multiplier	Units
0	Uint16	Protocol-ID, always 4650		–
2	Uint16	Voltage L1-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1% of the PT primary voltage (delta) have to be considered as zero.	PT Primary Voltage (delta) / 4000	V

Offset in Profibus (bytes)	Data type	Description	Multiplier	Units
4	Uint16	Voltage L2-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1% of the PT primary voltage (delta) have to be considered as zero.	PT Primary Voltage (delta) / 4000	V
6	Uint16	Voltage L3-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1% of the PT primary voltage (delta) have to be considered as zero.	PT Primary Voltage (delta) / 4000	V
8	Int16	Total Power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage (delta) is lower than 1.5% of the PT primary voltage, the power value has to be considered as zero.	PT Primary Voltage * CT primary / 1616.58	W
10	Int16	Total Reactive Power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage (delta) is lower than 1.5% of the PT primary voltage, the reactive power value has to be considered as zero.	PT Primary Voltage * CT primary / 1616.58	var
12	Uint16	Voltage L1-L2 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary Voltage / 4000	V
14	Uint16	Voltage L2-L3 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary Voltage / 4000	V
16	Uint16	Voltage L3-L1 This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	PT Primary Voltage / 4000	V
18	Uint16	Current L1 This value is calculated new after every voltage cycle. It is not filtered.	CT primary Current / 5000	A
20	Uint16	Current L2 This value is calculated new after every voltage cycle. It is not filtered.	CT primary Current / 5000	A
22	Uint16	Current L3 This value is calculated new after every voltage cycle. It is not filtered.	CT primary Current / 5000	A
24	Int16	Angle Wye Voltage L1-L2	0.1	°
26	Int16	Angle Wye Voltage L2-L3	0.1	°
28	Int16	Angle Wye Voltage L3-L1	0.1	°
30	Int16	Total Power Factor - Positive: lagging; Negative: leading	0.001	
32	Int16	Power Factor L1 - Positive: lagging; Negative: leading	0.001	
34	Int16	Power Factor L2 - Positive: lagging; Negative: leading	0.001	
36	Int16	Power Factor L3 - Positive: lagging; Negative: leading	0.001	
38	Int16	Frequency	0.01	Hz
40	Uint16	Overfreq. 1 latched	Mask: 8000h	Bit

Offset in Profibus (bytes)	Data type	Description	Multiplier	Units
		Overfreq. 2 latched	Mask: 4000h	Bit
		Underfreq. 1 latched	Mask: 2000h	Bit
		Underfreq. 2 latched	Mask: 1000h	Bit
		Overvolt. 1 latched	Mask: 0800h	Bit
		Overvolt. 2 latched	Mask: 0400h	Bit
		Undervolt. 1 latched	Mask: 0200h	Bit
		Undervolt. 2 latched	Mask: 0100h	Bit
		Overcurrent 1 latched	Mask: 0080h	Bit
		Overcurrent 2 latched	Mask: 0040h	Bit
		Overcurrent 3 latched	Mask: 0020h	Bit
		Negative load 1 latched	Mask: 0010h	Bit
		Negative load 2 latched	Mask: 0008h	Bit
		Positive load 1 latched	Mask: 0004h	Bit
		Positive load 2 latched	Mask: 0002h	Bit
		reserved	Mask: 0001h	Bit
42	Uint16	Unbalanced Load 1 latched	Mask: 8000h	Bit
		Unbalanced Load 2 latched	Mask: 4000h	Bit
		Voltage asymmetry 1 latched	Mask: 2000h	Bit
		Ground fault 1 latched	Mask: 1000h	Bit
		Ground fault 2 latched	Mask: 0800h	Bit
		reserved	Mask: 0400h	Bit
		reserved	Mask: 0200h	Bit
		reserved	Mask: 0100h	Bit
		reserved	Mask: 0080h	Bit
		reserved	Mask: 0040h	Bit
		reserved	Mask: 0020h	Bit
		reserved	Mask: 0010h	Bit
		reserved	Mask: 0008h	Bit
		reserved	Mask: 0004h	Bit
		reserved	Mask: 0002h	Bit
		reserved	Mask: 0001h	Bit
44	Uint16	reserved	Mask: 8000h	Bit
		reserved	Mask: 4000h	Bit
		reserved	Mask: 2000h	Bit
		reserved	Mask: 1000h	Bit
		reserved	Mask: 0800h	Bit

Offset in Profibus (bytes)	Data type	Description	Multiplier	Units
		reserved	Mask: 0400h	Bit
		reserved	Mask: 0200h	Bit
		reserved	Mask: 0100h	Bit
		Phase-Shift latched	Mask: 0080h	Bit
		reserved	Mask: 0040h	Bit
		QV monitoring step 1 latched	Mask: 0020h	Bit
		QV monitoring step 2 latched	Mask: 0010h	Bit
		Voltage asymmetry 2 latched	Mask: 0008h	Bit
		reserved	Mask: 0004h	Bit
		reserved	Mask: 0002h	Bit
		reserved	Mask: 0001h	Bit
46	Uint16	reserved	Mask: 8000h	Bit
		reserved	Mask: 4000h	Bit
		reserved	Mask: 2000h	Bit
		reserved	Mask: 1000h	Bit
		reserved	Mask: 0800h	Bit
		reserved	Mask: 0400h	Bit
		Time dependent voltage 3 latched	Mask: 0200h	Bit
		Time dependent voltage 4 latched	Mask: 0100h	Bit
		reserved	Mask: 0080h	Bit
		reserved	Mask: 0040h	Bit
		Time dependent voltage 1 latched	Mask: 0020h	Bit
		Time dependent voltage 2 latched	Mask: 0010h	Bit
		Voltage increase latched	Mask: 0008h	Bit
		reserved	Mask: 0004h	Bit
		Status voltage system turns CW	Mask: 0002h	Bit
		Status voltage system turns CCW	Mask: 0001h	Bit
48	Int32	Average Wye-Voltage	0.1	V
52	Int32	Average Delta-Voltage	0.1	V
56	Int32	Total Power	1	W
60	Int32	Total Reactive Power	1	var
64	Int32	Total Apparent Power	1	VA
68	Int32	Voltage L1-L2	0.1	V
72	Int32	Voltage L2-L3	0.1	V
76	Int32	Voltage L3-L1	0.1	V
80	Int32	Voltage L1-N	0.1	V

Offset in Profibus (bytes)	Data type	Description	Multiplier	Units
84	Int32	Voltage L2-N	0.1	V
88	Int32	Voltage L3-N	0.1	V
92	Int32	Current L1	0.001	A
96	Int32	Current L2	0.001	A
100	Int32	Current L3	0.001	A
104	Int32	Positive Energy	0.1	kWh
108	Int32	Negative Energy	-0.1	kWh
112	Int32	Positive Reactive Energy	0.1	kvarh
116	Int32	Negative Reactive Energy	-0.1	kvarh
120	Int32	Power L1	1	W
124	Int32	Power L2	1	W
128	Int32	Power L3	1	W
132	Int32	Reactive Power L1	1	var
136	Int32	Reactive Power L2	1	var
140	Int32	Reactive Power L3	1	var
144	Int32	Apparent Power L1	1	VA
148	Int32	Apparent Power L2	1	VA
152	Int32	Apparent Power L3	1	VA
156	Uint16	Relay 1 active	Mask: 8000h	Bit
		Relay 2 active	Mask: 4000h	Bit
		Relay 3 active	Mask: 2000h	Bit
		Relay 4 active	Mask: 1000h	Bit
		Relay 5 active	Mask: 0800h	Bit
		reserved	Mask: 0400h	Bit
		reserved	Mask: 0200h	Bit
		reserved	Mask: 0100h	Bit
		reserved	Mask: 0080h	Bit
		reserved	Mask: 0040h	Bit
		reserved	Mask: 0020h	Bit
		reserved	Mask: 0010h	Bit
		reserved	Mask: 0008h	Bit
		reserved	Mask: 0004h	Bit
		reserved	Mask: 0002h	Bit
		LED 1 active	Mask: 0001h	Bit
158	Uint16	Free running cyclical counter (10 msec) for connection test.	1	

9.2.1.3 Configuration Helmholz DP/CAN Coupler

General notes

Please consider the basic configuration of the Helmholz DP/CAN Coupler:

- Select the correct GSD file (DP2C_L2h.GSD).
- Set the CAN baud rate to the same value like configured in the MFR 300. The default setting is 1 MBaud.
- Configure 20 receive objects for CAN IDs 385 to 404. Each should have 8 bytes data length.

Fig. 69 shows the Profibus mapping (Helmholz) of the MFR 300 data. The data starts at address 10 hex (16 dec). The 16 bit data words are in big endian format (high byte/low byte). The first 16 bytes (starting with address 0) are for internal purposes of the Helmholz coupler and can be discarded.

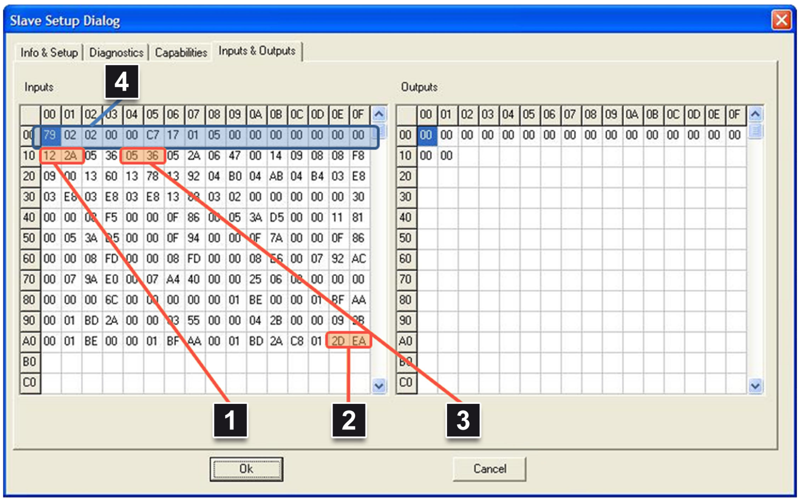


Fig. 69: Profibus mapping

1 Protocol number (122A hex → 4650 dec)
2 Counter
3 Voltage L2-N (0536 hex → 1334 x 690 V / 4000 = 230.115 V)
4 Reserved

For further configuration please consult the Helmholz DP/CAN Coupler (Profibus DP to CAN-Bus Coupler - 700-651-CAN01) documentation which can be found on the Helmholz website (*http://www.helmholz.de*).

9.2.1.4 Parameter Default Values

General notes

The following parameter default values are different compared to the MFR 300 Series standard default values shown in ⇨ *Chapter 4 "Configuration" on page 41*.

ID	Parameter	Default	Notes
Measurement			
1750	System rated frequency	60 Hz	Please refer to parameter 1750 ⇨ p. 42 for details.
1754	Rated current	2330 A	Please refer to parameter 1754 ⇨ p. 42 for details.
1752	Rated active power [kW]	2500.0 kW	Please refer to parameter 1752 ⇨ p. 42 for details.

ID	Parameter	Default	Notes
1806	CT primary rated current	2500 A/x	Please refer to parameter 1806 ↳ p. 45 for details.
CAN Interface			
9602	Transmission type	255	Please refer to parameter 9602 ↳ p. 49 for details.
Overfrequency (Level 1 & 2)			
1904 1910	Limit	1904: 103.0 % 1910: 105.0 %	Please refer to parameter 1904 ↳ p. 55 and 1910 ↳ p. 55 for details.
1905 1911	Delay	1905: 5.00 s 1911: 0.50 s	Please refer to parameter 1905 ↳ p. 55 and 1911 ↳ p. 55 for details.
Underfrequency (Level 1 & 2)			
1954 1960	Limit	1954: 97.0 % 1960: 95.0 %	Please refer to parameter 1954 ↳ p. 57 and 1950 ↳ p. 56 for details.
1961	Delay	0.50 s	Please refer to parameter 1961 ↳ p. 57 for details.
Overvoltage (Level 1 & 2)			
2004 2010	Limit	2004: 107.0 % 2010: 110.0 %	Please refer to parameter 2004 ↳ p. 51 and 2010 ↳ p. 51 for details.
2011	Delay	0.50 s	Please refer to parameter 2011 ↳ p. 51 for details.
Undervoltage (Level 1 & 2)			
2054 2060	Limit	2054: 93.0 % 2060: 90.0 %	Please refer to parameter 2054 ↳ p. 53 and 2060 ↳ p. 53 for details.
2061	Delay	0.50 s	Please refer to parameter 2061 ↳ p. 53 for details.
Positive Load (Level 1 & 2)			
2310	Limit	115.0 %	Please refer to parameter 2310 ↳ p. 58 for details.
2305 2311	Delay	2305: 10.00 s 2311: 00.30 s	Please refer to parameter 2305 ↳ p. 59 and 2311 ↳ p. 59 for details.
2307	Relay	Relay 4	Please refer to parameter 2307 ↳ p. 59 for details.
df/dt (ROCOF)			
3105	Delay	0.30 s	Please refer to parameter 3105 ↳ p. 67 for details.

9.2.2 MFR 300 CAN Protocol (Option SU03)

General notes

For backward compatibility reasons, a special data protocol was implemented.

The MFR 300 CAN Protocol (Option SU03) controllers have some additional features compared to the standard MFR 300 controllers. The differences are listed below.

- The CAN protocol (*Chapter 9.1.1.3 "Protocol 4600 (Unformatted Data)" on page 120*) is no longer supported.
- The protocol is replaced by *Chapter 9.2.2.1 "Data Protocol 4620 (Fast Unformatted Data)" on page 136*.
- Some parameter default values are different compared to the standard MFR 300 (*Chapter 9.2.2.2 "Parameter Default Values" on page 137*).

9.2.2.1 Data Protocol 4620 (Fast Unformatted Data)

General notes

The CAN transmit PDO 1 is sent out as multiplexed message. By default, one message is sent back upon each sync pulse.

A message has the following format:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Constant 0xDD	MUX	1. Data word		2. Data word		3. Data word	

Data words are in HighByte / LowByte sequence.

CAN transmit PDO 2 and PDO 3 are reserved for future enhancements.

CAN Data byte 1 (Mux)	Data byte	Parameter ID	Description	Multiplier	Units
1	2,3		Frequency	0.01	Hz
	4		Exponent for voltage values		
	5		Exponent for current values		
	6		Exponent for power and reactive power values		
	7		Always 0		
2	2,3		Voltage L1-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	10^(voltage exponent)	V
	4,5		Voltage L2-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	10^(voltage exponent)	V

CAN Data byte 1 (Mux)	Data byte	Parameter ID	Description	Multiplier	Units
	6,7		Voltage L3-N This value is calculated new after every voltage cycle. It is not filtered. Values smaller than 1.5% of the PT primary voltage have to be considered as zero.	10^(voltage exponent)	V
3	2,3		Current L1 This value is calculated new after every voltage cycle. It is not filtered.	10^(current exponent)	A
	4,5		Current L2 This value is calculated new after every voltage cycle. It is not filtered.	10^(current exponent)	A
	6,7		Current L3 This value is calculated new after every voltage cycle. It is not filtered.	10^(current exponent)	A
4	2,3		Total active power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the active power value has to be considered as zero. This is a two's complement value and may be positive or negative.	10^(power exponent)	W
	4,5		Total reactive power This value is calculated new after every voltage cycle of each phase. It is not filtered. If the voltage is lower than 1.5% of the PT primary voltage, the reactive power value has to be considered as zero. This is a two's complement value and may be positive or negative.	10^(power exponent)	var
	6,7		Power factor 100: pure active power. Positive values: inductive, Negative values: capacitive	0.01	

9.2.2.2 Parameter Default Values

General notes

The following parameter default values are different compared to the MFR 300 Series standard default values shown in ➪ *Chapter 4 "Configuration" on page 41*.

ID	Parameter	Default	Notes
CAN Interface			
9602	Transmission type	255	Please refer to parameter 9602 ➪ p. 49 for details.
9117	Producer heartbeat time	400 ms	Please refer to parameter 9117 ➪ p. 49 for details.

10 Glossary And List Of Abbreviations

AM	AnalogManager
BDEW	German community of 1,800 companies represented by the German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft)
CB	Circuit Breaker
CL	Code Level
CT	Current Transformer
DI	Discrete Input
DO	Discrete (Relay) Output
ECU	Engine Control Unit
FMI	Failure Mode Indicator
GCB	Generator Circuit Breaker
GGB	Generator Group Breaker
HMI	Human Machine Interface e.g., a front panel with display and buttons for interaction
I	Current
IOP	Islanded Operation in Parallel ("Islanded Parallel Operation")
LDSS	Load-Dependent Start/Stop operation
LM	LogicsManager©
MCB	Mains Circuit Breaker
MOP	Mains Operation in Parallel
MPU	Magnetic Pickup Unit
N.C.	Normally Closed (break) contact
N.O.	Normally Open (make) contact
NC	Neutral Contactor
OC	Occurrence Count
Operation	In (general) operation. State when the genset is running according to the selected mode, all parameters are in allowed values and ranges, and without OPEN requests or alarms. Somehow "waiting for next occurrence".
P	Real power
P/N	Part Number
PF	Power Factor
PID	Proportional Integral Derivative controller
PLC	Programmable Logic Control
PT	Potential (Voltage) Transformer
Q	Reactive power
S	Apparent power
S/N	Serial Number
SPN	Suspect Parameter Number
V	Voltage

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