EN Manual

PEM555

Universal measuring device
Software version 1.00.xx

B 9310 0555
B 9310 0556
B 9310 0557
B 9310 0558
B 9310 0559

PEM555_D00069_01_M_XXEN/02.2016

BENDER
The Power in Electrical Safety©

Bender GmbH & Co. KG
Londorfer Str. 65 • 35305 Gruenberg • Germany
Postfach 1161 • 35301 Gruenberg • Germany

Tel.: +49 6401 807-0
Fax: +49 6401 807-259

E-Mail: info@bender.de
www.bender.de

Table of Contents

1. Making effective use of this document 9

1.1 How to use this manual 9

1.2 Technical support: Service and support 10

1.3 Workshops 11

1.4 Delivery conditions, guarantee, warranty and liability 11

2. Safety 13

2.1 Intended use 13

2.2 Qualified personnel 13

2.3 General safety instructions 14

3. Device description 15

3.1 Area of application 15

3.2 Device features 15

3.3 Versions 16

3.4 Application example 17

3.5 Description of function 17

3.6 Front view and rear view 18

4. Installation and connection 19

4.1 Project planning 19

4.2 Safety instructions 19

4.3 Installing the device 19

4.3.1 Dimension diagrams 19

4.3.2 Front panel mounting 20

4.4 Connection of the device 21

4.4.1 Safety information 21

4.4.2 Back-up fuses 21

4.4.3 Connection of measuring current transformers 21

4.5 Instructions for connection ... 21
4.6 Wiring diagram ... 22
4.7 Connection diagram voltage inputs ... 23
4.7.1 Three-phase 4-wire system (TN, TT, IT system) ... 23
4.7.2 Three-phase 3-wire system ... 24
4.7.3 Connection via voltage transformers ... 25
4.8 Digital inputs ... 25
4.9 Digital outputs ... 26
4.10 Modbus TCP (connector pin assignment) ... 26

5. Commissioning ... 27

5.1 Check proper connection ... 27
5.2 Before switching on ... 27
5.3 Switching on ... 27
5.4 System ... 28

6. Operation ... 29

6.1 Getting to know the operating elements ... 29
6.2 LCD testing ... 30
6.3 Getting to know standard display areas ... 31
6.4 Power and current demand (demand display) ... 33
6.5 LED indication ... 34
6.6 Standard display ... 34
6.7 Data display ... 34
6.7.1 "V/I" button ... 35
6.7.2 "POWER"button ... 37
6.7.3 "HARMONICS" button ... 39
6.7.4 "ENERGY" button ... 40
6.8 Setup configuration via the front panel ... 41
6.8.1 Setup: Function of buttons ... 41
6.8.2 Setup: Overview diagram menu ... 41
6.9 Setup: adjustment possibilities ... 43
6.10 Configuration example ... 49

7. Application/inputs and outputs 51

7.1 Digital inputs (DI) 51
7.2 Digital outputs (DO) 51
7.3 Energy pulsing output 51
7.4 Power and energy 52
7.4.1 Basic measurements 52
7.4.2 Voltage and current phase angles 52
7.4.3 Energy 52
7.5 Demand DMD 53
7.6 Setpoints 54

8. Data logging 57

8.1 Peak demand memory 57
8.2 Memory for Max/Min values 57
8.3 Data recorder (DR) 59
8.3.1 Setup parameters 59
8.3.2 Key to measured quantities used for data recorders 60
8.4 Energy log 73
8.5 Waveform recorder (WFR) 74
8.6 Event log (SOE log) 75

9. Power Quality 77

9.1 Harmonic distortion 77
9.2 Unbalance 78
9.3 Setpoint Transient events 79
9.4 Time synchronisation 79

10. Modbus Register Map 81

10.1 Basic measurements 83
10.2 Energy measurement 87
10.3 Pulse counter 88
10.4 Fundamental measurement (PQ log) 88
10.5 Demand 91

10.5.1 Present demand 91
10.5.2 Maximum values per demand period 93
10.5.3 Minimum values per demand period 95
10.5.4 Peak demand of this month 96
10.5.5 Peak demand last month 97
10.5.6 Peak demand data structure 97
10.6 Max/Min log 98
10.6.1 Maximum values of this month 98
10.6.2 Min log of this month 99
10.6.3 Max log of last month 101
10.6.4 Min log last month 102
10.6.5 Max/Min log data structure 103
10.7 Setup parameters 104
10.8 Clear/reset register 107
10.9 Register Setpoints 108
10.10 Data recorder (DR) 111
10.10.1 Data recorder register 111
10.10.2 Structure data recorder registers 112
10.11 Waveform recorder (WFR) 114
10.12 Energy log 116
10.13 Event log (SOE log) 118
10.13.1 Event log register 118
10.13.2 Event log data structure 119
10.13.3 Event classification (SOE log) 119
10.14 Time setting 126
10.15 DOx control 127
10.16 Universal measuring device information 128

11. Technical data 131

11.1 Standards and certifications 133
11.2 Ordering information 133

INDEX 135

1. Making effective use of this document

1.1 How to use this manual

This manual is aimed at qualified personnel in electrical engineering and communications technology, installers and users of the product and must be kept ready for referencing in the immediate vicinity of the device.
To make it easier for you to understand and revisit certain sections of text and instructions in the manual, we have used symbols to identify important instructions and information. The meaning of these symbols is explained below:

DANGER	*The signal word indicates that there is a **high risk of danger,**, that will result in **death** or **serious injury** if not avoided.*
WARNING	*This signal word indicates a **medium risk of danger** that can lead to **death** or **serious injury** if not avoided.*
CAUTION	*This signal word indicates a **low level risk** that can result in **minor or moderate injury** or **damage to property** if not avoided.*
i	*This symbol denotes information intended to assist the user in making **optimum use** of the product.*

Although great care has been taken in the drafting of this operating manual, it may nevertheless contain errors and mistakes. Bender cannot accept any liability for injury to persons or damage to property resulting from errors or mistakes in this manual.
Each of the registered trademarks which appears in this document remains the property of its owner.

1.2 Technical support: Service and support

For commissioning and troubleshooting Bender offers you:

First level support

Technical support by phone or e-mail for all Bender products

- All questions about customer applications
- Commissioning
- Troubleshooting

Phone:	+49 6401 807-760*
Fax:	+49 6401 807-259
only available in Germany:	0700BenderHelp (Tel. and Fax)
E-mail:	support@bender-service.de

Repair service

Repair, calibration, update and replacement service for all Bender products

- Repair, calibration, testing and analysing Bender products
- Hardware and software update for Bender devices
- Delivery of replacement devices for faulty or incorrectly delivered Bender devices
- Extended warranty for Bender devices with in-house repair service resp. replacement devices at no extra cost

Phone:	+49 6401 807-780** (technical issues)
	+49 6401 807-784**, -785** (commercial matters)
Fax:	+49 6401 807-789
E-mail:	repair@bender-service.de

Please send the devices for **repair** to the following address:

Bender GmbH, Repair Service
Londorfer Strasse 65
35305 Gruenberg, Germany

Field service

On-site service for all Bender products

- Commissioning, parameter setting, maintenance, trouble shooting for Bender products
- Analysis of the electrical installation in the building (power quality test, EMC test, thermography)
- Practical training courses for customers

Phone:	+49 6401 807-752**, -762 **(technical issues)
	+49 6401 807-753** (commercial matters)
Fax:	+49 6401 807-759
E-mail:	fieldservice@bender-service.de
Internet:	www.bender.de

*Available from 7.00 a.m. to 8.00 p.m.on 365 days of the year (CET/UTC+1)
**Mo-Thu 7.00 a.m. - 8.00 p.m., Fr 7.00 a.m. - 13.00 p.m

1.3 Workshops

Bender would be happy to provide training in respect of the use of the universal measuring device.
Current dates of training courses and workshops can be found on the Internet at http://www.bender.de -> Know-how -> Seminars.

1.4 Delivery conditions, guarantee, warranty and liability

The conditions of sale and delivery set out by Bender apply.
For software products, the "Softwareklausel zur Überlassung von Standard- Software als Teil von Lieferungen, Ergänzung und Änderung der Allgemeinen Lieferbedingungen für Erzeugnisse und Leistungen der Elektroindustrie" (software clause in respect of the licensing of standard software as part of deliveries, modifications and changes to general delivery conditions for products and services in the electrical industry) set out by the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V., (German Electrical and Electronic Manufacturers' Association) also applies.
Conditions of sale and delivery can be obtained from Bender in printed or electronic format.

2. Safety

2.1 Intended use

The universal measuring device PEM555 is suitable for

- the analysis of energy and power
- monitoring of the power supply quality
- data recording for energy management.

As a compact device for front panel mounting, it is a replacement for analogue indicating instruments. Das PEM555 is suitable for 2, 3 and 4-wire systems and can be used in TN, TT and IT systems. The current measurement inputs of the PEM are connected via external ../1 A or ../5 A measuring current transformers. In principle, measurements in medium and high voltage systems are carried out via measurement transformers and voltage transformers.

Use for the intended purpose also includes:

- Device-specific settings according to local equipment and operating conditions.
- The observation of all information in the operating manual.

2.2 Qualified personnel

Only electrically skilled persons are authorised to install and commission this device. Electrically skilled persons are those who have the relevant education, knowledge and experience, as well as knowledge of the relevant safety standards and who are able to perceive risks and to avoid hazards which electricity can create when work activities are carried out on electrical installations. The electrically skilled person is specially trained for carrying out work activities in his specific working environment and has a thorough knowledge of the relevant standards and regulations. In Germany, an electrically skilled person must meet the requirements of the accident prevention regulation BGV A3. In other countries the applicable regulations have to be observed and followed.

2.3 General safety instructions

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

DANGER

Danger of electric shock!
Touching live parts will cause danger of electric shock with fatal consequences.
*All work activities on electrical installations as well as installation activities, commissioning activities and work activities with the device in operation may only be carried out by **electrically skilled persons**!*

- Only use Bender equipment:
  - as intended
  - in perfect working order
  - in compliance with the accident prevention regulations and guidelines applicable at the location of use
- Eliminate all faults immediately which may endanger safety.
- Do not make any unauthorised changes and only use replacement parts and optional accessories purchased from or recommended by the manufacturer of the equipment. Failure to observe this requirement can result in fire, electric shock and injury.
- Information plates must always be clearly legible. Replace damaged or illegible plates immediately.
- If the device is overloaded by overvoltage or a short-circuit current load, it must be checked and replaced if necessary.
- If the device is being used in a location outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. European standard EN 50110 can be used as a guide.

3. Device description

3.1 Area of application

For humans, electric current is not immediately visible. Universal measuring devices for monitoring electrical parameters are used wherever energy consumption, performance measurements or the quality of the supply voltage are to be made visible.
The PEM555 is suitable for monitoring

- power generation systems (PV systems, CHPs, hydro power and wind power plants)
- energy-intensive equipment and parts of installation
- sensitive equipment

3.2 Device features

The universal measuring device PEM555 for power quality and energy management is characterised by the following features:

- Accuracy class according to IEC 62053-22: 0.5 S
- Password protection
- 9 programmable setpoints
- LED pulse outputs for active and reactive energy
- Modbus RTU communication via RS-485 interface
- 6 digital inputs
- 3 digital outputs
- Power and current demands for particular time frames
- Peak demands with timestamps
- Individual, current/voltage harmonics up to the 31st harmonic
- Max and Min values
- 2 high-resolution waveform recorders (12.8 kHz)
- Data recorder
- Event log: 512 events, setup changes, active setpoints, DI status changes, DO switching operations
- Sag/swell detection
- Detection of transient events

- Communication:
  - Galvanically isolated RS-485 interface (1,200…19,200 bit/s)
  - Modbus/RTU protocol
  - Modbus/TCP (10/100 Mbit/s)
- Measured quantities
  - Phase voltages — U_{L1}, U_{L2}, U_{L3} in V
  - Line-to-line voltages — U_{L1L2}, U_{L2L3}, U_{L3L1} in V
  - Phase currents — I_1, I_2, I_3 in A
  - Neutral current (calculated) — *I0* in A
  - Neutral current (measured) — I_4 in A
  - Frequency — *f* in Hz
  - Phase angle — for *U* and *I* in °
  - Power per phase conductor — *P* in kW, *Q* in kvar, *S* in kVA
  - Total power — *P* in kW, *Q* in kvar, *S* in kVA
  - Displacement factor — cos (φ)
  - Power factor — λ
  - Active and reactive energy import — in kWh, kvarh
  - Active and reactive energy export — in kWh, kvarh
  - Voltage unbalance — in %
  - Current unbalance — in %
  - Harmonic distortion (THD, TOHD, TEHD) — for *U* and *I*
  - k-factor — for *I*

3.3 Versions

Type	Measuring voltage input 3(N)AC	Current input
PEM555	230/400 V	5 A
PEM555-151	69/120 V	1 A
PEM555-251	230/400 V	1 A
PEM555-455	400/690 V	5 A
PEM555-451	400/690 V	1 A

3.4 Application example

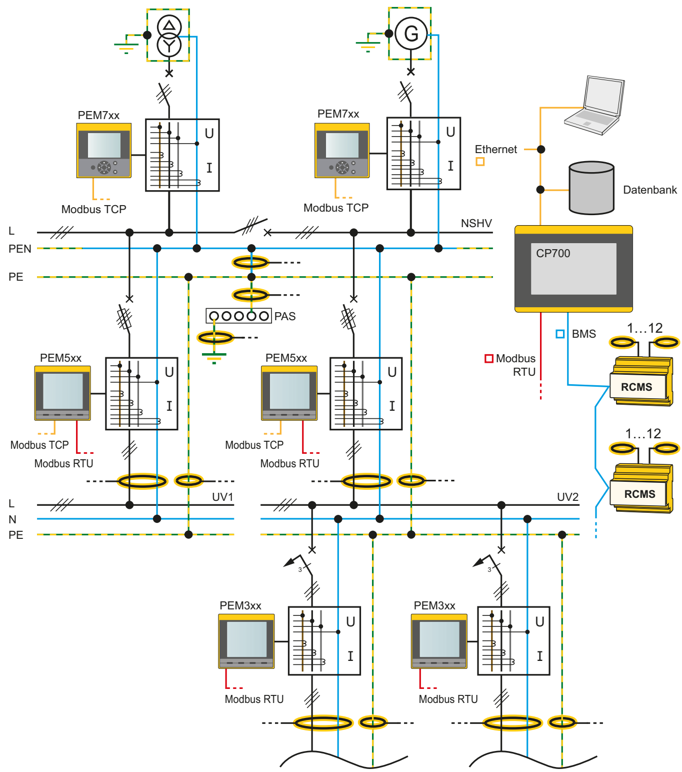


Fig. 3.1: Application example

3.5 Description of function

The digital universal measuring device PEM555 is suited for measuring and displaying electrical quantities of a public electricity network. The PEM575 is able to perform current, voltage, energy consumption and performance measurements as well as displaying individual harmonic components of current and voltage for assessment of the voltage and current quality.

The accuracy of the active energy metering corresponds to class 0.5 S in compliance with the DIN EN 62053-22 (VDE 0418 Part 3-22): 2003-11.

The large display of the panel mounting device makes the relevant measured quantities easily legible and enables fast configuration. In addition, the RS-485 interface allows a central evaluation and processing of data. Switching operations can be monitored or initiated via the digital inputs and outputs (Example: Switching off uncritical loads if the peak load limit value is exceeded).

The universal measuring device PEM555 provides the following functions:

- Provision of energy consumption data for a well-thought-out energy management
- Allocation of energy costs
- Power quality monitoring for cost reduction and increased plant availability
- High-resolution waveform recording allow analysis of power quality phenomena

3.6 Front view and rear view

The connecting terminals are located at the rear of the device.

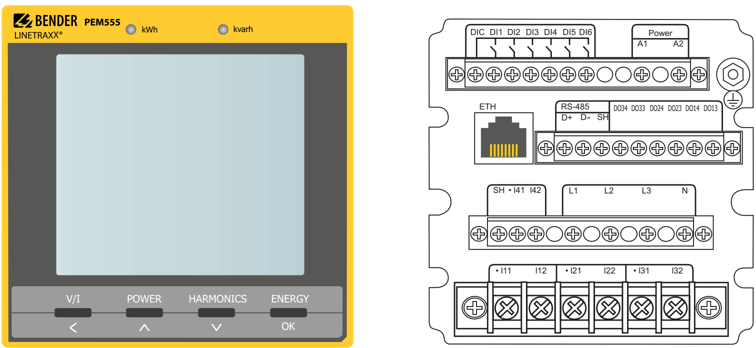


Fig. 3.2: Front view (left) and rear view (right) PEM555

4. Installation and connection

4.1 Project planning

For any questions associated with project planning, please contact Bender:
Internet: www.bender.de
Tel.: +49-6401-807-0

4.2 Safety instructions

Only electrically skilled persons are allowed to connect and commission the device. Such persons must have read this manual and understood all instructions relating to safety.

DANGER

Danger of electric shock!
Follow the basic safety rules when working with electricity.
***Consider the data on the rated voltage and supply voltage** as specified in the technical data!*

4.3 Installing the device

4.3.1 Dimension diagrams

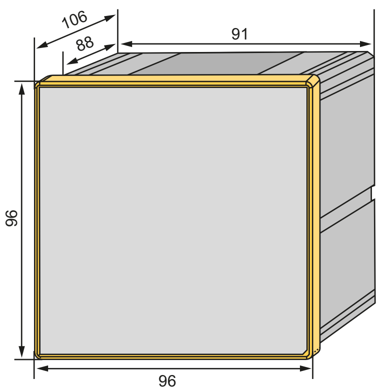


Fig. 4.1: Dimension diagram PEM555 (front view)

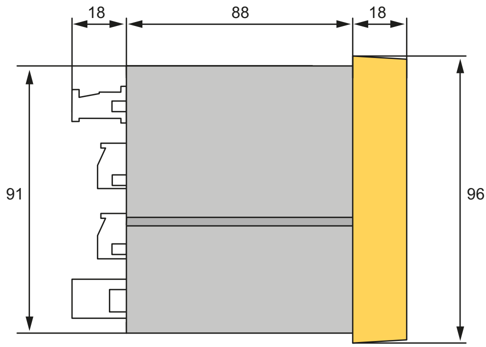


Fig. 4.2: Dimension diagram PEM555 (side view)

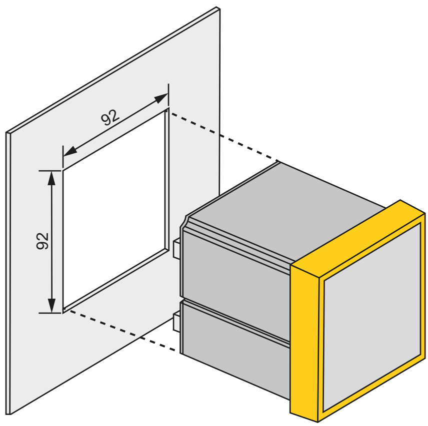


Fig. 4.3: Dimension diagram PEM555 (panel cutout)

4.3.2 Front panel mounting

A front panel cutout of 92 mm x 92 mm is necessary for installation.

1. Insert the device through the cutout in the front panel.
2. Insert the two installation clips into the equipment rail from behind.
3. Push the clips towards the front panel and tighten the associated screws by hand.
4. Check the device to ensure that it is firmly installed in the front panel.

The device is installed.

4.4 Connection of the device

4.4.1 Safety information

DANGER

Danger of electric shock!
Follow the basic safety rules when working with electricity.
***Consider the data on the rated voltage and supply voltage** as specified in the technical data!*

4.4.2 Back-up fuses

Back-up fuse supply voltage: 6 A
Short-circuit protection Protect the measuring inputs according to the standards (2 A recommended). A suitable isolation means must be provided. For details refer to the operating manuals of the measuring current transformers currently used.

*If the supply voltage U_s is supplied by an **IT system**, **both line conductors are to be protected**.*

4.4.3 Connection of measuring current transformers

When connecting the measuring current transformers it is important to consider the requirements of DIN VDE 0100-557 (VDE 0100-557) –
Low voltage installations - Part 5: Selection and erection of electrical equipment - Section 557: Auxiliary circuits.

4.5 Instructions for connection

- Connect the PEM555 to the supply voltage (terminals A1 and A2 resp. +/-). Connect terminal " ⏚ " to the protective conductor.
- Power protection by a 6 A fuse, quick response. If being supplied from an IT system, both lines have to be protected by a fuse.
- Connection to the RS-485 bus is made via the terminals D+, D- and SH. Up to 32 devices can be connected to the bus. The maximum cable length for the bus connection of all devices is 1200 m.

4.6 Wiring diagram

Connect the device according the wiring diagram. The connections are located at the rear of the device.

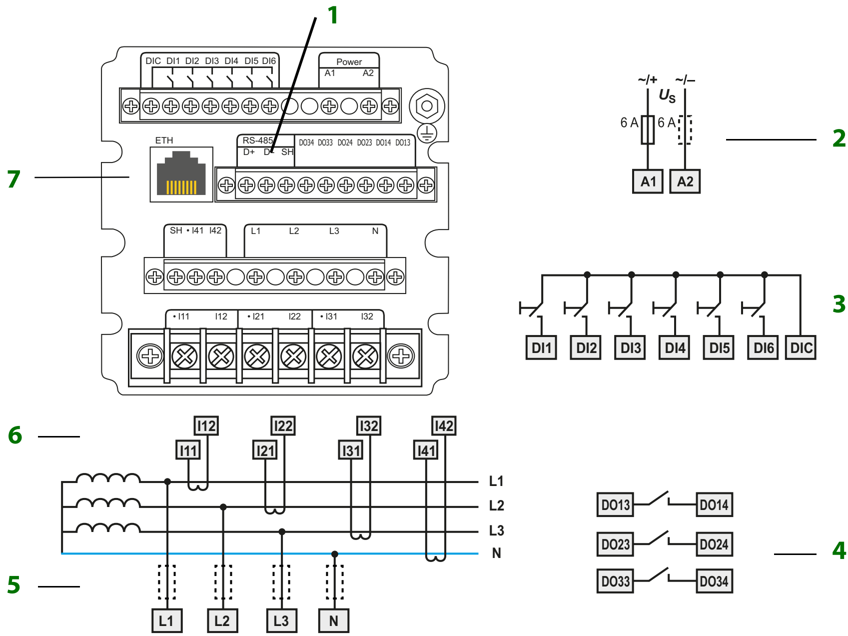


Fig. 4.4: Wiring diagram

Legend to wiring diagram

1	Connection RS-485 bus
2	Supply voltage. Power protection by a 6 A fuse, quick response. If being supplied from an **IT system**, both lines have to be protected by a fuse.
3	Digital inputs
4	Digital outputs (N/O contacts)
5	Measuring voltage inputs: The measuring leads should be protected with appropriate fuses.
6	Connection to the system to be monitored
7	Connection Modbus TCP

4.7 Connection diagram voltage inputs

4.7.1 Three-phase 4-wire system (TN, TT, IT system)

The universal measuring device PEM555 can be used in three-phase-4-wire systems, independent of the type of distribution system (TN, TT, IT system).

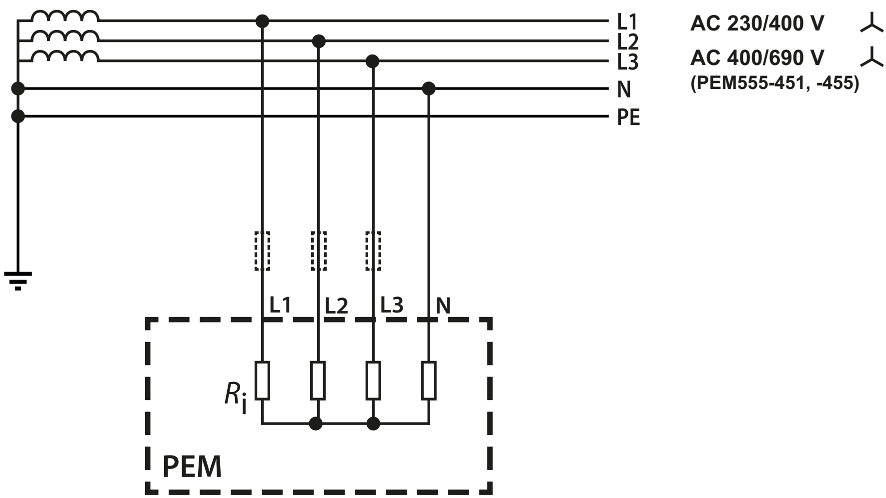


Fig. 4.5: Connection diagram three-phase 4-wire system (e.g. TN-S system)

4.7.2 Three-phase 3-wire system

The universal measuring device PEM555 can be used in three-phase-3-wire systems. The line voltage must not exceed AC 400 V.

*When used in 3-wire systems, the connection type (**TYPE**) has to be set to **DELTA** (refer to page 43). For this purpose, **the measuring inputs L2 and N** are to be **bridged**.*

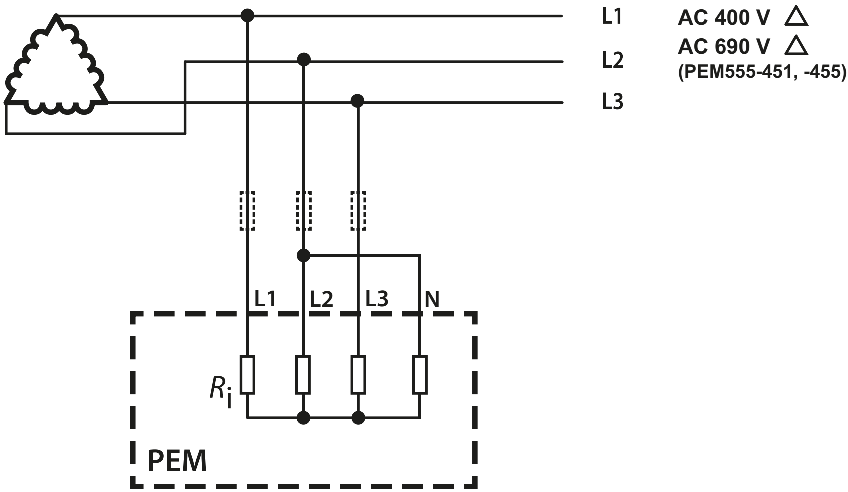


Fig. 4.6: Connection diagram three-phase-3-wire system

4.7.3 Connection via voltage transformers

The coupling via voltage transformers allows the use of the measuring device in medium and high voltage systems.
The transformation ratio can be adjusted in the PEM555 (1…2200).

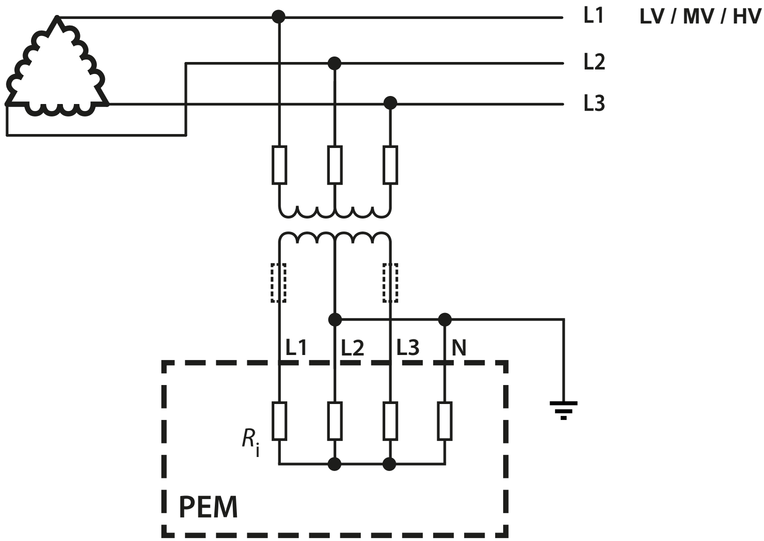
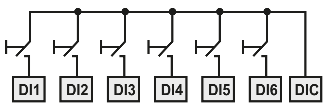


Fig. 4.7: Connection diagram 3-wire system via voltage transformers

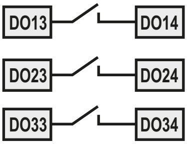
4.8 Digital inputs

The universal measuring device PEM555 provides 6 digital inputs. The inputs are supplied by a galvanically isolated DC 24 V voltage. An external circuit providing at least a current of I_{min} > 2.4 mA is required for triggering the inputs.

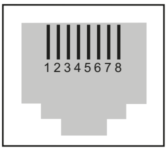


4.9 Digital outputs

The universal measuring device PEM555 features 3 configurable outputs (N/O contact).

	**Rated operational voltage**	AC 230 V	DC 24 V	AC 110 V	DC 12 V
	Rated operational current	5 A	5 A	6 A	5 A

4.10 Modbus TCP (connector pin assignment)

RJ45	Pin	Assignment
	1	Transmit Data +
	2	Transmit Data –
	3	Receive Data +
	4, 5, 7, 8	not used
	6	Receive Data –

5. Commissioning

5.1 Check proper connection

Observe the relevant standards and regulations that have to be observed for installation and connection as well as the operating manual of the respective device.

5.2 Before switching on

Before switching on think carefully about these questions:

1. Does the connected supply voltage correspond to the nameplates' information?
2. Are you sure that the nominal insulation voltage of the measuring current transformer has not been exceeded?
3. Does the measuring current transformer's maximum current correspond to the nameplate information of the connected device?

5.3 Switching on

After switching on, proceed as follows:

1. Connect the supply voltage.
2. Set the bus address/IP address.
3. Set the CT transformation ratio (for each channel).
4. Change the measuring current transformer's counting direction, if required.
5. Set the nominal voltage (line-to-line voltage U_{LL}).
6. Select wye connection or delta connection.

5.4 System

The universal measuring device PEM555 can be programmed and queried via Modbus RTU. For details refer to „chapter 10. Modbus Register Map“ or the Internet www.modbus.org.

In addition, it is possible to integrate the device into Bender's own BMS (Bender measuring device interface) bus protocol via additional communication modules. In this way, communication with (already existing) Bender devices for device parameterisation and visualisation of measured values and alarms can be achieved.
Help and examples of system integration can be found on the Bender homepage www.bender.de or you can contact our Bender Service for personal advice (see „chapter 1.2 Technical support: Service and support“).

6. Operation

6.1 Getting to know the operating elements

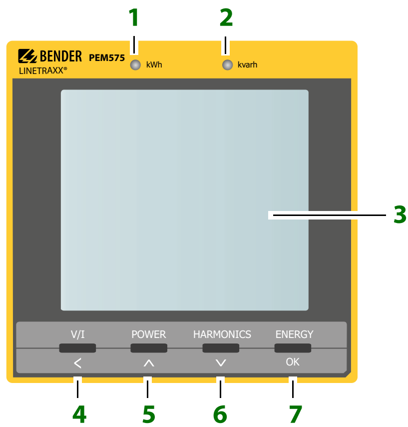


Fig. 6.1: Operating elements

Legend to operating elements

No.	Element	Description
1	LED kWh	Pulse output, see chapter 6.5 LED indication
2	LED kvarh	
3	LC display	
4	"V/I" button <	Display mean values and total values (current, voltage) **In the menu**: in case of numerical values: move the cursor one to the left by one position
5	"POWER" button Λ	Display power-related measured quantities **In the menu**: go up one entry in case of numerical values: increase the value
6	"HARMONICS" button V	Display harmonics **In the menu**: go back to the last parameter in the menu in case of numerical values: decrement a value Press > 3 s: toggles between setup and standard display mode
7	"ENERGY" button OK	Display measured values: active and reactive energy import/active and reactive energy export (line 5) **In the menu**: select parameters for modification save the new setting

6.2 LCD testing

Pressing both the "**POWER"** and "**HARMONICS"** buttons simultaneously for > 2 seconds enters the LCD testing mode.

During testing all LCD segments are switched on and off for five seconds three consecutive times. After completion of the test run, the device automatically returns to its normal display mode.

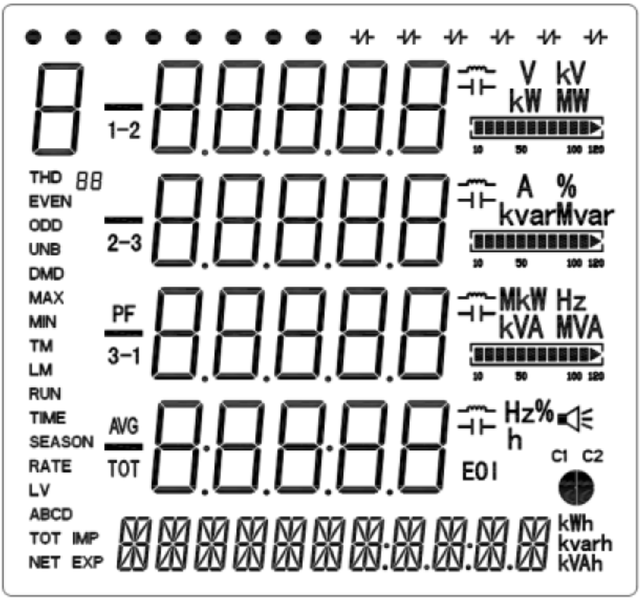
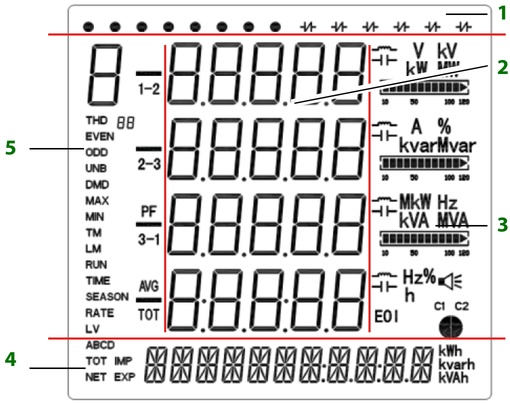


Fig. 6.2: Display during an LCD test

6.3 Getting to know standard display areas

The display can generally be divided into five areas.



Legend to standard display areas

No.	Description
1	Displays the indicators for DI status and DO status
2	Measured values
3	Harmonic Distortion HD, unbalance (unb), quadrant, measurement units
4	Displays energy information such as active energy (import, export, net energy and total energy in kWh), reactive energy (import, export, energy net amount and total energy in kvar), apparent energy (S_{ges} in kVAh)
5	Shows parameters for voltage, current, fundamental, power, total harmonic distortion THD, TOHD, TEHD (2^{nd}…31^{st} harmonic), k-factor, unbalance (unb), phase angle for voltages and currents, demands

Fig. 6.3: Display areas

Description of standard display indications (areas 1, 3 and 4)

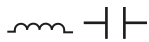
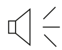
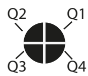
<table>
<tr><th>Area</th><th>Segments</th><th colspan="6">Symbol description</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2"></td><td colspan="3">DI open</td><td colspan="3">DI closed</td></tr>
<tr><td colspan="3">DO open</td><td colspan="3">DO closed</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3"></td><td colspan="3">V, kV, A, %, Hz
Measurement units for U, I, THD, f</td><td colspan="3">kW, MW, kvar, kVA, MVA
Measurement units for P, Q, S</td></tr>
<tr><td colspan="3">
Current value expressed as a percentage</td><td colspan="3">
inductive, capacitive</td></tr>
<tr><td colspan="2">C1 C2
Status communi-cation interface</td><td colspan="2">
Alarm symbol</td><td colspan="2">
Quadrant</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3"></td><td colspan="2">IMP kWh
Active energy import</td><td colspan="2">EXP kWh
Active energy export</td><td colspan="2">NET kWh
Active energy net amount</td></tr>
<tr><td colspan="2">TOT kWh
Total active energy</td><td colspan="2">IMP kvarh
Reactive energy import</td><td colspan="2">EXP kvarh
Reactive energy export</td></tr>
<tr><td colspan="2">NET kvarh
Reactive energy net amount</td><td colspan="2">TOT kvarh
Total reactive energy</td><td colspan="2"> kVAh
Apparent energy</td></tr>
</table>

Fig. 6.4: Standard display indications

6.4 Power and current demand (demand display)

The **demands** are indicated on the display according to the following scheme:

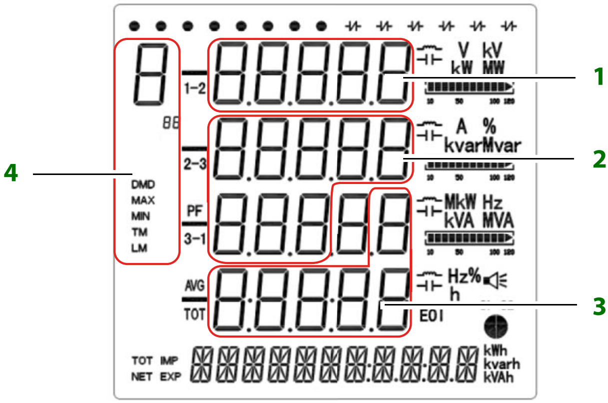


Fig. 6.5: Display: peak demand

Legend to demand display

No.	Display
1	Peak demand value
2	Peak demand timestamp (date): YYYY.MM.DD
3	Peak demand timestamp (time): HH:MM:SS
4	Demand displays: **A:** I_1 **b:** I_2 **C:** I_3 ***P:*** *Active power demand P* ***q:*** *Reactive power demand Q* ***S:*** *Apparent power demand* ***DMD:*** *Demand* ***MAX*** *Maximum* ***TM:*** *This month* ***LM:*** *Last month*

6.5 LED indication

The universal measuring device features two red LEDs on its front panel: kWh and kvarh. The two LED indicators are used for the indication of kWh and kvar, if the **EN PULSE function** is **enabled**. Energy pulsing can be enabled from the front panel through the EN Pulse setup parameter or via the communications interface.
The LEDs flash each time a certain amount of energy is reached (1 kWh resp.1 kvarh). The amount of energy displayed corresponds to the amount of energy measured by the measuring device. In order to determine the actual amount of energy, the flashing frequency can be calculated from the CT ratio and the pulse constant.

6.6 Standard display

The universal measuring device automatically shows the default display screen, if there is no button pressed for 3 minutes in the Setup mode.

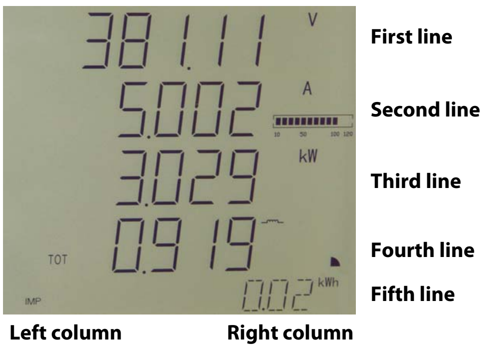


Fig. 6.6: Standard display

6.7 Data display

There are four buttons on the display to view measuring data: "V/I", "POWER" , "HARMONICS" and "ENERGY". The following tables illustrate how to retrieve individual values.

6.7.1 "V/I" button

Left column	Right column	First line	Second line	Third line	Fourth line
TOT	V A W	Ø U	Ø I	P_{ges}	Power factor λ_{ges}
U1 U2 U3 UAVG	V	*U_{L1}	*U_{L2}	*U_{L3}	*Ø U_{LN}
U1-2 U2-3 U3-1 U_{AVG}	V	U_{L1L2}	U_{L2L3}	U_{L3L1}	Ø U_{LL}
I1 I2 I3 IAVG	A	I_1	I_2	I_3	Ø I
I_4	A		I_4		
I_0	A		I_0 (neutral current, calculated)		
F	Hz			f	
U unb	%		Unbalance U		
I unb	%		Unbalance I		
PA U1 U_2 U3		Phase angle U_{L1}	Phase angle U_{L2}	Phase angle U_{L3}	
PA I_1 I_2 I_3		Phase angle I_1	Phase angle I_2	Phase angle I_3	

Left column	Right column	First line	Second line	Third line	Fourth line
I1 DMD I_2 I_3 I_{AVG}	A	Demand I_1	Demand I_2	Demand I_3	Ø Demand I
DMD I_4			Demand I_4		
A DMD MAX TM	A	Peak demand I_1 this month	YYYY.MM.DD hh:mm:ss		
b DMD MAX TM	A	Peak demand I_2 this month	YYYY.MM.DD hh:mm:ss		
C DMD MAX TM	A	Peak demand I_3 this month	YYYY.MM.DD hh:mm:ss		
A DMD MAX LM	A	Peak demand I_1 last month	YYYY.MM.DD hh:mm:ss		
b DMD MAX LM	A	Peak demand I_2 last month	YYYY.MM.DD hh:mm:ss		
C DMD MAX LM	A	Peak demand I_3 last month	YYYY.MM.DD hh:mm:ss		

Table 6.1: Display screens via the "V/I" button

Note on table 6.1:

* When the wiring mode is "DELTA", the display will be bypassed and does not appear.

6.7.2 "POWER"button

Left column	Right column	First line	Second line	Third line	Fourth line
* P_1 P_2 P_3 P_{TOT}	kW kW kW	P_{L1}*	P_{L2}*	P_{L3}*	P_{ges}
*q_1 q2 q3 q_{TOT}	var var var	Q_{L1}*	Q_{L2}*	Q_{L3}*	Q_{ges}
*S_1 S2 S3 S TOT	kVA kVA kVA	S_{L1}*	S_{L2}*	S_{L3}*	S_{ges}
*PF_1 PF_2 PF_3 PF_{TOT}		λ_{L1}*	λ_{L2}*	λ_{L3}*	λ_{ges}
*dPF1 dPF2 dPF3 d_{TOT}		Displacement factor cos $(\varphi)_{L1f0}$*	Displacement factor cos $(\varphi)_{L2f0}$*	Displacement factor cos $(\varphi)_{L3}$*	Displacement factor cos $(\varphi)_{(f0)}$
TOT	W var VA	P_{ges}	Q_{ges}	S_{ges}	λ_{ges}
DMD	W var VA	Demand P_{ges}	Demand Q_{ges}	Demand S_{ges}	Demand λ_{ges}
P DMD MAX TM		Peak demand *P* this month	YYYY.MM.DD hh:mm:ss		

Left column	Right column	First line	Second line	Third line	Fourth line
q DMD MAX TM	var	Peak demand *Q* this month	YYYY.MM.DD hh:mm:ss		
S DMD MAX TM	VA	Peak demand *S* this month	YYYY.MM.DD hh:mm:ss		
P DMD MAX LM	W	Peak demand *P* last month	YYYY.MM.DD hh:mm:ss		
q DMD MAX LM	var	Peak demand *Q* last month	YYYY.MM.DD hh:mm:ss		
S DMD MAX LM	VA	Peak demand *S* last month	YYYY.MM.DD hh:mm:ss		

Table 6.2: Display possibilities via the "POWER" button

Note on table 6.2:

* When the wiring mode is "DELTA", the display will be bypassed and does not appear.

6.7.3 "HARMONICS" button

Left column	Right column	First line	Second line	Third line	Fourth line
THD U_1 U2 U3 U_{AVG}	%	THD_{UL1}	THD_{UL2}	THD_{UL3}	Ø THD_{ULN}
THD $_I$1 I_2 I_3 IAVG	%	THD_{I1}	THD_{I2}	THD_{I3}	Ø THD_I
k 1 2 3		k-factor I_1	k-factor I_2	k-factor I_3	
U THD Even	%	$TEHD_{UL1}$	$TEHD_{UL2}$	$TEHD_{UL3}$	Ø $TEHD_{ULN}$
I THD Even		$TEHD_{I1}$	$TEHD_{I2}$	$TEHD_{I3}$	Ø $TEHD_I$
U THD ODD		$TOHD_{UL1}$	$TOHD_{UL2}$	$TOHD_{UL3}$	Ø $TOHD_{ULN}$
I THD ODD		$TOHD_{I1}$	$TOHD_{I2}$	$TOHD_{I3}$	Ø $TOHD_I$
HD2 U1 U2 U3 U_{AVG}	%	2^{nd} harmonic U_{L1}	2^{nd} harmonic U_{L2}	2^{nd} harmonic U_{L3}	Ø 2^{nd} harmonic U_{LN}
HD2 I1 I_2 I_3 I_{AVG}	%	2^{nd} harmonic I_1	2^{nd} harmonic I_2	2^{nd} harmonic I_3	Ø 2^{nd} harmonic I

Left column	Right column	First line	Second line	Third line	Fourth line
HD3 U1 U2 U3 U_{AVG}	%	3rd harmonic U_{L1}	3rd harmonic U_{L2}	3rd harmonic U_{L3}	Ø 3rd harmonic U_{LN}
...					
HD31 U_1 U2 U3 U_{AVG}	%	31st harmonic U_{L1}	31st harmonic U_{L2}	31st harmonic U_{L3}	Ø 31st harmonic U_{LN}
HD31 I1 I_2 I_3 I_{AVG}	%	31st harmonic I_1	31st harmonic I_2	31st harmonic I_3	Ø 31st harmonic I

Table 6.3: Display screens via the "HARMONICS" button

6.7.4 "ENERGY" button

The "Energy" button switches through the displays of the fifth line:

Left column	Right column	Value
IMP	kWh	Active energy import
EXP	kWh	Active energy export
NET	kWh	Active energy net amount
TOT	kWh	Total active energy
IMP	kvarh	Reactive energy import
EXP	kvarh	Reactive energy export
nEt	kvarh	Reactive energy net amount
TOT	kvarh	Total reactive energy
S	kVAh	Apparent energy

Table 6.4: Display screens via the "ENERGY" button

6.8 Setup configuration via the front panel

Pressing the "ENERGY" button for more than 3 seconds enters the Setup configuration mode.
Upon completion, pressing the "ENERGY" button for more than 3 seconds returns to the data display mode.

*A **correct password must be entered** before parameter changes are allowed.*
(factory setting: 0)

6.8.1 Setup: Function of buttons

The meanings of the buttons in the Setup mode are indicated below each button:

"**V / I":** arrow button " < "	Moves the cursor to the left by one position if the parameter being changed is a numerical value.
"**POWER":** arrow button " ∧ "	Advances to the next parameter in the menu or increments a numerical value.
"**HARMONICS"**: arrow button " ∨ "	Goes back to the last parameter in the menu or decrements a numerical value.
"**ENERGY":** OK	To confirm the value entered.

6.8.2 Setup: Overview diagram menu

The following diagram will help you to familiarise yourself with the menu.

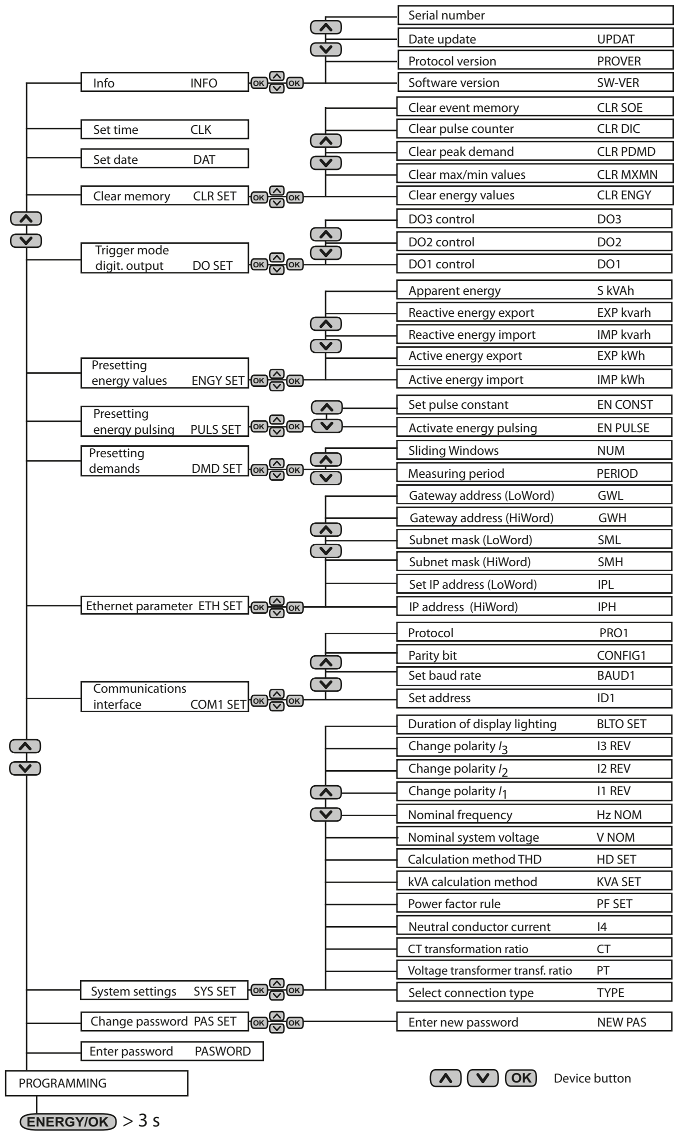


Fig. 6.7: Setup: Overview of setting options

6.9 Setup: adjustment possibilities

The table illustrates the display screens, their meaning and the adjustment possibilities.

Display screen Level 1 / Level 2	Parameters	Description	Adjustment possibilities	Factory setting
PROGRAMMING	Setup mode			
PASWORD	Password	Enter password	/	0
PAS SET		Change password?	YES/NO	NO
NEW PAS	New password	Enter new password	0000…9999	0
SYS SET	System settings		YES/NO	NO
TYPE	Wiring mode	Select wiring mode	WYE/DELTA/ DEMO	WYE
PT	Voltage trans-former	Select the transformation ratio of the voltage trans-former	1…10,000	1
CT	Measuring cur-rent transfor-mers	Select CT transformation ratio	1…30,000 (1 A) 1… 6,000 (5 A)	1
I4	Neutral current	Select CT transformation ratio for I_4	1…10,000	1
PF SET	Power factor rule	Power factor rule*	IEC/IEEE/-IEEE	IEC
KVA SET	*S* calculation method **		V/S	V
HD SET	Harmonic distortion calculation method ***		FUND/RMS	FUND
V NOM	Nominal voltage U_{nom} (equals U_{LL})		100…700 (V)	100
Hz NOM	Nominal frequency f_{nom}		50/60 (Hz)	50

Display screen Level 1 Level 2	Parameters	Description	Adjustment possibilities	Factory setting
I1 REV	I_1 CT	I_1 measuring current transformer, reverse polarity	YES/NO	NO
I2 REV	I_2 CT	*I2* measuring current transformer, reverse polarity	YES/NO	NO
I3 REV	I3 CT	I_3 measuring current transformer, reverse polarity	YES/NO	NO
BLTO SET	Display backlight	Backlight timeout	0…60 (minutes)	3
COM 1 SET	Configure communications interface		YES/NO	NO
ID1	Measuring device address	Set address for measuring device	1…247	100
BAUD1	Baud rate	Set baud rate	1200/2400/ 4800/9600/ 19200 bps	9600
CONFIG1	Parity bit	Parity bit configuration	8N2/8O1/8E1/ 8N1/8O2/8E2	8E1
PRO	Protocol		MODBUS/ EGATE	Modbus
ETH SET	Configure Ethernet parameters		YES/NO	NO
IPH	IP address (HiWord)			192.168
IPL	IP address (LoWord)			8.97
SMH	Subnet mask (HiWord)			255.255
SML	Subnet mask (LoWord)			255.0

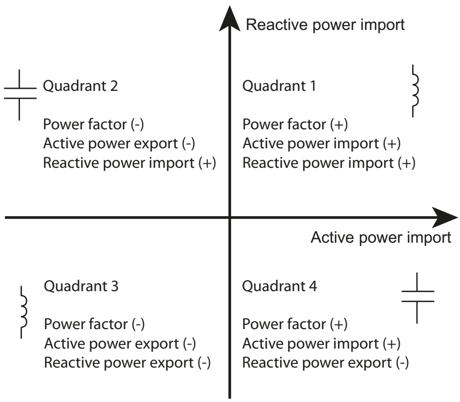
Display screen Level 1 Level 2	Parameters	Description	Adjustment possibilities	Factory setting
GWH	Gateway address (HiWord)			192.168
GWL	Gateway address (LoWord)			8.1
DMD SET	Demand measurement on/off		YES/NO	NO
PERIOD	Set demand period		1…99 (minutes)	15
NUM	Set number of sliding windows		1…15	1
PULS SET	Set pulse output		YES/NO	NO
EN PULSE	Energy pulsing	Enable kWh and kvarh energy pulsing	YES/NO	NO
EN CONST	Pulse constant	Number of LED pulses per amount of energy	1 K	1K
ENGY SET	Presetting of energy values		YES/NO	NO
IMP kWh	Active energy import	Preset active energy import	0… 999.999.999	0
EXP kWh	Active energy export	Preset active energy export	0… 999.999.999	0
IMP kvarh	Reactive energy import	Preset reactive energy import	0… 999.999.999	0
EXP kvarh	Reactive energy export	Presetting of reactive energy export	0… 999.999.999	0
kVAh	Apparent energy	Preset apparent energy	0… 999.999.999	0
DO SET	Change trigger mode for digital outputs		YES/NO	NO
DO1	Operating mode DO1	Set operating mode DO1	NORMAL/ON/ OFF	NOR- MAL

Display screen Level 1 Level 2	Parameters	Description	Adjustment possibilities	Factory setting
DO2	Operating mode DO2	Set operating mode DO2	NORMAL/ON/ OFF	NOR- MAL
DO3	Operating mode DO3	Set operating mode DO3	NORMAL/ON/ OFF	NOR- MAL
CLR SET	Clear memory		YES/NO	NO
CLR ENGY	Clear energy values	Clear kWh, kvar and kVAh	YES/NO	NO
CLR MXMN	Clear Max and Min values of this month		YES/NO	NO
CLR PDMD	Clear peak demand values of this month		YES/NO	NO
CLR DIC	Clear pulse counter		YES/NO	NO
CLR SOE	Clear event log		YES/NO	NO
DAT	Date	Set current date	YY-MM-DD	/
CLK	Time	Set current time	HH:MM:SS	/
Info	Device information (read only)		YES/NO	NO
SW-VER	Software version		/	/
PRO VER	Protocol version (50 means V5.0)		/	/
UPDAT	Date of the latest software update	yymmdd	/	/
	Serial number device		/	/

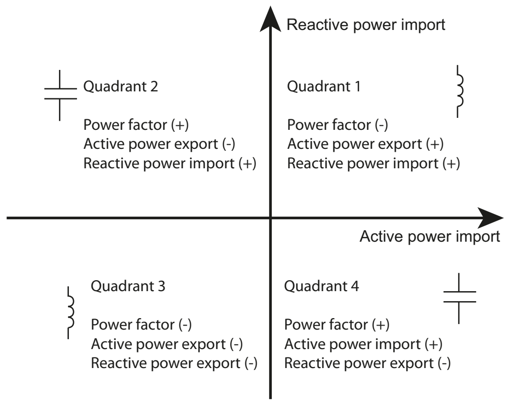
Table 6.5: Setup adjustment possibilities

Explanatory notes on table 6.5

*Power factor λ rules



IEC



IEEE

"**IEEE**" is the same as "**-IEEE**" but with the opposite sign.

** There are two ways **to calculate the apparent power *S*:**

Vector method V:

$$S_{ges} = \sqrt{P_{ges}^{2} + Q_{ges}^{2}}$$

Scalar method S:

$$S_{ges} = S_{L1} + S_{L2} + S_{L3}$$

Choose the calculation method:
V = Vector method
S = Scalar method

***There are two ways to **calculate** the **individual harmonic distortion:**

FUND
"Fundamental":

THD calculation of an individual harmonic (related to fundamental U_1 resp. I_1)

$$THD_{U(k)} = \frac{U_k}{U_1} \times 100\ \%$$

$$THD_{I(k)} = \frac{I_k}{I_1} \times 100\ \%$$

RMS
"Root Mean Square":

Distortion factor calculation of an individual harmonic (THF, related to the total value U_{ges} resp. I_{ges})

$$THF_{U(k)} = \frac{U_k}{\sqrt{\sum_{k=1}^{\infty} U_k^2}} \times 100\ \%$$

$$THF_{I(k)} = \frac{I_k}{\sqrt{\sum_{k=1}^{\infty} I_k^2}} \times 100\ \%$$

6.10 Configuration example

Setting of the transformation ratio for the measuring current transformer 1000:5 (=200)

Button	Display text	Description
OK > 3 s	PROGRAMMING	
⋀	PASWORD ****	
OK	PASWORD 0	0 flashes
OK	PASWORD 0	0 = factory setting
⋀	PAS SET NO	
⋀	SYS SET NO	
OK	SYS SET NO	NO flashes
⋀or⋁	SYS SET YES	YES flashes
OK	SYS SET YES	
⋀	TYPE WYE	Default setting
⋀	PT 1	Default setting
⋀	CT 1	Default setting
OK	CT 1	1 flashes (units place)
⋁	CT 0	0 flashes (units place)
<	CT 00	0 on the left flashes (tens place)
<	CT 0 0	0 on the left flashes (hundreds place)
⋀⋀	CT 200	2 flashes
OK	CT 200	CT ratio 200 set
OK > 3 s	Standard display	

Table 6.6: Configuration example

7. Application/inputs and outputs

7.1 Digital inputs (DI)

The device features six digital inputs which are internally operated with DC 24 V. Digital inputs are typically used for monitoring external states. The switching states of the digital inputs are indicated on the display or on connected system components. Changes in external statuses are stored as events in the SOE log in 1 ms resolution.

7.2 Digital outputs (DO)

The device features three digital outputs. **Digital outputs** are typically used for **active setpoint alarming**, **load control** or **remote control applications**.
Examples:

1. Manually operated from the front panel
   (see chapter 6.8 Setup configuration via the front panel)
2. Operation via communications interface (see chapter 10.15 DOx control).
3. Control setpoints: Control actions when a setpoint is exceeded
   (see chapter 7.6 Setpoints).
4. Triggered by transient events
   (see chapter 9.3 Setpoint Transient events).

Priority: Front panel control has a higher priority and overwrites the other applications. A general alarm can be activated when all setpoints control the same digital output. However, if the user intends to trigger a specific alarm, each DO may be controlled by one source only.

7.3 Energy pulsing output

The two LED pulse outputs are used for kWh and kvarh indication, if the function EN PULSE is enabled. Energy pulsing can be enabled from the front panel through the EN Pulse setup parameter or via the communications interface.

The LEDs flash each time a certain amount of energy is measured (1 kWh resp. 1 kvarh). In order to relate the flashing frequency to the amount of energy, the transformation ratios and the pulse constant have to be considered.

$$\text{pulses/kWh} = \frac{\text{pulse constant}}{\text{ratio VT x ratio CT}}$$

$$\text{energy/pulse} = \frac{\text{ratio VT x ratio CT}}{\text{pulse constant}}$$

Note:

VT = voltage transformer

CT = measuring current transformer

7.4 Power and energy

7.4.1 Basic measurements

The PEM555 provides the following basic measurements with a 1 second update rate:

- Three-phase voltages
- Three-phase currents
- Three-phase power
- Three-phase power factors λ
- Neutral current
- Frequency
- Energy import and export
- Voltage and current phase angles

7.4.2 Voltage and current phase angles

Phase angle analysis is used to identify the angle relationship between the voltages and currents of the three line conductors.

7.4.3 Energy

Basic energy measured quantities are:

- Active energy (import, export, net energy and total energy in kWh)
- Reactive energy (import, export, net energy and total energy in kvarh)
- Apparent energy(in kVAh)

The maximum value to be displayed is ± 999,999,999,99. When the maximum value is reached, the register will automatically roll over to zero. The counter value can be edited via software or through the front panel, password required.

7.5 Demand DMD

The demand is defined as an average consumption value over a fixed demand period. PEM555 supports the "Sliding window" measurement. In addition to the measurement period, also the number of the measurement periods to be considered are specified here. The following parameters can be set:

- **Number of measurement periods** (1…15)
- **Duration of measurement** (1…99 min)
  Example of a sliding window:
  Number of measurement periods: 3
  Duration of measurements: 20 min
  Measurement period for Sliding window: 3 x 20 min = 60 min

The following demand values are determined

- Voltages (U_1, U_2, U_3, ØU_{LN}, U_{L1L2}, U_{L2L3}, U_{L3L1}, ØU_{LL})
- Currents (I_1, I_2, I_3, Ø I, I_4)
- Active power P (P_1, P_2, P_3, P_{ges})
- Reactive power Q (Q_1, Q_2, Q_3, Q_{ges})
- Apparent power S (S_1, S_2, S_3, S_{ges})
- Power factor λ (λ_1, λ_2, λ_3, λ_{ges})
- Frequency
- Voltage unbalance
- Current unbalance
- Total harmonic distortion, voltage
  (THD_{U1}, THD_{U2}, THD_{U3})
- Total harmonic distortion, current
  (THD_{I1}, THD_{I2}, THD_{I3})

The **demand period** can be set using the buttons on the front panel or via the communications interface.
During the measurement period for sliding window (duration multiplied by the number of measurement periods) the consumption resp. the imported power is measured. Then the average demand value is indicated on the display and output via the communication interface.
The maximum demand value determined over the whole recording period (**peak demand**/) will be saved and displayed. The peak demand can be reset manually.
Setting possibilities see chapter 6.9 Setup: adjustment possibilities.

Extremal demand values per demand period

The PEM555 records the min and max values of the following measurements for each demand period

- Three-phase voltages
- Three-phase currents
- I_4
- Three-phase frequencies
- Total power
- Three-phase power factors λ
- Voltage unbalance
- Current unbalance
- Total harmonic distortion, voltage (THD_U)
- Total harmonic distortion, current (THD_I)

All recorded measuring values can be accessed via the communications interface.

7.6 Setpoints

The PEM555 features 9 user-programmable control setpoints which provide extensive control by allowing a user to initiate an action in response to a specific event (registers 6600...6689). The alarm symbol on the right side of the LC display is lit if there are any active setpoints.

Setpoints can be programmed via the **communications interface.**
The following **setup parameters** are provided:

1. **Setpoint type:** Specifies the monitoring condition (over setpoint or under setpoint) or is disabled.
2. **Setpoint parameters**: specifies the measured quantities to be monitored;

Key for setpoint	Measured quantity	Factor; Unit
1	U_{LN}	x 100; V
2	U_{LL}	x 100; V
3	I	x 1,000; A
4	I_4	x 1,000; A
5	f	x 100, Hz

Key for setpoint	Measured quantity	Factor; Unit
6	P_{ges}	kW
7	Q_{ges}	kvar
8	λ	x 1,000
9	DI1	**Over setpoint** active limit: DI= 1 (close) inactive limit: DI = 0 (open) **Under setpoint** active limit: DI= 0 (open) inactive limit: DI = 1 (close)
10	DI2	
11	DI3	
12	DI4	
13	DI5	
14	DI6	
15	Reserved	
16	Demand P_{ges}	kW
17	Demand Q_{ges}	kvar
18	Demand λ	x 1,000
19	THD_U	x 100, %
20	$TOHD_U$	x 100, %
21	$TEHD_U$	x 100, %
22	THD_I	x 100, %
23	$TOHD_I$	x 100, %
24	$TEHD_I$	x 100, %
25	Unbalance *U*	x 10, %
26	Unbalance *I*	x 10, %

Table 7.1: Setpoint parameters: Measured quantities

3. **Setpoint limit (active limit)**: Specifies the
   upper limits (*over*setpoint) resp.
   lower limits (*under*setpoint)
   that have to be violated before the setpoint becomes active (response value).

4. **Setpoint limit (inactive limit)**: Specifies the
lower limits (*over* setpoint) resp.
the upper limits (*under*setpoint)
that have to be violated before the setpoint becomes inactive, e.g. before returning to normal condition).
5. **Response delay:** Specifies the minimum period that a limit value must have been violated before an action is triggered.
Each status change of a setpoint generates an event that is stored in the event log. The range of the setpoint response delay is between 0…9.999 seconds.
6. **Delay on release:** Specifies the minimum period that the setpoint return condition must have met before returning to normal condition.
Each status change of a setpoint generates an event that is stored in the event log. The range of the setpoint delay on release is between 0…9.999 seconds.
7. **Setpoint trigger**: Specifies what action is carried out when the setpoint is activated. This action includes "No Trigger" and "Trigger DOx".

Key	Action	Key	Action
0	-	**11**	DR 8
1	DO1	**12**	DR 9
2	DO2	**13**	DR 10
3	DO3	**14**	DR 11
4	DR 1	**15**	DR 12
5	DR 2	**16**	DR 13
6	DR 3	**17**	DR 14
7	DR 4	**18**	DR 15
8	DR 5	**19**	DR 16
9	DR 6	**20**	WFR1
10	DR 7	**21**	WFR2

Table 7.2: Setpoint trigger

8. Data logging

8.1 Peak demand memory

The PEM555 stores the peak demand of the last month and this month with timestamp for I_1, I_2, I_3, P_{ges}, Q_{ges} and S_{ges} . All values can be accessed through the front panel buttons as well as the communications interface. Data for this month can be deleted through the front panel buttons as well as the communications interface.

8.2 Memory for Max/Min values

The PEM555 stores each new maximum and minimum value of this month and last month. Details about the applied **registers** and their data structure you will find beginning on **page 98**.
The stored values are listed in the table below.

This month		Last month	
Maximum values	**Minimum values**	**Maximum values**	**Minimum values**
$U_{L1\ max}$	$U_{L1\ min}$	$U_{L1\ max}$	$U_{L1\ min}$
$U_{L2\ max}$	$U_{L2\ min}$	$U_{L2\ max}$	$U_{L2\ min}$
$U_{L3\ max}$	$U_{L3\ min}$	$U_{L3\ max}$	$U_{L3\ min}$
Ø $U_{LN\ max}$	Ø $U_{LN\ min}$	Ø $U_{LN\ max}$	Ø $U_{LN\ min}$
$U_{L1L2\ max}$	$U_{L1L2\ min}$	$U_{L1L2\ max}$	$U_{L1L2\ min}$
$U_{L2L3\ max}$	$U_{L2L3\ min}$	$U_{L2L3\ max}$	$U_{L2L3\ min}$
$U_{L3L1\ max}$	$U_{L3L1\ min}$	$U_{L3L1\ max}$	$U_{L3L1\ min}$
Ø $U_{LL\ max}$	Ø $U_{LL\ min}$	Ø $U_{LL\ max}$	Ø $U_{LL\ min}$
$I_{1\ max}$	$I_{1\ min}$	$I_{1\ max}$	$I_{1\ min}$
$I_{2\ max}$	$I_{2\ min}$	$I_{2\ max}$	$I_{2\ min}$
$I_{3\ max}$	$I_{3\ min}$	$I_{3\ max}$	$I_{3\ min}$
Ø I_{max}	Ø I_{min}	Ø I_{max}	Ø I_{min}
$I4_{max}$	$I4_{min}$	$I4_{max}$	$I4_{min}$

This month		Last month	
Maximum values	**Minimum values**	**Maximum values**	**Minimum values**
$P_{ges\ max}$	$P_{ges\ min}$	$P_{ges\ max}$	$P_{ges\ min}$
$Q_{ges\ max}$	$Q_{ges\ min}$	$Q_{ges\ max}$	$Q_{ges\ min}$
$S_{ges\ max}$	$S_{ges\ min}$	$S_{ges\ max}$	$S_{ges\ min}$
$\lambda_{ges\ max}$	$\lambda_{ges\ min}$	$\lambda_{ges\ max}$	$\lambda_{ges\ min}$
f_{max}	f_{min}	f_{max}	f_{min}
THD $U_{L1\ max}$	THD $U_{L1\ min}$	THD $U_{L1\ max}$	THD $U_{L1\ min}$
THD $U_{L2\ max}$	THD $U_{L2\ min}$	THD $U_{L2\ max}$	THD $U_{L2\ min}$
THD $U_{L3\ max}$	THD $U_{L3\ min}$	THD $U_{L3\ max}$	THD $U_{L3\ min}$
THD $I_{1\ max}$	THD $I_{1\ min}$	THD $I_{1\ max}$	THD $I_{1\ min}$
THD $I_{2\ max}$	THD $I_{2\ min}$	THD $I_{2\ max}$	THD $I_{2\ min}$
THD $I_{3\ max}$	THD $I_{3\ min}$	THD $I_{3\ max}$	THD $I_{3\ min}$
(k-factor $I1)_{max}$	(k-factor $I1)_{min}$	(k-factor $I1)_{max}$	(k-factor $I1)_{min}$
(k-factor $I2)_{max}$	(k-factor $I_2)_{min}$	(k-factor $I2)_{max}$	(k-factor $I_2)_{min}$
(k-factor $I_3)_{max}$	(k-factor I3$)_{min}$	(k-factor $I_3)_{max}$	(k-factor I3$)_{min}$
max. unbalance *U*	min. unbalance *U*	max. unbalance *U*	min. unbalance *U*
max. unbalance *I*	min. unbalance *I*	max. unbalance *I*	min. unbalance *I*

Table 8.1: Max/Min memory for this month and last month

8.3 Data recorder (DR)

PEM555 has an internal memory of 2 MB and provides 16 data recorders. Each of these recorders is capable of recording 16 measured quantities. Programming of the data recorders is carried out exclusively via the communications interface.

Details about the applied **registers** and their data structure you will find on **page 59.**

8.3.1 Setup parameters

The following setup parameters are supported:

No.	Parameters	Setting
1	Trigger mode	0 = disabled 1 by timer 2 = by setpoint
2	Recording mode	0 = stop-when-full 1 = FIFO (first-in-first-out) (ring memory)
3	Number of records	0…65,535 (entries)
4	Recording interval	0…3,456,000 seconds (40 days)
5	Recording delay [1)]	0…43,200 seconds (12 h)
6	Number of measured quantities	0…16
7	Measured quantities 1…16 (see table 8.3)	0…322

Table 8.2: Setup data recorder

Notes on table 8.2

*The **data recorder is only operational** when the **parameters 1…4 are all non-zero**!*

[1] Recording delay":

In Trigger mode 1, a fixed time can be set in seconds to delay the start of the measurement (triggered by timer). Example: "300" means that the start of the measurement will be delayed by 5 minutes after being triggered by timer. In order to obtain evaluable results, the time set for recording delay should be less than that of the recording interval.

For Trigger mode 2, a recording delay cannot be set.

For details refer to
- Modbus register 7000…7383 (page 111).
- Data structure data recorder (page 113)

8.3.2 Key to measured quantities used for data recorders

16 measured quantities per data recorder can be selected from the table below:

Key	Measured quantity (data recorder)	Factor/unit
0	U_{L1}	x 100, V
1	U_{L2}	x 100, V
2	U_{L3}	x 100, V
3	Ø U_{LN}	x 100, V
4	U_{L1L2}	x 100, V
5	U_{L2L3}	x 100, V
6	U_{L3L1}	x 100, V
7	Ø U_{LL}	x 100, V
8	*I1*	x 1,000, A
9	*I2*	x 1,000, A
10	*I3*	x 1,000, A
11	Ø *I*	x 1,000, A
12	I_4 (measured)	x 1,000, A
13	P_{L1}	W
14	P_{L2}	W
15	P_{L3}	W
16	P_{ges}	W

Key	Measured quantity (data recorder)	Factor/unit
17	Q_{L1}	var
18	Q_{L2}	var
19	Q_{L3}	var
20	Q_{ges}	var
21	S_{L1}	VA
22	S_{L2}	VA
23	S_{L3}	VA
24	S_{ges}	VA
25	λ_{L1}	x 1,000
26	λ_{L2}	x 1,000
27	λ_{L3}	x 1,000
28	λ_{ges}	x 1,000
29	f	x 100, Hz
30	Counter DI1	
31	Counter DI2	
32	Counter DI3	
33	Counter DI4	
34	Counter DI5	
35	Counter DI6	
36	Voltage unbalance	x 1,000
37	Current unbalance	x 1,000
38	k-factor I_1	x 10
39	k-factor I_2	x 10
40	k-factor I_3	x 10
41	THD_{UL1}	x 10,000
42	THD_{UL2}	x 10,000
43	THD_{UL3}	x 10,000
44	$TOHD_{UL1}$	x 10,000
45	$TOHD_{UL2}$	x 10,000
46	$TOHD_{UL3}$	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
47	$TEHD_{UL1}$	x 10,000
48	$TEHD_{UL2}$	x 10,000
49	$TEHD_{UL3}$	x 10,000
50	THD_{I1}	x 10,000
51	THD_{I2}	x 10,000
52	THD_{I3}	x 10,000
53	$TOHD_{I1}$	x 10,000
54	$TOHD_{I2}$	x 10,000
55	$TOHD_{I3}$	x 10,000
56	$TEHD_{I1}$	x 10,000
57	$TEHD_{I2}$	x 10,000
58	$TEHD_{I3}$	x 10,000
59	U_{L1} 2^{nd} harmonic	x 10,000
60	U_{L2} 2^{nd} harmonic	x 10,000
61	U_{L3} 2^{nd} harmonic	x 10,000
62	U_{L1} 3^{rd} harmonic	x 10,000
63	U_{L2} 3^{rd} harmonic	x 10,000
64	U_{L3} 3^{rd} harmonic	x 10,000
65	U_{L1} 4^{nd} harmonic	x 10,000
66	U_{L2} 4^{th} harmonic	x 10,000
67	U_{L3} 4^{th} harmonic	x 10,000
68	U_{L1} 5^{th} harmonic	x 10,000
69	U_{L2} 5^{th} harmonic	x 10,000
70	U_{L3} 5^{th} harmonic	x 10,000
71	U_{L1} 6^{th} harmonic	x 10,000
72	U_{L2} 6^{th} harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
73	U_{L3} 6th harmonic	x 10,000
74	U_{L1} 7nd harmonic	x 10,000
75	U_{L2} 7th harmonic	x 10,000
76	U_{L3} 7th harmonic	x 10,000
77	U_{L1} 8th harmonic	x 10,000
78	U_{L2} 8th harmonic	x 10,000
79	*UL3* 8th harmonic	x 10,000
80	U_{L1} 9th harmonic	x 10,000
81	U_{L2} 9th harmonic	x 10,000
82	*UL3* 9th harmonic	x 10,000
83	U_{L1} 10th harmonic	x 10,000
84	U_{L2} 10th harmonic	x 10,000
85	U_{L3} 10th harmonic	x 10,000
86	U_{L1} 11th harmonic	x 10,000
87	U_{L2} 11th harmonic	x 10,000
88	U_{L2} 11th harmonic	x 10,000
89	U_{L1} 12th harmonic	x 10,000
90	U_{L2} 12th harmonic	x 10,000
91	U_{L3} 12th harmonic	x 10,000
92	U_{L1} 13th harmonic	x 10,000
93	U_{L2} 13th harmonic	x 10,000
94	U_{L3} 13th harmonic	x 10,000
95	U_{L1} 14th harmonic	x 10,000
96	U_{L2} 14th harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
97	U_{L3} 14th harmonic	x 10,000
98	U_{L1} 15th harmonic	x 10,000
99	U_{L2} 15th harmonic	x 10,000
100	U_{L3} 15th harmonic	x 10,000
101	U_{L1} 16th harmonic	x 10,000
102	U_{L2} 16th harmonic	x 10,000
103	U_{L3} 16th harmonic	x 10,000
104	U_{L1} 17th harmonic	x 10,000
105	U_{L2} 17th harmonic	x 10,000
106	U_{L3} 17th harmonic	x 10,000
107	U_{L1} 18th harmonic	x 10,000
108	U_{L2} 18th harmonic	x 10,000
109	U_{L3} 18th harmonic	x 10,000
110	U_{L1} 19th harmonic	x 10,000
111	U_{L2} 19th harmonic	x 10,000
112	U_{L3} 19th harmonic	x 10,000
113	U_{L1} 20th harmonic	x 10,000
114	U_{L2} 20th harmonic	x 10,000
115	U_{L3} 20th harmonic	x 10,000
116	U_{L1} 21st harmonic	x 10,000
117	U_{L2} 21st harmonic	x 10,000
118	U_{L2} 21st harmonic	x 10,000
119	U_{L1} 22nd harmonic	x 10,000
120	U_{L2} 22nd harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
121	U_{L3} 22nd harmonic	x 10,000
122	U_{L1} 23nd harmonic	x 10,000
123	U_{L2} 23rd harmonic	x 10,000
124	U_{L3} 23rd harmonic	x 10,000
125	U_{L1} 24th harmonic	x 10,000
126	U_{L2} 24th harmonic	x 10,000
127	U_{L3} 24th harmonic	x 10,000
128	U_{L1} 25th harmonic	x 10,000
129	U_{L2} 25th harmonic	x 10,000
130	U_{L3} 25th harmonic	x 10,000
131	I_1 2nd harmonic	x 10,000
132	I_2 2nd harmonic	x 10,000
133	I_3 2nd harmonic	x 10,000
134	I_1 3rd harmonic	x 10,000
135	I_2 3rd harmonic	x 10,000
136	I_3 3rd harmonic	x 10,000
137	I_1 4th harmonic	x 10,000
138	I_2 4th harmonic	x 10,000
139	I_3 4th harmonic	x 10,000
140	I_1 5th harmonic	x 10,000
141	I_2 5th harmonic	x 10,000
142	I_3 5th harmonic	x 10,000
143	I_1 6th harmonic	x 10,000
144	I_2 6th harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
145	I_3 6^{th} harmonic	x 10,000
146	I_1 7^{th} harmonic	x 10,000
147	I_2 7^{th} harmonic	x 10,000
148	I_3 7^{th} harmonic	x 10,000
149	I_1 8^{th} harmonic	x 10,000
150	I_2 8^{th} harmonic	x 10,000
151	I_3 8^{th} harmonic	x 10,000
152	I_1 9^{th} harmonic	x 10,000
153	I_2 9^{th} harmonic	x 10,000
154	I_3 9^{th} harmonic	x 10,000
155	I_1 10^{th} harmonic	x 10,000
156	I_2 10 th harmonic	x 10,000
157	I_3 10^{th} harmonic	x 10,000
158	I_1 11^{th} harmonic	x 10,000
159	I_2 11^{th} harmonic	x 10,000
160	I_2 11^{th} harmonic	x 10,000
161	I_1 12^{th} harmonic	x 10,000
162	I_2 12^{th} harmonic	x 10,000
163	I_3 12^{th} harmonic	x 10,000
164	I_1 13^{th} harmonic	x 10,000
165	I_2 13^{th} harmonic	x 10,000
166	I_3 13^{th} harmonic	x 10,000
167	I_1 14^{th} harmonic	x 10,000
168	I_2 14^{th} harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
169	I_3 14th harmonic	x 10,000
170	I_1 15th harmonic	x 10,000
171	I_2 15th harmonic	x 10,000
172	I_3 15th harmonic	x 10,000
173	I_1 16th harmonic	x 10,000
174	I_2 16th harmonic	x 10,000
175	I_3 16th harmonic	x 10,000
176	I_1 17th harmonic	x 10,000
177	I_2 17th harmonic	x 10,000
178	I_3 17th harmonic	x 10,000
179	I_1 18th harmonic	x 10,000
180	I_2 18th harmonic	x 10,000
181	I_3 18th harmonic	x 10,000
182	I_1 19th. harmonic	x 10,000
183	I_2 19th harmonic	x 10,000
184	I_3 19th harmonic	x 10,000
185	I_1 20th harmonic	x 10,000
186	I_2 20th harmonic	x 10,000
187	I_3 20th harmonic	x 10,000
188	I_1 21st harmonic	x 10,000
189	I_2 21st harmonic	x 10,000
190	I_2 21st harmonic	x 10,000
191	I_1 22nd harmonic	x 10,000
192	I_2 22nd harmonic	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
193	I_3 22nd harmonic	x 10,000
194	I_1 23rd harmonic	x 10,000
195	I_2 23rd harmonic	x 10,000
196	I_3 23rd harmonic	x 10,000
197	I_1 24th harmonic	x 10,000
198	I_2 24th harmonic	x 10,000
199	I_3 24th harmonic	x 10,000
200	I_1 25th harmonic	x 10,000
201	I_2 25th harmonic	x 10,000
202	I_3 25th harmonic	x 10,000
203	Demand U_{L1}	x 100, V
204	Demand U_{L2}	x 100, V
205	Demand U_{L3}	x 100, V
206	Ø Demand U_{LN}	x 100, V
207	Demand U_{L1L2}	x 100, V
208	Demand U_{L2L3}	x 100, V
209	Demand U_{L3L1}	x 100, V
210	Ø Demand U_{LL}	x 100, V
211	Demand I_1	x 1,000 A
212	Demand I_2	x 1,000 A
213	Demand I_3	x 1,000 A
214	Ø Demand I	x 1,000 A
215	Demand I_4 1)	x 1,000 A
216	Demand P_{L1}	W
217	Demand P_{L2}	W
218	Demand P_{L3}	W

Key	Measured quantity (data recorder)	Factor/unit
219	Demand P_{ges}	W
220	Demand Q_{L1}	var
221	Demand Q_{L2}	var
222	Demand Q_{L3}	var
223	Demand Q_{ges}	var
224	Demand S_{L1}	VA
225	Demand S_{L2}	VA
226	Demand S_{L3}	VA
227	Demand S_{ges}	VA
228	Demand λ_1	x 1,000
229	Demand λ_2	x 1,000
230	Demand λ_3	x 1,000
231	Demand λ_{ges}	x 1,000
232	Demand f	x 100, Hz
233	Demand voltage unbalance	x 1,000
234	Demand current unbalance	x 1,000
235	Demand THD_{UL1}	x 10,000
236	Demand THD_{UL2}	x 10,000
237	Demand THD_{UL3}	x 10,000
238	Demand THD_{I1}	x 10,000
239	Demand THD_{I2}	x 10,000
240	Demand THD_{I3}	x 10,000
241	$U_{L1\ max}$ (per demand period)	x 100, V
242	$U_{L2\ max}$ (per demand period)	x 100, V
243	$U_{L3\ max}$ (per demand period)	x 100, V
244	Ø $U_{LN\ max}$ (per demand period)	x 100, V
245	$U_{L1L2\ max}$ (per demand period)	x 100, V
246	$U_{L2L3\ max}$ (per demand period)	x 100, V

Key	Measured quantity (data recorder)	Factor/unit
247	$U_{L3L1\ max}$ (per demand period)	x 100, V
248	Ø $U_{LL\ max}$ (per demand period)	x 100, V
249	$I_{1\ max}$ (per demand period)	x 1,000 A
250	$I_{2\ max}$ (per demand period)	x 1,000 A
251	$I_{3\ max}$ (per demand period)	x 1,000 A
252	Ø I_{max} (per demand period)	x 1,000 A
253	$I_{4\ max}$ (per demand period)	x 1,000 A
254	$P_{L1\ max}$ (per demand period)	W
255	$P_{L2\ max}$ (per demand period)	W
256	$P_{L3\ max}$ (per demand period)	W
257	$P_{ges\ max}$ (per demand period)	W
258	$Q_{L1\ max}$ (per demand period)	var
259	$Q_{L2\ max}$ (per demand period)	var
260	$Q_{L3\ max}$ (per demand period)	var
261	$Q_{ges\ max}$ (per demand period)	var
262	$S_{L1\ max}$ (per demand period)	VA
263	$S_{L2\ max}$ (per demand period)	VA
264	$S_{L3\ max}$ (per demand period)	VA
265	$S_{ges\ max}$ (per demand period)	VA
266	$\lambda_{1\ max}$ (per demand period)	x 1,000
267	$\lambda_{2\ max}$ (per demand period)	x 1,000
268	$\lambda_{3\ max}$ (per demand period)	x 1,000
269	$\lambda_{ges\ max}$ (per demand period)	x 1,000
270	f_{max} (per demand period)	x 100, Hz
271	max. voltage unbalance (per demand period)	x 1,000
272	max. current unbalance (per demand period)	x 1,000
273	$THD_{UL1\ max}$ (per demand period)	x 10,000
274	$THD_{UL2\ max}$ (per demand period)	x 10,000

Key	Measured quantity (data recorder)	Factor/unit
275	$THD_{UL3\ max}$ (per demand period)	x 10,000
276	$THD_{I1\ max}$ (per demand period)	x 10,000
277	$THD_{I2\ max}$ (per demand period)	x 10,000
278	$THD_{I3\ max}$ (per demand period)	x 10,000
279	$U_{L1\ min}$ (per demand period)	x 100, V
280	$U_{L2\ min}$ (per demand period)	x 100, V
281	$U_{L3\ min}$ (per demand period)	x 100, V
282	Ø $U_{LN\ min}$ (per demand period)	x 100, V
283	$U_{L1L2\ min}$ (per demand period)	x 100, V
284	$U_{L2L3\ min}$ (per demand period)	x 100, V
285	$U_{L3L1\ min}$ (per demand period)	x 100, V
286	Ø $U_{LL\ min}$ (per demand period)	x 100, V
287	$I_{1\ min}$ (per demand period)	x 1,000 A
288	$I_{2\ min}$ (per demand period)	x 1,000 A
289	$I_{3\ min}$ (per demand period)	x 1,000 A
290	Ø I_{min} (per demand period)	x 1,000 A
291	$I_{4\ min}$ (per demand period)	x 1,000 A
292	$P_{L1\ min}$ (per demand period)	W
293	$P_{L2\ min}$ (per demand period)	W
294	$P_{L3\ min}$ (per demand period)	W
295	$P_{ges\ min}$ (per demand period)	W
296	$Q_{L1\ min}$ (per demand period)	var
297	$Q_{L2\ min}$ (per demand period)	var
298	$Q_{L3\ min}$ (per demand period)	var
299	$Q_{ges\ min}$ (per demand period)	var
300	$S_{L1\ min}$ (per demand period)	VA
301	$S_{L2\ min}$ (per demand period)	VA
302	$S_{L3\ min}$ (per demand period)	VA

Key	Measured quantity (data recorder)	Factor/unit
303	$S_{ges\ min}$ (per demand period)	VA
304	$\lambda_{1\ min}$ (per demand period)	x 1,000
305	$\lambda_{2\ min}$ (per demand period)	x 1,000
306	$\lambda_{3\ min}$ (per demand period)	x 1,000
307	$\lambda_{ges\ min}$ (per demand period)	x 1,000
308	f_{min} (per demand period)	x 100, Hz
309	min. voltage unbalance (per demand period)	x 1,000
310	min. current unbalance (per demand period)	x 1,000
311	$THD_{UL1\ min}$ (per demand period)	x 10,000
312	$THD_{UL2\ min}$ (per demand period)	x 10,000
313	$THD_{UL3\ min}$ (per demand period)	x 10,000
314	$THD_{I1\ min}$ (per demand period)	x 10,000
315	$THD_{I2\ min}$ (per demand period)	x 10,000
316	$THD_{I3\ min}$ (per demand period)	x 10,000
317	Active energy export $_{ges}$	kWh
318	Active energy import $_{ges}$	kWh
319	Active energy $_{ges}$	kWh
320	Reactive energy export $_{ges}$	kvarh
321	Reactive energy import $_{ges}$	kvarh
322	Reactive energy $_{ges}$	kvarh

Table 8.3: Key to measured quantities for data recorders

8.4 Energy log

The energy log stores the following measured values for a selectable period of time

- Active energy import
- Active energy export
- Reactive energy import
- Reactive energy export
- Apparent energy

These measured values are stored in a non-volatile memory and will not suffer any loss in the event of power failure. For the recording of the total energy values such as P_{ges} or Q_{ges} the data recorder has to be used.
The energy log can only be programmed via the communications interface.
The following setup parameters are supported:

No.	Parameters	Setting
1	Recording mode	0 = disabled 1 = stop-when-full 2 = FIFO (First-In-First-Out)
2	Number of measurements	0…65535 (entries)
3	Recording interval	0 = 5 min 1 = 10 min 2 = 15 min 3 = 30 min 4 = 60 min
4	Start time	yy/mm/dd, hh:mm:ss
5	Number of measured quantities	0…5
6	Measured quantity 1…5	0 = Import P 1 = Export P 2 = Import Q 3 = Export Q 4 = S

Table 8.4: Setup energy log

The energy log will only become active when the setup settings 1…5 are all non-zero.
For details refer to Modbus register 7700…7712.

8.5 Waveform recorder (WFR)

The PEM555 provides two waveform recorders (WFR) which together can store 6 entries. The newest entry will replace the oldest entry on a first-in-first-out basis: The 7th entry overwrites the 1st one, the 8th the second one etc.
WFR data is stored in a non-volatile memory and will not suffer any loss in the event of power failure.
Each waveform recorder can simultaneously record 3-phase voltage and current signals at a maximum resolution of 128 samples per cycle.
Waveform recorders can be triggered by

- Setpoints
- Transient events
- Communications interface (manual)

During this process the **control via communications interface has the highest priority**. Other WFR triggers will be ignored until recording is completed.

The programming of the waveform recorder is only supported by the communications interface. For details about the applied **register** and their data structure, refer to **page 114** ff. The following setup parameters are supported:

No.	Parameters	Setting
1	Number of records	0…6 (entries)
2	Number of samples per cycle	16, 32, 64, 128 (samples)
3	Cycles per record	40, 20, 10, 5 (cycles)
4	Number of cycles before the event	0…5 (cycles)

The total capacity of WFR1 and WFR 2 is 6 entries. The valid formats of "number of samples per cycle" and "Cycles per record" are:

16 x 40
32 x 20
64 x 10
128 x 5

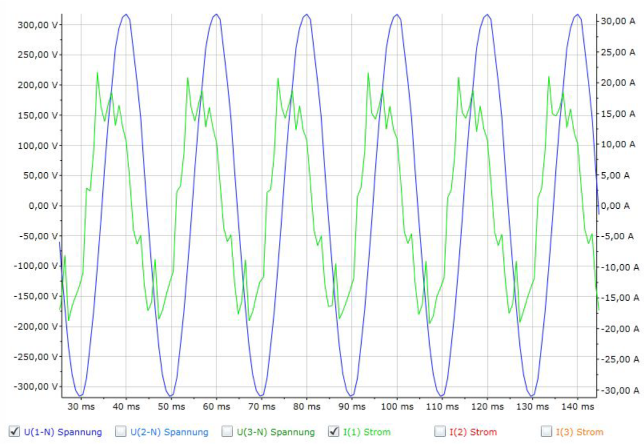


Fig. 8.1: Graphical representation of a waveform recording displayed in CP700

8.6 Event log (SOE log)

The device can store up to 64 events. The newest entry will replace the oldest entry on a first-in-first-out basis: Das 65th event overwrites the first one, the 66th the second one, etc.

Possible events:

- Failure supply voltage
- Setpoint status change
- Relay actions
- Digital input status changes
- Setup changes

Each event record includes the event classification, the relevant parameter values and a timestamp in 1 ms resolution.

All event entries can be retrieved via the communications interface. For details about the applied **register** and their data structure, refer to **page 118** ff.

The event log can be cleared using the buttons on the front panel or via communications interface.

9. Power Quality

9.1 Harmonic distortion

The device provides an analysis of

- Total Harmonic Distortion (THD)
- Even total harmonic distortion (TEHD)
- Odd total harmonic distortion (TOHD)
- k-factor
- All harmonics up to the 31st order

An evaluation of the harmonic components takes place provided that there is a current flow of at least 150 mA (current input 1 A) resp. 750 mA (current input 5 A).
Individual harmonic distortions (THD) or individual distortion factors (THF) are determined.

Harmonic distortion (THD)

$$\text{THD}_{U(k)} = \frac{U_k}{U_1} \times 100\ \%$$

$$\text{THD}_{I(k)} = \frac{I_k}{I_1} \times 100\ \%$$

Distortion factor (THF)

$$\text{THF}_{U(k)} = \frac{U_k}{\sqrt{\sum_{k=1}^{\infty} U_k^2}} \times 100\ \%$$

$$\text{THF}_{I(k)} = \frac{I_k}{\sqrt{\sum_{k=1}^{\infty} I_k^2}} \times 100\ \%$$

k-factor calculation

$$\text{k-factor} = \frac{\sum_{h=1}^{h=h_{max}} (I_h h)^2}{\sum_{h=1}^{h=h_{max}} (I_h)^2}$$

I_h	= rms I of the harmonic No. h
h_{max}	= number of the max. harmonic
h	= harmonic No. h

All harmonics parameters are available through the communications interface. For details about the applied **register** and their data structure, refer to **page 88**.
The values can also be accessed through the buttons on the front panel.

The following measured quantities are supported:

	L1	L2	L3	N
Harmonics, **voltage**	THD	THD	THD	-
	TEHD	TEHD	TEHD	-
	TOHD	TOHD	TOHD	-
	2^{nd} harmonic	2^{nd} harmonic	2^{nd} harmonic	-
	…	…	…	-
	31^{st} harmonic	31^{st} harmonic	31^{st} harmonic	-
Harmonics, **current**	THD	THD	THD	THD
	TEHD	TEHD	TEHD	TEHD
	TOHD	TOHD	TOHD	TOHD
	k-factor	k-factor	k-factor	k-factor
	2^{nd} harmonic	2^{nd} harmonic	2^{nd} harmonic	2^{nd} harmonic
	…	…	…	…
	31^{st} harmonic	31^{st} harmonic	31^{st} harmonic	31^{st} harmonic

Table 9.1: Measured quantities: harmonic distortion

9.2 Unbalance

The PEM555 can measure voltage and current Unbalances. The calculation method of Voltage and Current Unbalances is listed below:

$$\text{Unbalance}_U = \frac{U_2}{U_1} \times 100\ \% \qquad \text{Unbalance}_I = \frac{I_2}{I_1} \times 100\ \%$$

U_1 is positive sequence voltage and U_2 is negative sequence voltage;
I_1 is positive sequence current and I_2 is negative sequence current.

With left rotation field the max. display value is 6000 %.

9.3 Setpoint Transient events

The universal measuring device can detect transient events in the event of voltage disturbances. The setpoint parameter setting for transient events can only be carried out via the communications interface (**registers 6059… 6060**). The following set-up parameters are supported:

1. Enable transient events — disabled/enabled
2. Transient event limit — 0.05…1.00 x U_n

9.4 Time synchronisation

The universal measuring device provides timestamps for all recorded data. The clock needs to be configured properly to achieve precise events and power quality analysis. The PEM555 features a clock that has a maximum error of 0.5 s per day. The internal battery keeps the real-time clock running in case of voltage interruption. There are two methods to synchronise the clock:

- SNTP server
- GPS via external device

10. Modbus Register Map

This chapter provides a complete description of the Modbus register (protocol version 6.0) for the PEM555 series to facilitate access to information. In general, the registers are implemented as Modbus Read Only Registers (RO = read only). with the exception of the DO control registers, which are implemented as Write Only Registers (WO = write only).
The PEM555 supports the 4-digit addressing scheme and the following Modbus functions.

1. Holding register for reading values
   (Read Holding Register; function code 0x03)
2. Register for DO status setup
   (Force Single Coil; function code 0x05)
3. Register for device programming
   (Preset Multiple Registers; function code 0x10)
4. General read reference
   (Read General Reference; function code 0x14)

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

Explanatory comments relating to the read reference (function code 0x14)

The Modbus function code "0x14" is used to access data from the

- data recorder (DR log)
- energy log
- Waveform recorder (WFR log)

Data packet structure (function code 0x14)

Read reference request packet (master to PEM)		Read reference response packet (PEM to master)	
Slave address	1 byte	Slave address	1 byte
Function code (0x14)	1 byte	Function code (0x14)	1 byte
Byte count	1 byte	Byte count	1 byte
Sub-Req X, reference type (0x06)	1 byte	Sub-Res X, byte count	1 byte
Sub-Req X, File number	2 bytes	Sub-Res X, Reference type (0x06)	1 byte
Sub-Req X, Start address	2 bytes	Sub-Res X, Register data	NxN_0 bytes
Sub-Req X, Register count	2 bytes	Sub-Res X+1…	
Sub-Req X+1…			
Error check	2 bytes	Error check	2 bytes

Table 10.1: Data packet structure (function code 0x14)

10.1 Basic measurements

Register	Property	Description	Format	Scale/unit
0000	RO	U_{L1} 1)	Float	V
0002	RO	U_{L2} 1)	Float	V
0004	RO	U_{L3} 1)	Float	V
0006	RO	Ø U_{LN}	Float	V
0008	RO	U_{L1L2}	Float	V
0010	RO	U_{L2L3}	Float	V
0012	RO	U_{L3L1}	Float	V
0014	RO	Ø U_{LL}	Float	V
0016	RO	I_1	Float	A
0018	RO	I_2	Float	A
0020	RO	I_3	Float	A
0022	RO	Ø I	Float	A
0024	RO	P_{L1} 1)	Float	W
0026	RO	P_{L2} 1)	Float	W
0028	RO	P_{L3} 1)	Float	W
0030	RO	P_{ges}	Float	W
0032	RO	Q_{L1} 1)	Float	var
0034	RO	Q_{L2} 1)	Float	var
0036	RO	Q_{L3} 1)	Float	var
0038	RO	Q_{ges}	Float	var
0040	RO	S_{L1} 1)	Float	VA
0042	RO	S_{L2} 1)	Float	VA
0044	RO	S_{L3} 1)	Float	VA
0046	RO	S_{ges}	Float	VA
0048	RO	λ_{L1} 1)	Float	

Register	Property	Description	Format	Scale/unit
0050	RO	λ_{L2} 1)	Float	
0052	RO	λ_{L3} 1)	Float	
0054	RO	λ_{ges}	Float	
0056	RO	f	Float	Hz
0058	RO	I_4 (measured)	Float	A
0060	RO	I_0 (= I_4 calculated)	Float	A
0062…0069	Reserved			
0070	RO	Unbalance *U*	UINT16	x 1,000 2)
0071	RO	Unbalance *I*	UINT16	x 1,000
0072…0075	Reserved			
0076	RO	Phase angle U_{L1}	UINT16	x 100, °
0077	RO	Phase angle U_{L2}	UINT16	x 100, °
0078	RO	Phase angle U_{L3}	UINT16	x 100, °
0079	RO	Phase angle I_1	UINT16	x 100, °
0080	RO	Phase angle I_2	UINT16	x 100, °
0081	RO	Phase angle I_3	UINT16	x 100, °
0082…0084	Reserved			
0085	RO	Status digital inputs 3)	UINT16	
0086	RO	Status digital outputs 4)	UINT16	
0087	RO	Alarm 5)	UINT32	
0089	RO	SOE Pointer 6)	UINT32	
0091	Reserved			
0093	RO	WFR1 Log Pointer7)	UINT32	
0095	RO	WFR2 Log Pointer7)	UINT32	
0097	RO	Energy Log Pointer 8)	UINT32	
0099	RO	DR1 Pointer 9)	UINT32	
0101	RO	DR2 Pointer 9)	UINT32	
0103	RO	DR3 Pointer 9)	UINT32	

Register	Property	Description	Format	Scale/unit
0105	RO	DR4 Pointer 9)	UINT32	
0107	RO	DR5 Pointer 9)	UINT32	
…				
0129	RO	DR16 Pointer 9)	UINT32	
0131	RO	Total memory 10)	UINT32	
0133	RO	Available memory 10)	UINT32	

Table 10.2: Basic measurements

Notes on table 10.2:

1) Only in the case of **wye connection** (WYE).

2) "x 1,000" means that the value returned by the register is 1000 times the measured value (the measured value can be determined by dividing the value of the register 1000).

3) Status register 0085:
Represents the **status of the six digital inputs**
B0 B5 for DI1 DI6 (1 = active/closed; 0 = inactive/opened)

4) Status register 0086:
Represents the **status of the three digital outputs**
B0 for DO1 (1 = active/closed; 0 = inactive/opened)
B1 for DO2 (1 = active/closed; 0 = inactive/opened)
B2 for DO3 (1 = active/closed; 0 = inactive/opened)

5) The **alarm register 0087** indicates the various alarm statuses (1 = active, 0 = inactive). Details of the alarm register are shown in the following table:

Bit No.	Alarm by event	Bit No.	Alarm by event
B0	Setpoint 1	**B5**	Setpoint 6
B1	Setpoint 2	**B6**	Setpoint 7
B2	Setpoint 3	**B7**	Setpoint 8
B3	Setpoint 4	**B8**	Setpoint 9
B4	Setpoint 5	**B9…B31**	Reserved

Table 10.3: Bit sequence alarm register (0087)

6) The SOE pointer points to the last entry added. The event log can store up to 64 events. It works like a ring buffer according to the FIFO principle: The 65th value overwrites the first value, the 66th the second one and so on. The event log can be reset in the setup parameter menu (see page 46).

7) The PEM555 utilises two waveform recorders (**WFR**). Each WFR has its own pointer that indicates the most recently added entry in each case. The two WFR together can store up to 6 events. It works like a ring buffer according to the FIFO principle: the 7th entry overwrites the first value, the 8th the second one and so on. The WFR log can be reset via the communications interface.

8) The range of the **Energy Log Pointer** can be between 0 and 0xFFFFFFFF. As soon as the maximum value is reached, it starts again with 0. The Energy Log can always be reset via the communications interface.

9) The PEM555 provides 16 data recorders (DR1…DR16). Each DR has its own pointer that points to the last entry in each case. Each DR can be reset via the communications interface.

10) The total memory size of the PEM555 is 2 MB (2048 kB).
Used memory = 2048 kB - Available memory.

10.2 Energy measurement

Register	Property	Description	Format	Unit
0200	RW	Active energy import	UINT32	kWh
0202	RW	Active energy export	UINT32	kWh
0204	RO	Active energy net amount	INT32	kWh
0206	RO	Total active energy	UINT32	kWh
0208	RW	Reactive energy import	UINT32	kvarh
0210	RW	Reactive energy export	UINT32	kvarh
0212	RO	Reactive energy net amount	INT32	kvarh
0214	RO	Total reactive energy	UINT32	kvarh
0216	RW	Apparent energy	UINT32	kVAh
0218	RO	Reactive energy import, fractional value	Float	Ws
0220	RO	Active energy export, fractional value	Float	Ws
0222	RO	Active energy net value	Float	Ws
0224	RO	Total active energy value	Float	Ws
0226	RO	Reactive energy import value	Float	vars
0228	RO	Reactive energy export value	Float	vars
0230	RO	Reactive energy net value	Float	vars
0232	RO	Total amount of reactive energy	Float	vars
0234	RO	Apparent energy, fractional value	Float	VAs

Table 10.4: Energy measurements

Note:
After reaching the maximum value of 999,999,999 kWh/kvarh/kVAh, the measurement starts again with 0.

10.3 Pulse counter

The value stored in the registers **0350…0360** is 1000 times the actual value, i. e. the measured value can be determined by dividing the register value by 1000.

Register	Property	Description	Format
0350	RW	Pulse counter DI1	UINT32
0352	RW	Pulse counter DI2	UINT32
0354	RW	Pulse counter DI3	UINT32
0356	RW	Pulse counter DI4	UINT32
0358	RW	Pulse counter DI5	UINT32
0360	RW	Pulse counter DI6	UINT32

Table 10.5: Pulse counter

10.4 Fundamental measurement (PQ log)

Register	Property	Description	Format	Unit
0450	RO	$\lambda_{L1\ (f0)}$ [1)]	Float	
0452	RO	$\lambda_{L2\ (f0)}$ [1)]	Float	
0454	RO	$\lambda_{L3\ (f0)}$ [1)]	Float	
0456	RO	$\lambda_{ges\ (f0)}$	Float	
0458	RO	k-factor I_1	UINT16	x 10
0459	RO	k-factor I_2	UINT16	x 10
0460	RO	k-factor I_3	UINT16	x 10
0461	RO	THD_{UL1}	UINT16	x 10,000
0462	RO	THD_{UL2}	UINT16	x 10,000
0463	RO	THD_{UL3}	UINT16	x 10,000
0464	RO	THD_{I1}	UINT16	x 10,000
0465	RO	THD_{I2}	UINT16	x 10,000

Register	Property	Description	Format	Unit
0466	RO	THD_{I3}	UINT16	x 10,000
0467	RO	THD_{I4} [2)] or reserved	UINT16	x 10,000
0468	RO	$TOHD_{UL1}$	UINT16	x 10,000
0469	RO	$TOHD_{UL2}$	UINT16	x 10,000
0470	RO	$TOHD_{UL3}$	UINT16	x 10,000
0471	RO	$TOHD_{I1}$	UINT16	x 10,000
0472	RO	$TOHD_{I2}$	UINT16	x 10,000
0473	RO	$TOHD_{I3}$	UINT16	x 10,000
0474	RO	$TOHD_{I4}$ [2)] or reserved	UINT16	x 10,000
0475	RO	$TEHD_{UL1}$	UINT16	x 10,000
0476	RO	$TEHD_{UL2}$	UINT16	x 10,000
0477	RO	$TEHD_{UL3}$	UINT16	x 10,000
0478	RO	$TEHD_{I1}$	UINT16	x 10,000
0479	RO	$TEHD_{I2}$	UINT16	x 10,000
0480	RO	$TEHD_{I3}$	UINT16	x 10,000
0481	RO	$TEHD_{I4}$ [2)] or reserved	UINT16	x 10,000
0482	RO	U_{L1} 2^{nd}. harmonic	UINT16	x 10,000
0483	RO	U_{L2} 2^{nd} harmonic	UINT16	x 10,000
0484	RO	U_{L3} 2^{nd} harmonic	UINT16	x 10,000
0485	RO	I_1 2^{nd} harmonic	UINT16	x 10,000
0486	RO	I_2 2^{nd} harmonic	UINT16	x 10,000
0487	RO	I_3 2^{nd} harmonic	UINT16	x 10,000

Register	Property	Description	Format	Unit
0488	RO	I_4 2nd harmonic [2)] or reserved	UINT16	x 10,000
…	RO	…	UINT16	x 10,000
0685	RO	U_{L1} 31st harmonic	UINT16	x 10,000
0686	RO	U_{L2} 31st harmonic	UINT16	x 10,000
0687	RO	U_{L3} 31st harmonic	UINT16	x 10,000
0688	RO	I_1 31st harmonic	UINT16	x 10,000
0689	RO	I_2 31st harmonic	UINT16	x 10,000
0690	RO	I_3 31st harmonic	UINT16	x 10,000
0691	RO	I_4 31st harmonic [2)] or reserved	UINT16	x 10,000

Table 10.6: Harmonic measurements

Notes on table 10.6:

1) Only in the case of wye connection (WYE). Related to fundamental f_0 .
2) only if the device is equipped with the I_4 input, otherwise it is reserved.

10.5 Demand

10.5.1 Present demand

Register	Property	Description	Format	Unit
1000	RO	Demand U_{L1}	INT32	x 100, V
1002	RO	Demand U_{L2}	INT32	x 100, V
1004	RO	Demand U_{L3}	INT32	x 100, V
1006	RO	Ø Demand U_{LN}	INT32	x 100, V
1008	RO	Demand U_{L1L2}	INT32	x 100, V
1010	RO	Demand U_{L2L3}	INT32	x 100, V
1012	RO	Demand U_{L3L1}	INT32	x 100, V
1014	RO	Ø Demand U_{LL}	INT32	x 100, V
1016	RO	Demand I_1	INT32	x 1,000 A
1018	RO	Demand I_2	INT32	x 1,000 A
1020	RO	Demand I_3	INT32	x 1,000 A
1022	RO	Ø Demand I	INT32	x 1,000 A
1024	RO	Demand I_4 [1)] or reserved	INT32	x 1,000 A
1026	RO	Demand P_{L1}	INT32	W
1028	RO	Demand P_{L2}	INT32	W
1030	RO	Demand P_{L3}	INT32	W
1032	RO	Demand P_{ges}	INT32	W
1034	RO	Demand Q_{L1}	INT32	var
1036	RO	Demand Q_{L2}	INT32	var
1038	RO	Demand Q_{L3}	INT32	var
1040	RO	Demand Q_{ges}	INT32	var

Register	Property	Description	Format	Unit
1042	RO	Demand S_{L1}	INT32	VA
1044	RO	Demand S_{L2}	INT32	VA
1046	RO	Demand S_{L3}	INT32	VA
1048	RO	Demand S_{ges}	INT32	VA
1050	RO	Demand λ_1	INT32	x 1,000
1052	RO	Demand λ_2	INT32	x 1,000
1054	RO	Demand λ_3	INT32	x 1,000
1056	RO	Demand λ_{ges}	INT32	x 1,000
1058	RO	Demand f	INT32	x 100, Hz
1060	RO	Demand unbalance U	INT32	x 1,000
1062	RO	Demand unbalance I	INT32	x 1,000
1064	RO	Demand THD_{UL1}	INT32	x 10,000
1066	RO	Demand THD_{UL2}	INT32	x 10,000
1068	RO	Demand THD_{UL3}	INT32	x 10,000
1070	RO	Demand THD_{I1}	INT32	x 10,000
1072	RO	Demand THD_{I2}	INT32	x 10,000
1074	RO	Demand THD_{I3}	INT32	x 10,000

Table 10.7: Register: Present demands

1) Only if the device is equipped with the I_4 input, otherwise it is reserved

10.5.2 Maximum values per demand period

Register	Property	Description	Format	Unit
1400	RO	$U_{L1\ max}$	INT32	x 100, V
1402	RO	$U_{L2\ max}$	INT32	x 100, V
1404	RO	$U_{L3\ max}$	INT32	x 100, V
1406	RO	Ø $U_{LN\ max}$	INT32	x 100, V
1408	RO	$U_{L1L2\ max}$	INT32	x 100, V
1410	RO	$U_{L2L3\ max}$	INT32	x 100, V
1412	RO	$U_{L3L1\ max}$	INT32	x 100, V
1414	RO	Ø $U_{LL\ max}$	INT32	x 100, V
1416	RO	$I_{1\ max}$	INT32	x 1,000 A
1418	RO	$I_{2\ max}$	INT32	x 1,000 A
1420	RO	$I_{3\ max}$	INT32	x 1,000 A
1422	RO	Ø I_{max}	INT32	x 1,000 A
1424	RO	$I_{4\ max}$ [1)] or reserved	INT32	x 1,000 A
1426	RO	$P_{L1\ max}$	INT32	W
1428	RO	$P_{L2\ max}$	INT32	W
1430	RO	$P_{L3\ max}$	INT32	W
1432	RO	$P_{ges\ max}$	INT32	W
1434	RO	$Q_{L1\ max}$	INT32	var
1436	RO	$Q_{L2\ max}$	INT32	var
1438	RO	$Q_{L3\ max}$	INT32	var
1440	RO	$Q_{ges\ max}$	INT32	var
1442	RO	$S_{L1\ max}$	INT32	VA
1444	RO	$S_{L2\ max}$	INT32	VA
1446	RO	$S_{L3\ max}$	INT32	VA

Register	Property	Description	Format	Unit
1448	RO	$S_{ges\ max}$	INT32	VA
1450	RO	$\lambda_{1\ max}$	INT32	x 1,000
1452	RO	$\lambda_{2\ max}$	INT32	x 1,000
1454	RO	$\lambda_{3\ max}$	INT32	x 1,000
1456	RO	$\lambda_{ges\ max}$	INT32	x 1,000
1458	RO	f_{max}	INT32	x 100, Hz
1460	RO	max. unbalance *U*	INT32	x 1,000
1462	RO	max. unbalance *I*	INT32	x 1,000
1464	RO	$THD_{UL1\ max}$	INT32	x 10,000
1466	RO	$THD_{UL2\ max}$	INT32	x 10,000
1468	RO	$THD_{UL3\ max}$	INT32	x 10,000
1470	RO	$THD_{I1\ max}$	INT32	x 10,000
1472	RO	$THD_{I2\ max}$	INT32	x 10,000
1474	RO	$THD_{I3\ max}$	INT32	x 10,000

Table 10.8: Maximum values per demand period

1) **Register 1424** is valid only if the device is equipped with the I_4 input, otherwise it is reserved.

10.5.3 Minimum values per demand period

Register	Property	Description	Format	Unit
1600	RO	$U_{L1\,min}$	INT32	x 100, V
1602	RO	$U_{L2\,min}$	INT32	x 100, V
1604	RO	$U_{L3\,min}$	INT32	x 100, V
1606	RO	Ø $U_{LN\,min}$	INT32	x 100, V
1608	RO	$U_{L1L2\,min}$	INT32	x 100, V
1610	RO	$U_{L2L3\,min}$	INT32	x 100, V
1612	RO	$U_{L3L1\,min}$	INT32	x 100, V
1614	RO	Ø $U_{LL\,min}$	INT32	x 100, V
1616	RO	$I_{1\,min}$	INT32	x 1,000 A
1618	RO	$I_{2\,min}$	INT32	x 1,000 A
1620	RO	$I_{3\,min}$	INT32	x 1,000 A
1622	RO	Ø I_{min}	INT32	x 1,000 A
1624	RO	$I_{4\,min}$ [1)] or reserved	INT32	x 1,000 A
1626	RO	$P_{L1\,min}$	INT32	W
1628	RO	$P_{L2\,min}$	INT32	W
1630	RO	$P_{L3\,min}$	INT32	W
1632	RO	$P_{ges\,min}$	INT32	W
1634	RO	$Q_{L1\,min}$	INT32	var
1636	RO	$Q_{L2\,min}$	INT32	var
1638	RO	$Q_{L3\,min}$	INT32	var
1640	RO	$Q_{ges\,min}$	INT32	var
1642	RO	$S_{L1\,min}$	INT32	VA
1644	RO	$S_{L2\,min}$	INT32	VA
1646	RO	$S_{L3\,min}$	INT32	VA
1648	RO	$S_{ges\,min}$	INT32	VA
1650	RO	$\lambda_{1\,min}$	INT32	x 1,000

Register	Property	Description	Format	Unit
1652	RO	$\lambda_{2\ min}$	INT32	x 1,000
1654	RO	$\lambda_{3\ min}$	INT32	x 1,000
1656	RO	$\lambda_{ges\ min}$	INT32	x 1,000
1658	RO	f_{min}	INT32	x 100, Hz
1660	RO	min. unbalance U	INT32	x 1,000
1662	RO	min. unbalance I	INT32	x 1,000
1664	RO	$THD_{UL1\ min}$	INT32	x 10,000
1666	RO	$THD_{UL2\ min}$	INT32	x 10,000
1668	RO	$THD_{UL3\ min}$	INT32	x 10,000
1670	RO	$THD_{I1\ min}$	INT32	x 10,000
1672	RO	$THD_{I2\ min}$	INT32	x 10,000
1674	RO	$THD_{I3\ min}$	INT32	x 10,000

Table 10.9: Minimum values per demand period

1) **Register 1624** is valid only if the device is equipped with the I_4 input, otherwise it is reserved.

10.5.4 Peak demand of this month

The value of the peak demand register is 1000 times the actual value. To obtain a value in kW, kVA or kvar, the value of the register has to be divided by 1,000.

Register	Property	Description	Format	Unit
1800…1805	RO	Peak demand P_{ges} of this month	see table 10.12	W
1806…1811	RO	Peak demand Q_{ges} of this month		var
1812…1817	RO	Peak demand S_{ges} of this month		VA
1818…1823	RO	Peak demand I_1 of this month		x 1,000 A
1824…1829	RO	Peak demand I_2 of this month		x 1,000 A
1830…1835	RO	Peak demand I_3 of this month		x 1,000 A

Table 10.10: Peak demand of this month

10.5.5 Peak demand last month

The value of the peak demand register is 1.000 times the actual value. To obtain a value in kW, kVA or kvar, the value of the register has to be divided by 1,000.

Register	Property	Description	Format	Unit
1850…1855	RO	Peak demand P_{ges} of last month	see table 10.12	W
1856…1861	RO	Peak demand Q_{ges} of last month		var
1862…1867	RO	Peak demand S_{ges} of last month		VA
1868…1873	RO	Peak demand I_1 of last month		x 1,000 A
1874…1879	RO	Peak demand I_2 of last month		x 1,000 A
1880…1885	RO	Peak demand I_3 of last month		x 1,000 A

Table 10.11: Peak demand of last month

10.5.6 Peak demand data structure

Offset	Property	Description	Format	Note
+ 0	RO	Peak demand value	INT32	
+ 2	RO	HiWord: year	UINT16	1…99 (year-2000)
	RO	LoWord: month		1…12
+ 3	RO	HiWord: day	UINT16	1…28/29/30/31
	RO	LoWord: hour		0…23
+ 4	RO	HiWord: minute	UINT16	0…59
	RO	LoWord: Second		0…59
+ 5	RO	Milliseconds	UINT16	1…999

Table 10.12: Peak demand data structure

10.6 Max/Min log

10.6.1 Maximum values of this month

Register	Property	Description	Format	Factor/unit
2000…2005	RO	$U_{L1\ max}$	see table 10.17	x 100, V
2006…2011	RO	$U_{L2\ max}$		x 100, V
2012…2017	RO	$U_{L3\ max}$		x 100, V
2018…2023	RO	Ø $U_{LN\ max}$		x 100, V
2024…2029	RO	$U_{L1L2\ max}$		x 100, V
2030…2035	RO	$U_{L2L3\ max}$		x 100, V
2036…2041	RO	$U_{L3L1\ max}$		x 100, V
2042…2047	RO	Ø $U_{LL\ max}$		x 100, V
2048…2053	RO	$I_{1\ max}$		x 1,000 A
2054…2059	RO	$I_{2\ max}$		x 1,000 A
2060…2065	RO	$I_{3\ max}$		x 1,000 A
2066…2071	RO	Ø I_{max}		x 1,000 A
2072…2077	RO	$I_{4\ max}$ 1) or reserved		x 1,000 A
2078…2083	RO	$P_{ges\ max}$		W
2084…2089	RO	$Q_{ges\ max}$		var
2090…2095	RO	$S_{ges\ max}$		VA
2096…2101	RO	$\lambda_{ges\ max}$		x 1,000
2102…2107	RO	f_{max}		x 100, Hz
2108…2113	RO	$THD_{UL1\ max}$		x 10,000
2114…2119	RO	$THD_{UL2\ max}$		x 10,000
2120…2125	RO	$THD_{UL3\ max}$		x 10,000

Register	Property	Description	Format	Factor/unit
2126…2131	RO	$THD_{I1\ max}$	see table 10.17	x 10,000
2132…2137	RO	$THD_{I2\ max}$		x 10,000
2138…2143	RO	$THD_{I3\ max}$		x 10,000
2144…2149	RO	k-factor I_1		x 10
2150…2155	RO	k-factor I_2		x 10
2156…2161	RO	k-factor I_3		x 10
2162…2167	RO	max. unbalance U		x 1,000
2168…2173	RO	max. unbalance I		x 1,000

Table 10.13: Max log of this month

1) **Register 2072…2077** are valid only if the device is equipped with the I_4 input, otherwise it is reserved

10.6.2 Min log of this month

Register	Property	Description	Format	Factor/unit
2300…2305	RO	$U_{L1\ min}$	see table 10.17	x 100, V
2306…2311	RO	$U_{L2\ min}$		x 100, V
2312…2317	RO	$U_{L3\ min}$		x 100, V
2318…2323	RO	Ø $U_{LN\ min}$		x 100, V
2324…2329	RO	$U_{L1L2\ min}$		x 100, V
2330…2335	RO	$U_{L2L3\ min}$		x 100, V
2336…2341	RO	$U_{L3L1\ min}$		x 100, V
2342…2347	RO	Ø $U_{LL\ min}$		x 100, V
2348…2353	RO	$I_{1\ min}$		x 1,000 A
2354…2359	RO	$I_{2\ min}$		x 1,000 A
2360…2365	RO	$I_{3\ min}$		x 1,000 A

Register	Property	Description	Format	Factor/unit
2366…2371	RO	Ø I_{min}	see table 10.17	x 1,000 A
2372…2377	RO	$I_{4\ min}$ 1) or reserved		x 1,000 A
2378…2383	RO	$P_{ges\ min}$		W
2384…2389	RO	$Q_{ges\ min}$		var
2390…2395	RO	$S_{ges\ min}$		VA
2396…2401	RO	$\lambda_{ges\ min}$		x 1,000
2402…2407	RO	f_{min}		x 100, Hz
2408…2413	RO	$THD_{UL1\ min}$		x 10,000
2414…2419	RO	$THD_{UL2\ min}$		x 10,000
2420…2425	RO	$THD_{UL3\ min}$		x 10,000
2426…2431	RO	$THD_{I1\ min}$		x 10,000
2432…2437	RO	$THD_{I2\ min}$		x 10,000
2438…2443	RO	$THD_{I3\ min}$		x 10,000
2444…2449	RO	k-factor I_1		x 10
2450…2455	RO	k-factor I_2		x 10
2456…2461	RO	k-factor I_3		x 10
2462…2467	RO	min. unbalance U		x 1,000
2468…2473	RO	min. unbalance I		x 1,000

Table 10.14: Min log of this month

1) **Register 2372…2377** are valid only if the device is equipped with the I_4 input, otherwise it is reserved.

10.6.3 Max log of last month

Register	Property	Description	Format	Factor/unit
2600…2605	RO	$U_{L1\ max}$	see table 10.17	x 100, V
2606…2611	RO	$U_{L2\ max}$		x 100, V
2612…2617	RO	$U_{L3\ max}$		x 100, V
2618…2623	RO	Ø $U_{LN\ max}$		x 100, V
2624…2629	RO	$U_{L1L2\ max}$		x 100, V
2630…2635	RO	$U_{L2L3\ max}$		x 100, V
2636…2641	RO	$U_{L3L1\ max}$		x 100, V
2642…2647	RO	Ø $U_{LL\ max}$		x 100, V
2648…2653	RO	$I_{1\ max}$		x 1,000 A
2654…2659	RO	$I_{2\ max}$		x 1,000 A
2660…2665	RO	$I_{3\ max}$		x 1,000 A
2666…2671	RO	Ø I_{max}		x 1,000 A
2672…2677	RO	$I_{4\ max}$ 1) or reserved		x 1,000 A
2678…2683	RO	$P_{ges\ max}$		W
2684…2689	RO	$Q_{ges\ max}$		var
2690…2695	RO	$S_{ges\ max}$		VA
2696…2701	RO	$\lambda_{ges\ max}$		x 1,000
2702…2707	RO	f_{max}		x 100, Hz
2708…2713	RO	$THD_{UL1\ max}$		x 10,000
2714…2719	RO	$THD_{UL2\ max}$		x 10,000
2720…2725	RO	$THD_{UL3\ max}$		x 10,000
2726…2731	RO	$THD_{I1\ max}$		x 10,000
2732…2737	RO	$THD_{I2\ max}$		x 10,000
2738…2743	RO	$THD_{I3\ max}$		x 10,000

Register	Property	Description	Format	Factor/unit
2744…2749	RO	k-factor I_1	see table 10.17	x 10
2750…2755	RO	k-factor I_2		x 10
2756…2761	RO	k-factor I_3		x 10
2762…2767	RO	max. voltage unbalance		x 1,000
2768…2773	RO	max. current unbalance		x 1,000

Table 10.15: Max log of last month

1) **Register 2672…2677** are valid only if the device is equipped with the I_4 input, otherwise it is reserved

10.6.4 Min log last month

Register	Property	Description	Format	Factor/unit
2900…2905	RO	$U_{L1\ min}$	see table 10.17	x 100, V
2906…2911	RO	$U_{L2\ min}$		x 100, V
2912…2917	RO	$U_{L3\ min}$		x 100, V
2918…2923	RO	Ø $U_{LN\ min}$		x 100, V
2924…2929	RO	$U_{L1L2\ min}$		x 100, V
2930…2935	RO	$U_{L2L3\ min}$		x 100, V
2936…2941	RO	$U_{L3L1\ min}$		x 100, V
2942…2947	RO	Ø $U_{LL\ min}$		x 100, V
2948…2953	RO	$I_{1\ min}$		x 1,000 A
2954…2959	RO	$I_{2\ min}$		x 1,000 A
2960…2965	RO	$I_{3\ min}$		x 1,000 A
2966…2971	RO	Ø I_{min}		x 1,000 A
2972…2977	RO	$I_{4\ min}$ 1) or reserved		x 1,000 A
2978…2983	RO	$P_{ges\ min}$		W
2984…2989	RO	$Q_{ges\ min}$		var
2990…2995	RO	$S_{ges\ min}$		VA

Register	Property	Description	Format	Factor/unit
2996…3001	RO	$\lambda_{ges\ min}$	see table 10.17	x 1,000
3002…3007	RO	f_{min}		x 100, Hz
3008…3013	RO	$THD_{UL1\ min}$		x 10,000
3014…3019	RO	$THD_{UL2\ min}$		x 10,000
3020…3025	RO	$THD_{UL3\ min}$		x 10,000
3026…3031	RO	$THD_{I1\ min}$		x 10,000
3032…3037	RO	$THD_{I2\ min}$		x 10,000
3038…3043	RO	$THD_{I3\ min}$		x 10,000
3044…3049	RO	k-factor I_1		x 10
3050…3055	RO	k-factor I_2		x 10
3056…3061	RO	k-factor I_3		x 10
3062…3067	RO	min. unbalance *U*		x 1,000
3068…3073	RO	min. unbalance *I*		x 1,000

Table 10.16: Minimum log of last month

1) **Register 2972…2977** are valid only if the device is equipped with the I_4 input, otherwise it is reserved.

10.6.5 Max/Min log data structure

Offset	Property	Description	Format	Note
+ 0	RO	Max resp. Min value	INT32	
+ 2	RO	HiWord: Year	UINT16	1…99 (year-2000)
	RO	LoWord: month		1…12
+ 3	RO	HiWord: day	UINT16	1…28/29/30/31
	RO	LoWord: hour		0…23
+ 4	RO	HiWord: Minute	UINT16	0…59
	RO	LoWord: Second		0…59
+ 5	RO	Millisecond	UINT16	0…999

Table 10.17: Max/Min log data structure

10.7 Setup parameters

Register	Property	Description	Format	Range/unit
6000	RW	Transformation ratio, voltage transformer	UINT16	1*…10,000
6001	RW	Transformation ratio, measuring current transformer	UINT16	1*…6.000 (current input 5 A) 1*…30.000 (current input 1 A)
6002	RW	Transformation ratio, measuring current transformer I_4	UINT16	1*…10,000
6003	RW	Wiring mode	UINT16	0 = WYE* 1 = DELTA 2 = DEMO
6004	RW	U_{nom}	UINT16	100*…700 V (U_{LL})
6005	RW	f_{nom}	UINT16	0 = 50 Hz*; 1 = 60 Hz
6006	RW	Protocol interface 1 (RS-485)	UINT16	0* = Modbus 1 = EGATE
6007	RW	Device address interface 1 (RS-485)	UINT16	1…247 (100*)
6008	RW	Baud rate interface 1 (RS-485)	UINT16	0 = 1,200; 1 = 2,400 2 = 4,800; 3 = 9,600* 4 = 19,200; 5 = 38,400
6009	RW	Parity interface 1 (RS-485)	UINT16	0 = 8N2; 1 = 8O1 2 = 8E1*; 3 = 8N1 4 = 8O2 ; 5 = 8E2
6010	RW	IP address	UINT32	192.168.0.100* Contents of register for factory setting: 0xC0A80064
6012	RW	Subnet mask	UINT32	288.255.255.0* Contents of register for factory setting: 0xFFFFFF00

Register	Property	Description	Format	Range/unit
6014	RW	Gateway address	UINT32	192.168.0.1* Contents of register for factory setting: 0x0A80001
6016	RW	Power factor λ rule	UINT16	0* = IEC; 1 = IEEE 2 = -IEEE
6017	RW	Calculation method *S*	UINT16	0* = vector 2 = scalar
6018	RW	Demand period	UINT16	1…60 minutes (15*)
6019	RW	Number of measurement periods (sliding windows)	UINT16	1*…15
6020	RW	Function DI1	UINT16	0 = digital input 1 = pulse counter 2 = SYNC DI 3 = PPS
6021	RW	Function DI2	UINT16	
6022	RW	Function DI3	UINT16	
6023	RW	Function DI4	UINT16	
6024	RW	Function DI5	UINT16	
6025	RW	Function DI6	UINT16	
6026	RW	Debounce time DI1	UINT16	1…1,000 ms (20*)
6027	RW	Debounce time DI2	UINT16	
6028	RW	Debounce time DI3	UINT16	
6029	RW	Debounce time DI4	UINT16	
6030	RW	Debounce time DI5	UINT16	
6031	RW	Debounce time DI6	UINT16	
6032	RW	Resolution of setting DI1	UINT32	1*…1,000,000
6034	RW	Resolution of setting DI2	UINT32	
6036	RW	Resolution of setting DI3	UINT32	
6038	RW	Resolution of setting DI4	UINT32	
6040	RW	Resolution of setting DI5	UINT32	
6042	RW	Resolution of setting DI6	UINT32	

Register	Property	Description	Format	Range/unit
6044	RW	Function DO1	UINT16	0*= digital output
6045	RW	Function DO2	UINT16	
6046	RW	Function DO3	UINT16	
6047…6050		Reserved		
6052	RW	Polarity measuring current transformer L1	UINT16	0* = normal 1 = reversed
6053	RW	Polarity measuring current transformer L2	UINT16	0* = normal 1 = reversed
6054	RW	Polarity measuring current transformer L3	UINT16	0* = normal 1 = reversed
6055	RW	Calculation method harmonic distortion***	UINT16	0 = Fundamental 1*= RMS
6056	RW	Enable energy pulse	UINT16	0*= disable 1 = enable
6057	RW	Pulse constant	UINT16	0* = 1,000 imp/kxh 1 = 3,200 imp/kxh 2 = 5,000 imp/kxh 3 = 6,400 imp/kxh 4 = 12,800 imp/kxh
6058		Reserved		
6059	RW	Enable transient events	UINT16	0*= disable 1 = enable
6060	RW	Limit for transient events [1)]	UINT16	5…100 (x 0.01 U_{nom}) (50*)
6061	RW	Backlight timeout	UINT16	0 = Display is always switched on 1…60 min (3*)

Table 10.18: Setup parameters

Notes table 10.18:

Register 6000 and 6001

Current input 5 A: Transformation ratio current x transformation ratio voltage < 1,000,000
Current input 1 A: Transformation ratio current x transformation ratio voltage < 5,000,000

[1)] **Register 6060** A transient event only triggers WFR1

10.8 Clear/reset register

Register	Property	Description	Format	Unit
6400	WO	Manual trigger WFR1	UINT16	Writing 0xFF00 to the register triggers the respective waveform recorder
6401	WO	Manual trigger WFR2	UINT16	
6402	WO	Clear DR1	UINT16	Writing 0xFF00 to the register clears the respective DR
6403	WO	Clear DR2	UINT16	
…				
6416	WO	Clear DR15	UINT16	
6417	WO	Clear DR16	UINT16	
6418	WO	Clear WFR1	UINT16	Writing 0xFF00 to the register clears the respective log
6419	WO	Clear WFR2	UINT16	
6420	WO	Clear energy log	UINT16	
6421	Reserved			
6422	WO	Clear event log	UINT16	
6423	WO	Clear energy register	UINT16	
6424	WO	Clear Max/Min log of this month	UINT16	
6425	WO	Clear peak demand log of this month	UINT16	
6426	WO	Clear counter DI1	UINT16	Writing 0xFF00 to the register clears the respective counter
6427	WO	Clear counter DI2	UINT16	
…				
6430	WO	Clear counter DI5	UINT16	
6431	WO	Clear counter DI6	UINT16	
6432…6436	Reserved			
6437	WO	Clear all logs (registers 6400…6431)	UINT16	Writing 0xFF00 to the register clears all logs mentioned above

Table 10.19: Clear/reset register

10.9 Register Setpoints

Register	Property	Description	Format
6600…6609	RW	Setpoint 1	Register structure, refer to table 10.21
6610…6619	RW	Setpoint 2	
6620…6629	RW	Setpoint 3	
6630…6639	RW	Setpoint 4	
6640…6649	RW	Setpoint 5	
6650…6659	RW	Setpoint 6	
6660…6669	RW	Setpoint 7	
6670…6679	RW	Setpoint 8	
6680…6689	RW	Setpoint 9	

Table 10.20: Register Setpoints

Register structure setpoint

Offset	Property	Description	Format	Unit
0	RW	Type	UINT16	0 = disabled 1 = over setpoint 2 = under setpoint
+1	RW	Measured quantity 1)	UINT16	1*…26
+2	RW	Active limit	INT32	5000*
+4	RW	Inactive limit	INT32	1,000*
+6	RW	Active delay	UINT16	0…9,999 s (1*)
+7	RW	Inactive delay	UINT16	0…9,999 s (1*)
+8	RW	Trigger 1 2)	UINT16	0…21 (1*)
+9	RW	Trigger 2 2)	UINT16	0…21 (2*)

Table 10.21: Register structure setpoint

Notes table 10.21:

[1)] Measured quantity: "Measured quantity" specifies the value to be monitored.
The following measured quantities can be set:

Key	Measured quantity	Scale/unit
1	U_{LN}	x 100, V
2	U_{LL}	x 100, V
3	*I*	x 1,000, A
4	*I4*	x 1,000, A
5	*F*	x 100, Hz
6	P_{ges}	kW
7	S_{ges}	kvar
8	λ	x 1,000
9	DI1	**Setpoint**: DI closed (DI = 1), DI open (DI = 0)
10	DI2	
11	DI3	
12	DI4	
13	DI5	
14	DI6	
15	Reserved	
16	Demand P_{ges}	kW
17	Demand Q_{ges}	kvar
18	Demand λ	x 1,000
19	THD_U	x 10,000
20	$TOHD_U$	x 10,000
21	$TEHD_U$	x 10,000
22	THD_I	x 10,000
23	$TOHD_I$	x 10,000
24	$TEHD_I$	x 10,000
25	Unbalance *U*	x 1,000
26	Unbalance *I*	x 1,000

Table 10.22: Setpoint parameter "Measured quantity"

[2)] Trigger

The trigger specifies what action the setpoint will take when it becomes active

Key	Action	Key	Action
0	—	11	DR8
1	DO1	12	DR9
2	DO2	13	DR10
3	DO3	14	DR11
4	DR1	15	DR12
5	DR2	16	DR13
6	DR3	17	DR14
7	DR4	18	DR15
8	DR5	19	DR16
9	DR6	20	WFR1
10	DR7	21	WFR2

Table 10.23: Setpoint trigger

10.10 Data recorder (DR)

10.10.1 Data recorder register

Register	Property	Description	Format
7000…7022	RW	Data recorder 1 (DR1)	Format see table 10.25
7023…7045	RW	Data recorder 2 (DR2)	
7046…7068	RW	Data recorder 3 (DR3)	
7069…7091	RW	Data recorder 4 (DR4)	
7092…7114	RW	Data recorder 5 (DR5)	
7115…7137	RW	Data recorder 6 (DR6)	
7138…7160	RW	Data recorder 7 (DR7)	
7161…7138	RW	Data recorder 8 (DR8)	
7134…7206	RW	Data recorder 9 (DR9)	
7107…7229	RW	Data recorder 10 (DR10)	
7230…7252	RW	Data recorder 11 (DR11)	
7253…7275	RW	Data recorder 12 (DR12)	
7276…7298	RW	Data recorder 13 (DR13)	
7299…7321	RW	Data recorder 14 (DR14)	
7322…7344	RW	Data recorder 15 (DR15)	
7345…7367	RW	Data recorder 16 (DR16)	
7368	RO	DR1 record size (bytes)	UINT16
7369	RO	DR2 record size (bytes)	UINT16
7370	RO	DR3 record size (bytes)	UINT16
7371	RO	DR4 record size (bytes)	UINT16
7372	RO	DR5 record size (bytes)	UINT16
7373	RO	DR6 record size (bytes)	UINT16
7374	RO	DR7 record size (bytes)	UINT16
7375	RO	DR8 record size (bytes)	UINT16
7376	RO	DR9 record size (bytes)	UINT16

Register	Property	Description	Format
7377	RO	DR10 record size (bytes)	UINT16
7378	RO	DR11 record size (bytes)	UINT16
7379	RO	DR12 record size (bytes)	UINT16
7380	RO	DR13 record size (bytes)	UINT16
7381	RO	DR14 record size (bytes)	UINT16
7382	RO	DR15 record size (bytes)	UINT16
7383	RO	DR16 record size (bytes)	UINT16

Table 10.24: Data recorder register

10.10.2 Structure data recorder registers

Offset	Property	Description	Format	Range/options
+ 0	RW	Trigger mode 1)	UINT16	0* = disabled 1 = triggered by timer 2 = triggered by setpoint
+ 1	RW	Recording mode	UINT16	0*= stop-when-full 1 = FIFO (First-In-First-Out)
+ 2	RW	Number of records	UINT16	0…65,535 (5,760*)
+ 3	RW	Recording interval	UINT32	1…3,456,000 s (900*)
+ 5	RW	Recording delay 2)	UINT16	0*…43,200 s
+ 6	RW	Number of measured quantities 3)	UINT16	0…16*
+ 7	RW	Measured quantity 1	UINT16	0*…322
+ 8	RW	Measured quantity 2	UINT16	0*…322
+ 9	RW	Measured quantity 3	UINT16	0*…322
+ 10	RW	Measured quantity 4	UINT16	0*…322
+ 11	RW	Measured quantity 5	UINT16	0*…322
+ 12	RW	Measured quantity 6	UINT16	0*…322
+ 13	RW	Measured quantity 7	UINT16	0*…322

Offset	Property	Description	Format	Range/options
+ 14	RW	Measured quantity 8	UINT16	0*…322
+ 15	RW	Measured quantity 9	UINT16	0*…322
+ 16	RW	Measured quantity 10	UINT16	0*…322
+ 17	RW	Measured quantity 11	UINT16	0*…322
+ 18	RW	Measured quantity 12	UINT16	0*…322
+ 19	RW	Measured quantity 13	UINT16	0*…322
+ 20	RW	Measured quantity 14	UINT16	0*…322
+ 21	RW	Measured quantity 15	UINT16	0*…322
+ 22	RW	Measured quantity 16	UINT16	0*…322

Table 10.25: Data recorder register structure

Notes: table 10.25

*The data recorder is only operational when the **offset entries +1, +2, +3 and +6 are all non-zero**!*

1) Data recorders can be triggered by a **timer** (the internal clock) **or** a **setpoint**. In trigger mode 2 when the setpoint goes active, the recorder starts to record, and when the setpoint becomes inactive, the data recorder stops.

2) Recording delay: In Trigger mode 1, a fixed time can be set in seconds to delay the start of the measurement (triggered by timer). .Example: "300" means that the recording will be delayed by 5 minutes after being triggered by timer. In order to obtain evaluable results, the time set for recording delay should be less than that of the recording interval.

   For Trigger mode 2, a recording delay cannot be set.

3) For data recorders the measured quantities 0…322 listed in table 8.3 can be used.

*Modifying an offset parameter will **clear the DR log** and reset the pointer to 0.*

10.11 Waveform recorder (WFR)

The PEM555 utilises two independent waveform recorders (WFR1 and WFR2) which together can store 6 entries.
Each waveform recorder can simultaneously record 3-phase voltage and current signals at a maximum resolution of 128 samples per cycle.

Register	Property	Description		Format
7600	RW	WFR 1	Number of records	0*…6
7601	RW		Number of samples per cycle)	0 = 16 1 = 32 2 = 64 3*= 128
7602	RW		Number of cycles per record2)	40/20/10/5*
7603	RW		Number of cycles before the event occurred	0*…5
7604	RW	WFR2	Number of records1)	0*…6
7605	RW		Number of samples 2)	0 = 16 1 = 32 2 = 64 3*= 128
7606	RW		Number of cycles per record2)	40/20/10/5*
7607	RW		Number of cycles before the event occurred	0*…5

Table 10.26: Register waveform recorder

Notes table 10.26:

1) The waveform recorders' overall capacity is 6, i.e. the total number of records in WFR1 and WFR2 must be ≤ 6. If the entry "Number of records = 0" is selected, both waveform recorders will be disabled.
2) The following WFR formats (number of samples per cycle x number of cycles) can be selected:16 x 40, 32 x 20, 64 x 10, 128 x 5.

*Modifying any of the registers **7600…7607** will clear the WFR log and reset the pointer to 0.*

Waveform recorder data structure (WFR log)

The waveform recorder data are secondary side values.

For **voltage values** the **factor of 10**
and for **current values** the **factor 1000** is to be taken into account.

The voltage and current values of the primary side are calculated as follows:
$U_{primary} = U_{secondary}$ x voltage transformer transformation ratio/10
$I_{primary} = I_{secondary}$ x CT transformation ratio/1,000

Offset	Property	Description	Format	Range/options
+ 0	RO	Trigger mode	UINT16	0*= disabled 1 = manual 2 = setpoint 3 = transient event
+ 1	RO	HiWord: year	UINT16	0…99 (year - 2000)
	RO	LoWord: month		1…12
+ 2	RO	HiWord: day	UINT16	1…31
	RO	LoWord: hour		1…23
+ 3	RO	HiWord: minute	UINT16	0…59
	RO	LoWord: second		0…59
+ 4	RO	millisecond	UINT16	0…999
+ 5…N+4	RO	U_{L1} of sample $N^{\#}$	UINT16	x 10, V
N+5…2N+4	RO	U_{L2} of sample $N^{\#}$	UINT16	x 10, V
2N+5…3N+4	RO	U_{L3} of sample $N^{\#}$	UINT16	x 10, V
3N+5…4N+4	RO	I_1 of sample $N^{\#}$	UINT16	x 1,000, A
4N+5…5N+4	RO	I_2 of sample $N^{\#}$	UINT16	x 1,000, A
5N+5…6N+4	RO	I_3 of sample $N^{\#}$	UINT16	x 1,000, A

Table 10.27: Waveform recorder data structure

$N^{\#}$ = number of sample (1…N)

10.12 Energy log

Register	Property	Description		Format	Range/options	
7700	RW	Recording mode		UINT16	0*= disabled 1 = stop-when-full 2 = FIFO	
7701	RW	Number of records[1)]		UINT16	0…65,535 (5,760*)	
7702	RW	Recording interval		UINT16	0 = 5 min 1 = 10 min 2*= 15 min 3 = 30 min 4 = 60 min	
7703	RW	Start-up time[2)]	HiWord: year	UINT16	0…99 (year - 2000)	
			LoWord: month		1…12	
7704	RW		HiWord: day	UINT16	1…31	
			LoWord: hour		1…23	
7705	RW		HiWord: minute	UINT16	0…59	
			LoWord: second		0…59	
7706	RW	Number of measured quantities (N)		UINT16	0…5*	
7707	RW	Measured quantity 1		UINT16	0 = active energy import 1 = active energy export 2 = reactive energy import 3 = reactive energy export 4 = apparent energy	0*
7708	RW	Measured quantity 2		UINT16		1*
7709	RW	Measured quantity 3		UINT16		2*
7710	RW	Measured quantity 4		UINT16		3*
7711	RW	Measured quantity 5		UINT16		4*
7712	RO	Data record size		UINT16	Unit: bytes	

Table 10.28: Energy log registers

Notes on table 10.28:

1) If the entry "Number of records = 0" is selected, the energy log will be disabled.
2) When the current time meets or exceeds the start-up time, the energy log starts to record.

*Modifying any of the **registers 7701…7711** will clear the WFR log and reset the pointer to 0.*

Energy log data structure

Offset	Property	Description	Format	Range/options
+0	RO	Measured quantity 1	INT32	-
+2	RO	Measured quantity 2	INT32	-
…	RO	…	INT32	-
+2N	RO	Measured quantity N (N = 0…5)	INT32	-
+2N+1	RO	HiWord: year	UINT16	0…99 (year - 2000)
		LoWord: month		1…12
+2N+2	RO	HiWord: day	UINT16	1…31
		LoWord: hour		1…23
+2N+3	RO	HiWord: minute	UINT16	0…59
		LoWord: second		0…59
+2N+4	RO	millisecond	UINT16	0…999

Table 10.29: Energy log data structure

10.13 Event log (SOE log)

Each event entry occupies 8 registers, as shown in the following table. The internal data structure of the event log is listed in table 10.31.

10.13.1 Event log register

Register	Property	Description	Format
10000…10007	RO	Event 1	Format see table 10.31
10008…10015	RO	Event 2	
10016…10023	RO	Event 3	
10024…10031	RO	Event 4	
10032…10039	RO	Event 5	
10040…10047	RO	Event 6	
10048…10055	RO	Event 7	
10056…10063	RO	Event 8	
10064…10071	RO	Event 9	
10072…10079	RO	Event 10	
10080…10087	RO	Event 11	
…			
10504…10511	RO	Event 64	

Table 10.30: Event log (SOE log)

10.13.2 Event log data structure

The following table describes the internal data structure of the 8 registers, which belong to each entry in the event log (SOE log).

Offset	Property	Description	Format
+ 0	RO	Reserved	UINT16
+ 1	RO	HiWord: Event classification LoWord: Sub classification (see table 10.13.3)	UINT16
+ 2	RO	HiWord: year-2000 LoWord: month (1…12)	UINT16
+ 3	RO	HiWord: day (0…31) LoWord: hour (1…23)	UINT16
+ 4	RO	HiWord: minute (0…59) LoWord: second (0…59)	UINT16
+ 5	RO	millisecond (0…999)	UINT16
+ 6	RO	Event value	INT32

Table 10.31: Event data structure

10.13.3 Event classification (SOE log)

Event classif.	Event sub classif.	Event value Unit Option	Description
1	1	1/0	DI1 closed/opened
	2	1/0	DI2 closed/opened
	3	1/0	DI3 closed/opened
	4	1/0	DI4 closed/opened
	5	1/0	DI5 closed/opened
	6	1/0	DI6 closed/opened
2	1	1/0	DO 1 closed/opened by communications interface

Event classif.	Event sub classif.	Event value Unit Option	Description
2	2	1/0	DO2 closed/opened by communications interface
	3	1/0	DO3 closed/opened by communications interface
	4	1/0	DO1 closed/opened by setpoint
	5	1/0	DO2 closed/opened by setpoint
	6	1/0	DO3 closed/opened by setpoint
3	1	Trigger value x 100	>-Setpoint U_{LN} exceeded
	2	Trigger value x 100	>-Setpoint U_{LL} exceeded
	3	Trigger value x 1,000	>-Setpoint *I* exceeded
	4	Trigger value x 1,000	>-Setpoint I_4 exceeded
	5	Trigger value x 100	>-Setpoint *f* exceeded
	6	Trigger value	>-Setpoint P_{ges} exceeded
	7	Trigger value	>-Setpoint Q_{ges} exceeded
	8	Trigger value x 1,000	>-Setpoint λ_{ges} exceeded
	9	1	Setpoint DI1 close active
	10	1	Setpoint DI2 close active
	11	1	Setpoint DI3 close active
	12	1	Setpoint DI4 close active
	13	1	Setpoint DI5 close active
	14	1	Setpoint DI6 close active
	15	Reserved	
	16	Trigger value	>-Setpoint demand P_{ges} exceeded
	17	Trigger value	>-Setpoint demand Q_{ges} exceeded
	18	Trigger value x 1,000	>-Setpoint demand λ_{ges} exceeded
	19	Trigger value x 100	>-Setpoint THD_U exceeded

Event classif.	Event sub classif.	Event value Unit Option	Description
	20	Trigger value x 100	>-Setpoint $TOHD_U$ exceeded
	21	Trigger value x 100	>-Setpoint $TEHD_U$ exceeded
	22	Trigger value x 100	>-Setpoint THD_I exceeded
	23	Trigger value x 100	>-Setpoint $TOHD_I$ exceeded
	24	Trigger value x 100	>-Setpoint $TEHD_I$ exceeded
	25	Trigger value x 10	>-Setpoint unbalance *U* exceeded
	26	Trigger value x 10	>-Setpoint unbalance *I* exceeded
	Reserved		
	46	Return value x 100	>-Setpoint U_{LN} return
	47	Return value x 100	>-Setpoint U_{LL} return
	48	Return value x 1,000	>-Setpoint *I* return
	49	Return value x 1,000	>-Setpoint I_4 return
3	50	Return value x 100	>-Setpoint *f* return
	51	Return value	>-Setpoint P_{ges} return
	52	Return value	>-Setpoint Q_{ges} return
	53	Return value x 1,000	>-Setpoint λ_{ges} return
	54	0	Setpoint DI1 close return
	55	0	Setpoint DI2 close return
	56	0	Setpoint DI3 close return
	57	0	Setpoint DI4 close return
	58	0	Setpoint DI5 close return
	59	0	Setpoint DI6 close return
	60	Reserved	
	61	Return value	>- Setpoint demand P_{ges} return
	62	Return value	>-Setpoint demand Q_{ges} return

Event classif.	Event sub classif.	Event value Unit Option	Description
3	63	Return value x 1,000	>-Setpoint demand λ_{ges} return
	64	Reserved	
	65		
	66		
	67	Return value x 100	>-Setpoint THD_U return
	68	Return value x 100	>-Setpoint $TOHD_U$ return
	69	Return value x 100	>-Setpoint $TEHD_U$ return
	70	Return value x 100	>-Setpoint THD_I return
	71	Return value x 100	>-Setpoint $TOHD_I$ return
		Reserved	
	90	Trigger value x 100	Under <-Setpoint U_{LN}
	91	Trigger value x 100	Under <-Setpoint U_{LL}
	92	Trigger value x 1,000	Under <-Setpoint I
	93	Trigger value x 1,000	<-Under I_4 setpoint
	94	Trigger value x 100	Under <-Setpoint f
	95	Trigger value	Under <-Setpoint P_{ges}
	96	Trigger value	<-Under setpoint Q_{ges}
	97	Trigger value x 1,000	Under <-Setpoint λ_{ges}
	98	0	Setpoint DI1 open active
	99	0	Setpoint DI2 open active
	100	0	Setpoint DI3 open active
	101	0	Setpoint DI4 open active
	102	0	Setpoint DI5 open active
	103	0	Setpoint DI6 open active
	104	Reserved	

Event classif.	Event sub classif.	Event value Unit Option	Description
3	105	Trigger value	Under <-Setpoint demand P_{ges}
	106	Trigger value	Under <-Setpoint demand Q_{ges}
	107	Trigger value x 1,000	Under <-Setpoint demand λ_{ges}
	108	Trigger value x 100	Under <-Setpoint THD_U
	109	Trigger value x 100	Under <-Setpoint $TOHD_U$
	110	Trigger value x 100	Under <-Setpoint $TEHD_U$
	111	Trigger value x 100	Under <-Setpoint THD_I
	112	Trigger value x 100	Under <-Setpoint $TOHD_I$
	113	Trigger value x 1,000	Under <-Setpoint $TEHD_I$
	114	Trigger value x 10	Under <-Setpoint voltage unbalance
	115	Trigger value x 10	Under <-Setpoint current unbalance
		Reserved	
	135	Return value x 100	<-Setpoint U_{LN} return
	136	Return value x 100	<-Setpoint U_{LL} return
	137	Return value x 1,000	<-Setpoint I return
	138	Return value x 1,000	<-Setpoint I_4 return
	139	Reserved	
	140	Return value	<-Setpoint P_{ges} return
	141	Return value	<-Setpoint Q_{ges} return
	142	Return value x 1,000	<-Setpoint λ_{ges} return
	143	1	Setpoint DI1 open return
	144	1	Setpoint DI2 open return
	145	1	Setpoint DI3 open return
	146	1	Setpoint DI4 open return
	147	1	Setpoint DI5 open return

Event classif.	Event sub classif.	Event value Unit Option	Description
3	148	1	Setpoint DI6 open return
	149	Reserved	
	150	Return value	<-Setpoint demand P_{ges} return
	151	Return value	<-Setpoint demand Q_{ges} return
	152	Return value x 1,000	<-Setpoint demand λ_{ges} return
	153	Reserved	
	154		
	155		
	156	Return value x 100	<-Setpoint THD$_U$ return
	157	Return value x 100	<-Setpoint TOHD$_U$ return
	158	Return value x 100	<-Setpoint TEHD$_U$ return
	159	Return value x 100	<-Setpoint THD$_I$ return
	160	Return value x 100	<-Setpoint TOHD$_I$ return
	161	Return value x 100	<-Setpoint TEHD$_I$ return
	162	Return value x 10	<-Setpoint voltage unbalance return
	163	Return value x 10	<-Setpoint current unbalance return
	164	Reserved	
	165		
4	1	0	Battery voltage low
	2	0	Fault power supply CPU
	3	0	A/D fault
	4	0	NVRAM fault
	5	0	Error system parameter
	6	0	Fault parameter calibration
	7	0	Fault parameter setpoint
	8	0	Fault parameter data recorder

Event classif.	Event sub classif.	Event value Unit Option	Description
4	9	0	Fault parameter waveform recorder
	10	0	Fault parameter energy log
5	1	0	Supply voltage on
	2	0	Supply voltage off
	3	0	Clock set via front panel
	4	0	Setup changed via device buttons
	5	0	DI counter cleared via front panel
	6	0	Event log cleared via front panel
	7	0	Reserved
	8	0	Energy values cleared via front panel
	9	0	Data recorder cleared via front panel
	10	0	Waveform recorder cleared via front panel
	11	0	Energy log cleared via front panel
	12	0	Max/Min value log of this month cleared via front panel
	13	0	Peak demand of this month cleared via front panel
	14	0	Setup changed via communications interface
	15	0	DI counter cleared via communications interface
	16	0	Event log cleared via communications interface
	17	0	Max/Min value log of last month cleared via communicationsinterface
	18	0	Energy values cleared via communications interface
	19	0	Data recorder cleared via communications interface

Event classif.	Event sub classif.	Event value Unit Option	Description
5	20	0	Waveform recorder cleared via communications interface
	21	0	Energy log cleared via communications interface
	22	0	Max/Min value log of this month cleared via communications interface
	23	0	Peak demand of this month cleared via communications interface
	24	0	Peak demand of last month cleared via communications interface
6	1	0	Waveform reorder triggered by communications interface (remote control)
	2	Setpoint 1…9	Waveform recorder triggered by setpoint
	3	Setpoint 1…9	Data recorder triggered by setpoint
	4	0	Waveform recorder triggered by transient event

Table 10.32: Event classification

10.14 Time setting

There are two time register formats supported by PEM555:

1. Year/month/day/hour/minute/second register 9000…9002
2. UNIX-time register 9004

When sending the time via Modbus communications, care should be taken to only write one of the two time register sets. All registers within a time register set must be written in a single transaction.
If all the registers **9000…9004** are set, both timestamp registers will be updated to reflect the new time specified in the UNIX time register set. Time specified in the first display format will be ignored.

Optionally, the register **9003** displays milliseconds. When broadcasting time, the function code has to be set to 0x10 (Preset Multiple Register). Incorrect date or time values will be rejected by the universal measuring device.

Register	Property	Description	Format	Note
9000	RW	Year and month	UINT16	HiWord: year - 2000 LoWord: month (1…12)
9001	RW	Day and hour	UINT16	HiWord: day (1…31) LoWord: hour (0…23)
9002	RW	Minute and second	UINT16	HiWord: minute (0…59) LoWord: second (0…59)
9003	RW	Millisecond	UINT16	0…999
9004	RW	UNIX time	UINT32	Time in seconds elapsed since January 01, 1970 (00:00:00 h) (946684800…4102444799)

Table 10.33: Timestamp register

10.15 DOx control

The control register of the digital outputs are implemented as Write-Only registers (WO) and can be controlled with the function code 0x05. In order to query the current DO status, the register **0086** has to be read out.

PEM555 supports the execution of commands to the outputs in two steps (**ARM before EXECUTING**): Before sending an open or close command to one of the outputs, it must be activated first. This is achieved by writing 0xFF00 to the appropriate DO register. If an "Execute" command is not received within 15 seconds, the output will be deactivated again.

Each command to be executed sent to an output not being activated before, will be ignored by the PEM555 and returned as an exception code 0x04.

Register	Property	Format	Description	Note
9100	WO	UINT16	Activate DO1 close	Writing 0xFF00
9101	WO	UINT16	Execute DO1 close	Writing 0xFF00
9102	WO	UINT16	Activate DO1 open	Writing 0xFF00

Register	Property	Format	Description	Note
9103	WO	UINT16	Execute DO1 open	Writing 0xFF00
9104	WO	UINT16	Activate DO2 close	Writing 0xFF00
9105	WO	UINT16	Execute DO2 close	Writing 0xFF00
9106	WO	UINT16	Activate DO2 open	Writing 0xFF00
9107	WO	UINT16	Execute DO2 open	Writing 0xFF00
9108	WO	UINT16	Activate DO3 close	Writing 0xFF00
9109	WO	UINT16	Execute DO3 close	Writing 0xFF00
9110	WO	UINT16	Activate DO3 open	Writing 0xFF00
9111	WO	UINT16	Execute DO3 open	Writing 0xFF00

Table 10.34: Digital output control register

10.16 Universal measuring device information

Register	Property	Description	Format	Note
9800… 9819	RO	Model*	UINT16	see table 10.36
9820	RO	Software version	UINT16	e.g.: 10000 = V1.00.00
9821	RO	Protocol version	UINT16	e.g.: 40 = V4.0
9822	RO	Software update date (year-2000)	UINT16	e.g.: 080709 = July 9, 2008
9823	RO	Date of software update: month	UINT16	
9824	RO	Date of software update: day	UINT16	
9825…9826	RO	Serial number	UINT32	
9827…9829	Reserved			
9830	RO	Input current	UINT16	0 = 5 A, 1 = 1 A
9831	RO	U_S	UINT16	100/400 (V)

Table 10.35: Measuring device information

* The model of the universal measuring device is included in the registers 9800…9819. A coding example is given in the table below using the "PEM555" by way of example.

Register	Value (Hex)	ASCII
9800	0x50	P
9801	0x45	E
9802	0x4D	M
9803	0x35	5
9804	0x35	5
9805	0x35	5
9806…9819	0x20	Null

Table 10.36: ASCII coding of "PEM555"

11. Technical data

Insulation co-ordination

Measuring circuit

Rated insulation voltage .... 300 V
Overvoltage category III
Pollution degree 2

Supply circuit

Rated insulation voltage .... 300 V
Overvoltage category II
Pollution degree 2

Supply voltage

Rated supply voltage U_S .... AC/DC 95...415 V
Frequency range of U_S .... DC, 44...440 Hz
Power consumption .... ≤ 11 VA

Measuring circuit

Measuring voltage inputs

$U_{L1-N,L2-N,L3-N}$ .... 230 V
.... 400 V (only -451, -455)
.... 69 V (only -151)
$U_{L1-L2,L2-L3,L3-L1}$ .... 400 V
.... 690 V (only -451, -455)
.... 120 V (only -151)
Measuring range .... 10... 120 % U_N
Rated frequency .... 45...65 Hz
Internal resistance (L-N) .... > 500 kΩ

Measuring current inputs

External measuring current transformer .... should at least comply with accuracy class 0,5 S
Burden .... n.A., internal current transformers
Measuring range .... 0.1... 120% I_N
PEM555/PEM555-455
I_n .... 5 A
Measuring current transformer ratio .... 1...6000
Accuracy class according with 5 A measuring current transformer 0.5

Accuracy class according with 1 A measuring current transformer 1

PEM555-…51

I_n .... 1 A

Measuring current transformer ratio .... 1…30000

Accuracy class according with 1 A measuring current transformer 0.5

PEM555-251

I_N .... 1 A

Accuracy (v.M. = of measured value/v.S. = of full scale value)

Phase voltage U_{L1-N}, U_{L2-N}, U_{L3-N} .... ± 0.2 % of measured value

Current .... ±0.2 % of measured value / +0.05% of full scale value

Neutral current I_4 .... 0.5 % of full scale value

Frequency .... ± 0.02 Hz

Phasing .... ± 1 °

Active energy measurement according to .... DIN EN 62053-22 (VDE 0418 Part 3-22)

r.m.s. voltage measurement according to .... DIN EN 61557-12 (VDE 0413-12), chapter 4.7.6

r.m.s. phase current measurement according to .... DIN 61557-12 (VDE 0413-12), chapter 4.7.5

Frequency measurement according to .... DIN EN 61557-12 (VDE 0413-12), chapter 4.7.4

Interface

Interface/protocol .... RS-485/Modbus RTU

Baud rate .... 1.2…19.2 kbits / s

Cable length .... 0…1200 m

Recommended cable

(shielded, shield connected to PE on one side) .... min. J-Y(St)Y min. 2x0.8

Switching elements

Outputs .... 3 N/O contacts

Operating principle .... N/O operation

Rated operational voltage .... AC 230 V … DC 24 V… AC 110 V …. DC 12 V

Rated operational current .... 5 A .... 5 A .... 6 A .... 5 A

Minimum contact rating .... 1 mA at AC/DC ≥ 10 V

Inputs .... six electrically separated digital inputs

I_{min} .... 2.4 mA

U_{DI} .... DC 24 V

Environment/EMC

EMC .... IEC 61326-1

Operating temperature .... -25…+55 °C

Climatic class according to IEC 60721 (stationary use) 3K5

Classification of mechanical conditions acc. to IEC 60721 (stationary use) 3M4

Height .... to 4000 m

Connection

Connection .... screw terminals

Other

Degree of protection, installation IP20
Degree of protection, front IP52
Weight .... ≤ 1100 g

11.1 Standards and certifications

PEM555 was designed in accordance with the following standards:

DIN EN 62053-22 (VDE 0418 Part 3-22)
Electricity meter equipment (AC) - Particular requirements - Part 22: Static meters for active energy (classes 0.2 S and 0.5 S (IEC 62053);

DIN EN 61557-12 (VDE 0413-12)
Elektrische Sicherheit in Niederspannungsnetzen bis AC 1000 V und DC 1500 V – Geräte zum Prüfen, Messen oder Überwachen von Schutzmaßnahmen – Teil 12: (Electrical safety in low voltage distribution systems up to AC 1000 V and DC 1500 V - Equipment for testing, measuring or monitoring of protective measures -Part 12) Performance measuring and monitoring device (PMD)

11.2 Ordering information

Type	Current input	Article number
PEM555 230/400 V, 50 Hz	5 A	B 9310 0555
PEM555-151 69/120 V	1 A	B 9310 0559
PEM555-251 230/400 V, 50 Hz	1 A	B 9310 0556
PEM555-455 400/690 V, 50 Hz	5 A	B 9310 0557
PEM555-451 400/690 V, 50 Hz	1 A	B 9310 0558

INDEX

A

Apparent power, calculation 47
Application example 17
Area of application 15

B

Back-up fuses 21
Button
- "ENERGY" 40
- "HARMONICS" 29, 39
- "POWER" 29
- "V/I" 29, 35

C

Calculation individual harmonic distortion 48
Commissioning 27
Configuration example
- 49

Connection
- Three-phase 4-wire system 23

Connection diagram
- Connection via voltage transformers 25
- Three-phase 3-wire system 24
- Three-phase 3-wire systems 25
- Three-phase 4-wire system 23

Connection of measuring current transformers 21
Connection via voltage transformers 25
Control
- Digital outputs 127

D

Demand 53
Demand display 33
Demand period 53
Description of function 17
Device features 15
Digital inputs 25, 51
Digital output 26
- Modbus control 127

Digital outputs 51
Dimension diagram 19
Display mode
- Data display 34
- Standard display 34

DOx control 127

E

Energy pulsing
- Display 51
- enable/disable 45
- LED indication 34

Event
- Classification 119
- Memory 75
- Modbus register 118

F

Front panel mounting 20
Front view 18

H

Harmonics 39, 77
How to use this manual 9

I

Inputs, digital 25
Installation 19
Intended use 13

K
k-factor 39

L
LC display
- LCD 30
- Power and current demands 33
- Standard display areas 31—??
- Standard display indications ??—32

LED indication 34
Logging
- Energy 73
- Peak demand 57

Logic modules 57

M
Max/Min log data structure 103
Measured quantities for data recorders 60
Measuring current transformers 21
Memory
- Data recorder 59
- Event 75
- Max and Min values 57
- Waveform recorder 74

Modbus
- Basic measurements 83
- Clear/reset 107
- Data recorder 111
- Demand 91
- Energy log 116
- Energy measurement 87
- Event log 118
- Harmonic 88
- Max/Min log 98
- Measuring device information 128
- Peak demand 96
- Register Map 81
- Register Setpoints 108
- Setup parameters 104
- SOE log 118
- TCP (connector pin assignment) 26
- WFR 114

O
Operating elements 29
Output, digital 26

P
Phase angle
- Current 52
- Voltage 52

Power factor rules 47
Power Quality 77
Pulse counter 88

R
Rear view 18

S
Safety instructions 14, 19, 21
Service 10
Set demand period 53
Setpoint trigger 56
Setup
- Adjustment possibilities 43—47

SOE log
- Data structure 97
- Modbus 118

Standard display areas 31
Start
- Function of buttons 41
- Overview diagram menu 41
- SETUP mode 41

Support 10

T
Technical data 131

TEHD 39, 77
testing
- LCD 30
THD 39
Time setting 126
TOHD 39, 77
Total harmonic distortion 39

U

Unbalance 79

V

Versions 16

W

Wiring diagram 22
Work activities on electrical installations 13
Workshops 11

Bender GmbH & Co. KG
Postfach 1161 • 35301 Gruenberg • Germany
Londorfer Str. 65 • 35305 Gruenberg • Germany

Tel.: +49 6401 807-0
Fax: +49 6401 807-259

E-Mail: info@bender.de
www.bender.de
Photos: Bender

BENDER Group