EN Manual

BENDER
The Power in Electrical Safety©

PEM330/PEM333/PEM333-P

Universal measuring device

Software version starting 1.20.13

B 9310 0330
B 9310 0331
B 9310 0333
B 9310 0334
B 9310 0335
B 9310 0336

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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

Email: info@bender.de
www.bender.de

Photos: Bender archives

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1. Making effective use of this document

1.1 How to use this manual

This manual is intended for experts in electrical engineering and electronics!

In order to make it easier for you to find specific text passages or references in this manual and for reasons of comprehensibility, important information is emphasized by symbols. 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 **electrocution** 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 to make **optimum use of the product**.*

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

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

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

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

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

Tel.: +49 6401 807-752**, -762 **(technical issues)
+49 6401 807-753** (commercial matters)

Fax: +49 6401 807-759

e-mail: fieldservice@bender-service.com
Internet: www.bender-de.com

*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 Training courses

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 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., the 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 PEM330/PEM333 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. The PEM330/PEM333 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 compliant with 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 PEM330/PEM333…1
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 PEM330/PEM333… for power quality and energy management is characterised by the following features:

- Accuracy class in accordance with IEC 62053-22: 0,5 S
- LED pulse outputs for active and reactive energy
- Demands of power and current for particular time frames
- Peak demands with timestamps
- Modbus RTU communication via RS-485 (PEM333… only)
- 2 digital inputs (PEM333… only)
- Programmable setpoints (PEM333… only)
- 2 digital outputs (PEM333… only)
- 2 pulse outputs (PEM333-…P only)

- 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) — I_4 in A
  - Frequency — f in Hz
  - Phase angle — for U and I in °
  - Power per phase conductor — S in kVA, P in kW, Q in kvar
  - Total power — S in kVA, P in kW, Q in kvar
  - 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 %
  - Total harmonic distortion (THD) — for U and I
  - k-factor — for I
  - Max/Min values per line conductor
  - Total max/min values

3.3 Versions

	PEM330	PEM330-251	PEM333	PEM333-251	PEM333-255P	PEM333-251P
RS-485	-	-	x	x	x	x
Programmable setpoints	-	-	6	6	6	6
Digital inputs	-	-	2	2	2	2
Digital outputs	-	-	2	2	-	-
Digital pulse outputs	-	-	-	-	2	2
Sampling rate	1.6 kHz	1.6 kHz	1.6 kHz	1.6 kHz	1.6 kHz	1.6 kHz
THD-Calculation	15^{th}	15^{th}	15^{th}	15^{th}	15^{th}	15^{th}
Current input	5 A	1 A	5 A	1 A	5 A	1 A
System protocol (Entries)	32	32	32	32	32	32

3.4 Example of application

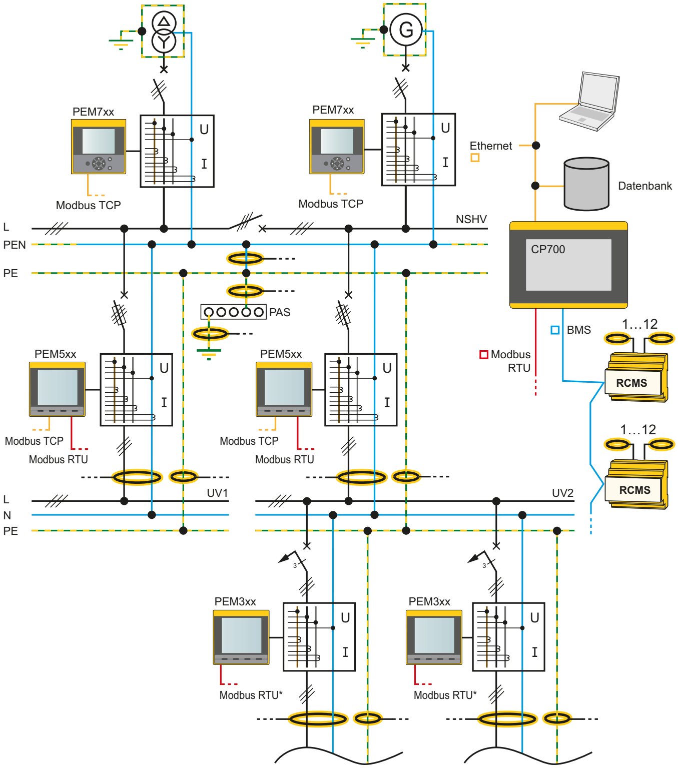


Abb. 3.1: Example of application

**) PEM333… only*

3.5 Description of function

The digital universal measuring device PEM330/PEM333… is suitable for measuring and displaying electrical parameters of electricity networks. The device measures current, voltage, energy consumption and power as well as the total harmonic distortion 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 current measurement inputs of the PEM are connected via external …/1 A or …/5 A measuring current transformers.

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 PEM330/PEM333 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

**) PEM333… only*

3.6 Front view

Abb. 3.2: Front view PEM330/PEM333

3.7 Connecting terminals

The connecting terminals are located on the rear.

4. Installation and connection

4.1 Project planning

For any questions associated with project planning, please contact Bender:
Internet: www.bender-de.com
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

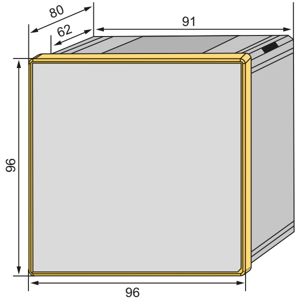


Abb. 4.1: Dimension diagram PEM33… (front view)

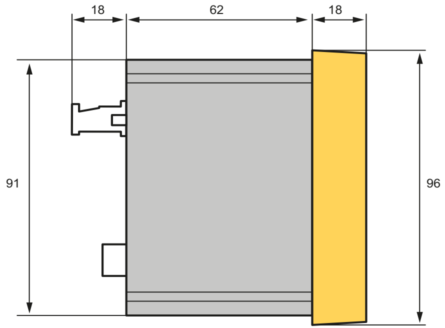


Abb. 4.2: Dimension diagram PEM33… (side view)

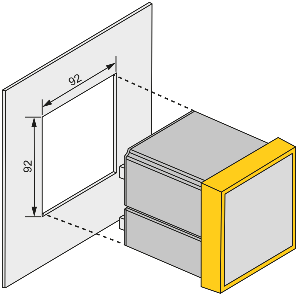


Abb. 4.3: Dimension diagram PEM33x (panel cut-out)

4.3.2 Front panel mounting

A front panel cutout of 92 mm x 92 mm is required for the device.

1. Fit the device through the cut-out in the front panel.
2. Put the 4 transparent mounting brackets from behind on the edges of the device.
3. Push the clips tightly against the panel to secure the device.
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 requirements of the standards. A suitable separator must be provided in order to switch off the power. 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 phase conductors are to be protected**.

4.4.3 Connection of measuring current transformers

When connecting the measuring current transformers, the requirements of DIN VDE 0100-557 (VDE 0100-557) – Errichten von Niederspannungsanlagen (Low-voltage electrical installations) - Teil (Part) 5: Auswahl und Errichtung elektrischer Betriebsmittel (Selection and erection of electrical equipment) - Abschnitt (Clause) 557: Auxiliary circuits

4.5 Instructions for connection

- Connect the PEM330/PEM333 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 on the rear of the device.

4.6.1 PEM330

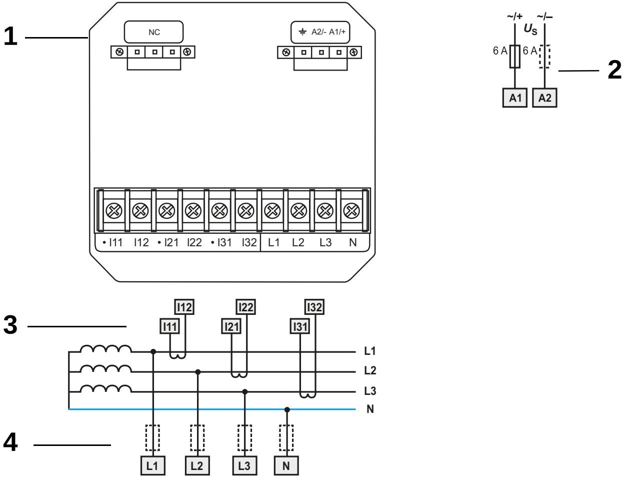


Abb. 4.4: Wiring diagram PEM330

Legend to wiring diagram PEM330

1	Not connected
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	Connection to the system to be monitored (connections I… which are not required have to be short-circuited)
4	Measuring voltage inputs: The measuring leads should be protected with appropriate fuses.

4.6.2 PEM333

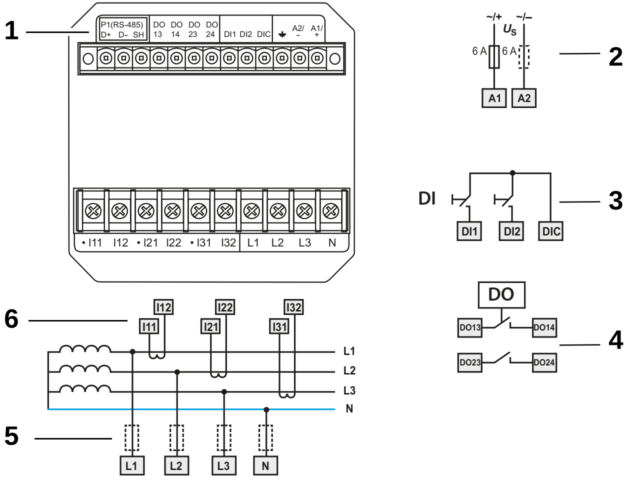


Abb. 4.5: Wiring diagram PEM333

Legend to wiring diagram PEM333

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 (connections I… which are not required have to be short-circuited)

Digital outputs PEM333

The universal measuring device PEM333 features 2 configurable outputs (N/O contacts).

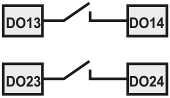


Abb. 4.6: Digital outputs PEM333

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

Digital inputs PEM333

The universal measuring device PEM333… provides 2 digital inputs. The inputs are supplied by a galvanically isolated DC 24 V voltage. Through an external wiring a current of at least I_{min} > 2.4 mA must flow in order to trigger the inputs.

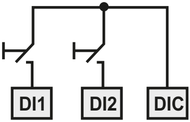


Abb. 4.7: Digital inputs PEM333

4.6.3 PEM333-…P

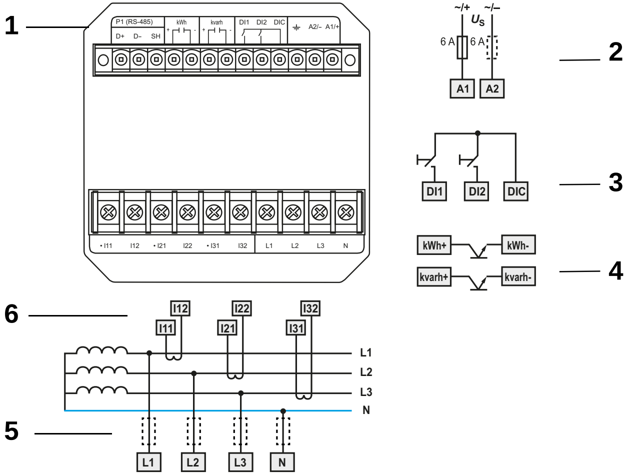


Abb. 4.8: Wiring diagram

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	Pulse outputs (opto-coupler) for kWh and kvarh max. valid external voltage 80 V; max. switching current 50 mA
5	Measuring voltage inputs: The measuring leads should be protected with appropriate fuses.
6	Connection to the system to be monitored (connections I… which are not required have to be short-circuited)

Pulse outputs PEM333-…P (internal connection diagram)

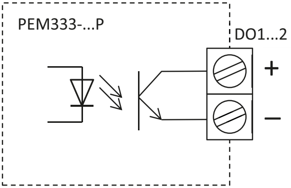


Abb. 4.9: Pulse outputs PEM333-…P (internal connection diagram))

Digital inputs PEM333-…P

The universal measuring device PEM333-…P provides 2 digital inputs. The inputs are supplied by a galvanically isolated DC 24 V voltage. Through an external wiring a current of at least I_{min} > 2.4 mA must flow in order to trigger the inputs.

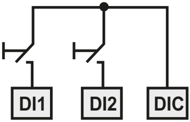


Abb. 4.10: Digital inputs PEM333-…P

4.7 Connection diagram voltage inputs

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

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

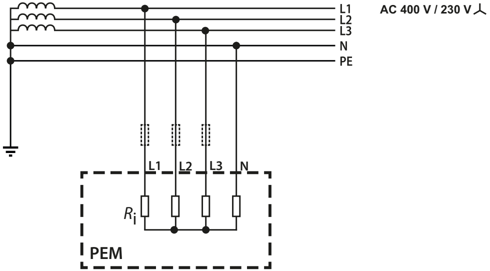


Abb. 4.11: Connection diagram three-phase 4-wire system (e.g. TN-S system)

4.7.2 Three-phase 3-wire system

The PEM can be used in three-phase 3-wire systems.

The line-to-line voltage must not exceed AC 400 V.

*For usage in three-wire systems, the connection type (TYPE) has to be set to delta (**DELTA**) (see page 51).*
*For this purpose, the **measurement inputs L2 and N are to be bridged**.*

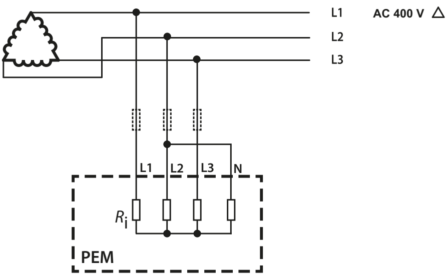


Abb. 4.12: Connection diagram three-phase 3-wire system

4.7.3 One-phase 3-wire system (1P3W)

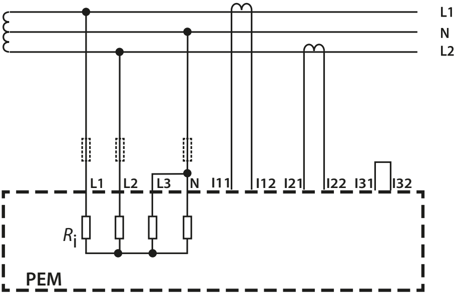


Abb. 4.13: Connection diagram one-phase 3-wire system

4.7.4 One-phase 2-wire system (1P2W)

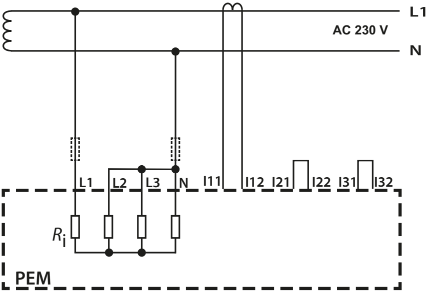


Abb. 4.14: Connection diagram one-phase 2-wire system

4.7.5 Connection via voltage transformers

The coupling via measuring voltage transformers allows the use of a measuring device in medium and high voltage systems. The transformation ratio in PEM330/PEM333 can be adjusted (1…2200).

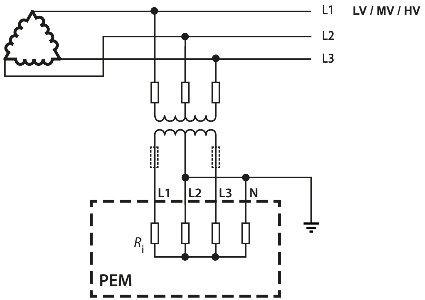


Abb. 4.15: Connection diagram via voltage transformers

5. Commissioning

5.1 Check proper connection

During installation and connection, abide by the relevant standards and regulations and follow the operating manuals for the device.

5.2 Before switching on

Before switching on think carefully about these questions:

1. Does the connected supply voltage U_S correspond to the nameplates information?
2. Is the nominal system voltage of the measuring current transformer not 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 transformer ratio (for each channel).
4. Change the measuring current transformer's counting direction, if required.
5. Set the nominal voltage.
6. Select connection: wye, delta, one-phase-…connection.

5.4 System integration and visualisation

The universal measuring device PEM333… can be parameterised and queried via Modbus-RTU. For details refer to Chapter 8. Modbus Register Map and to the internet www.modbus.org.

In addition, it can be incorporated into Bender's own BMS (Bender measuring device interface) bus protocol via additional communication modules. This allows communication with Bender devices (already existing) to realise device parameter setting and visualisation of measuring values and alarms.

Examples and information about system integration you will find on our homepage www.bender.de or you can personally discuss it with Bender service experts (see "Chapter 1. 2 Technical support: Service and support").

6. Operation

6.1 Getting to know the operating elements

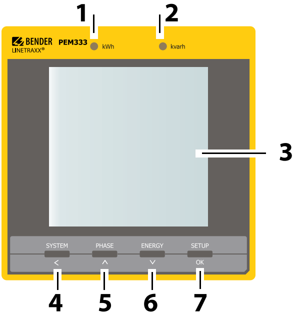


Abb. 6.1: Operating elements

Legend to operating elements

No.	Element	Description
1	LED "kWh"	Pulse output, see "Chapter 6.5 LED indication", page 41
2	LED "kvarh"	
3	LC display	
4	"SYSTEM" button <	Display mean value and total value (current, voltage) **in the menu**: in case of numerical values: move the cursor one position to the left
5	"PHASE" button Λ	Display line-conductor related measured quantities **in the menu**: go up one entry in case of numerical values: increasing the value

6	"ENERGY" button ∨	Display measured values: Active and reactive energy import/active and reactive energy export (line 4) **in the menu**: move down one entry in case of numerical values: reduce the value
7	"SETUP" button OK	Press > 3 s: switching between setup menu and standard display **in the menu**: selection of the parameter to be edited confirm entry

6.2 LC display test

Simultaneously press the "PHASE" and "ENERGY" buttons for > 2 seconds enters the LCD testing mode. During testing, all LCD segments are illuminated for one second and then turned off for 1 second. This cycle will be repeated 3 times. After completion of the test run, the device automatically returns to its normal display mode.

Abb. 6.2: Display during an LCD test

6.3 Getting to know standard display indications

The display is divided into five areas.

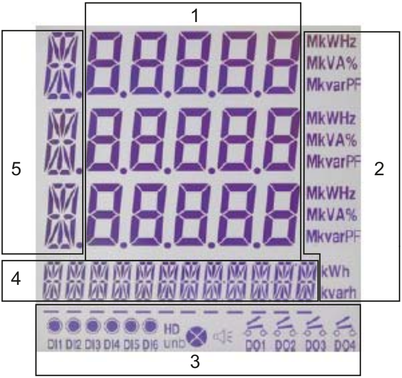
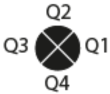


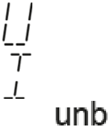
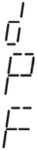
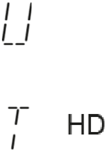
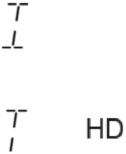
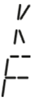
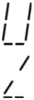
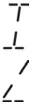
Abb. 6.3: Display areas

Legend to the display areas

1	Measured values
2	Measurement units
3	Displays the indicators for digital inputs and outputs (DI status, DO status), total harmonic distortion THD, unbalance (unb), quadrant (see page 38)
4	Displays energy information such as active energy import and export and reactive energy import and export and apparent energy
5	Symbols (see page 39 for explanation)

Description of the default display screens (segments 3-5)

Area	Segments	Symbol description	
3		 DI open	 DO open
		 DI closed	 DO closed
		HD Total harmonic distortion	unb Unbalance
		 Quadrant	 Alarm symbol
4		 Indicator apparent energy	Export indicator (active and reactive energy)

Area	Segments	Symbol description		
5		 Phase voltage	 Line-to-line voltage	
		 Neutral current (I_4)	 Voltage-/current-unbalance	 Demand
		 Displacement factor	 Total harmonic distortion $U_{L1/L2/L3}$ (THD)	 Total harmonic distortion $I_{1/2/3}$ (THD)
		 k-factor	 Phase angle $U_{L1/L2/L3}$	 Phase angle $I_{1/2/3}$

Tab. 6.1: Standard display indications

6.4 Power and current demand (Demand display)

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

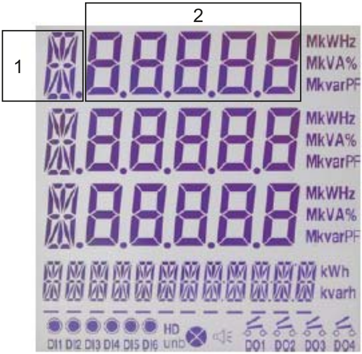


Abb. 6.4: Display: peak demand

1 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 S

2 Peak demand value

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. The setting can be carried out in the setup menu using the buttons on the front or via the communication interface (PEM333 only). The frequency of flashing per energy amount can be set using the pulse constant (EN CONST). 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.

First line

Second line

Third line

Abb. 6.5: Standard display

6.7 Data display for wye or delta connection

There are three buttons that are used to indicate the measured data: "SYSTEM", "PHASE" and "ENERGY". The following tables illustrate how to retrieve individual values for **wye or delta connection** (setup menu point TYPE, register 41012).

6.7.1 "SYSTEM" button

Column left	Column right	First line	Second line	Third line
	A W PF	Ø I	P_{ges}	Power factor λ
L_L	V kvar Hz	Ø U_{LL}	Q_{ges}	F
	kW kvar kVA	P_{ges}	Q_{ges}	S_{ges}
L_N	V A kW	Wye connection: Ø U_{LN} Delta connection: Ø U_{LL}	Ø I	P_{ges}
I 4	A	* I_4		
U I	% %	*	Unbalance U	Unbalance I
D M D	A A A	Demand I_1	Demand I_2	Demand I_3

Column left	Column right	First line	Second line	Third line
D M D	kW kvar kVA	Demand *P*	Demand *Q*	Demand *S*

Tab. 6.2: Data display screens via "SYSTEM" button

Comment:

* In "delta connection" mode the display shows "– "

6.7.2 "PHASE" button

Column left	Column right	First line	Second line	Third line
	A A A	I_1	I_2	I_3
Ln Ln Ln	V V V	U_{L1}*	U_{L2}*	U_{L3}*
LL LL LL	V V V	U_{L1L2}	U_{L2L3}	U_{L3L1}
	kW kW kW	P_{L1}*	P_{L2}*	P_{L3}*
	var var var	Q_{L1}*	Q_{L2}*	Q_{L3}*
	kVA kVA kVA	S_{L1}*	S_{L2}*	S_{L3}*

Column left	Column right	First line	Second line	Third line
	PF PF PF	λ_{L1}*	λ_{L2}*	λ_{L3}*
d P F	PF PF PF	Displacement factor cos $(\varphi)_{L1}$*	Displacement factor cos $(\varphi)_{L2}$*	Displacement factor cos $(\varphi)_{L3}$*
U T	% % %	THD U_{L1}	THD U_{L2}	THD U_{L3}
I T	% % %	THD I_1	THD I_2	THD I_3
K F		k-factor I_1	k-factor I_2	k-factor I_3
U ∠		Phase angle U_{L1}	Phase angle U_{L2}	Phase angle U_{L3}
I ∠		Phase angle I_1	Phase angle I_2	Phase angle I_3

Tab. 6.3: Display screens via "PHASE" button

Comment:
* In "delta connection" mode the display shows "– ".

6.7.3 "ENERGY" button

Parameters in the fourth line:

Column left	Column right	Value
	kWh	Active energy import
--	kWh	Active energy export
	kvarh	Reactive energy import
--	kvarh	Reactive energy export
S		Apparent energy

Tab. 6.4: Display screens via "ENERGY" button

6.8 Data display for one-phase connections

There are three buttons that are used to indicate the measured data: "SYSTEM", "PHASE" and "ENERGY". The following tables illustrate how to retrieve individual values for setting **"1P2W" or "1P3W"** (Setup menu point TYPE, register 41012).

6.8.1 Button „SYSTEM“

Column left	Column right	First line	Second line	Third line
	A W PF	Ø I	P_{ges}	Power factor λ_{ges}
L_L	V kvar Hz	Ø U_{LL} *	Q_{ges}	f
	kW kvar kVA	P_{ges}	Q_{ges}	S_{ges}

Column left	Column right	First line	Second line	Third line
I	A	Demand I_1	Demand I_2 *	--
D M D	kW kvar kVA	Demand P	Demand Q	Demand S

Tab. 6.5: Data display screens via "SYSTEM" button

Comment:
** for 1P2W: display „--“*

6.8.2 Button „PHASE“

Column left	Column right	First line	Second line	Third line
	A A	I_1	I_2*	
1_N* 2_N*	V V	U_{L1}	U_{L2}*	
12*	V V	U_{L1L2*}		
	kW kW	P_{L1}	P_{L2}*	
	var var	Q_{L1}	Q_{L2}*	
	kVA kVA	S_{L1}	S_{L2}*	
	PF PF	λ_{L1}	λ_{L2}*	
d P F	PF PF	Displacement factor cos $(\varphi)_{L1}$	Displacement factor cos $(\varphi)_{L2}$*	
U T	% %	THD U_{L1}	THD U_{L2}*	

Column left	Column right	First line	Second line	Third line
I T	% %	THD I_1	THD I_2*	
K F		k-factor I_1	k-factor I_2*	
U* ∠		Phase angle U_{L1}*	Phase angle U_{L2}*	
I* ∠		Phase angle I_1*	Phase angle I_2*	

Tab. 6.6: Display screens via "PHASE" button

* not for 1P2W

6.8.3 Button „ENERGY“

Parameters in the fourth line:

Column left	Column right	Value
	kWh	Active energy import
--	kWh	Active energy export
	kvarh	Reactive energy import
--	kvarh	Reactive energy export
S		Apparent energy

Tab. 6.7: Display screens via "ENERGY" button

6.9 Setup using the "SETUP" button

Press the "SETUP" button for more than 3 s to access the setup mode.
Press the "SETUP" button again to return to the default display screen.

To be able to change parameters, you must first enter the password.
(factory setting: 0)

6.9.1 "SETUP": Meaning of the buttons

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

"SETUP"	Enter button:	to confirm the value entered
"PHASE"	Arrow button " ∧ ":	Advances to the next parameter in the menu or increments a numeric value
"ENERGY"	Arrow button " ∨ ":	Goes back to the last parameter in the menu or decrements a numeric value.
"SYSTEM"	Arrow button " < ":	moves the cursor to the left by one position if the parameter being changed is a numeric value

6.9.2 SETUP: Overview diagram menu

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

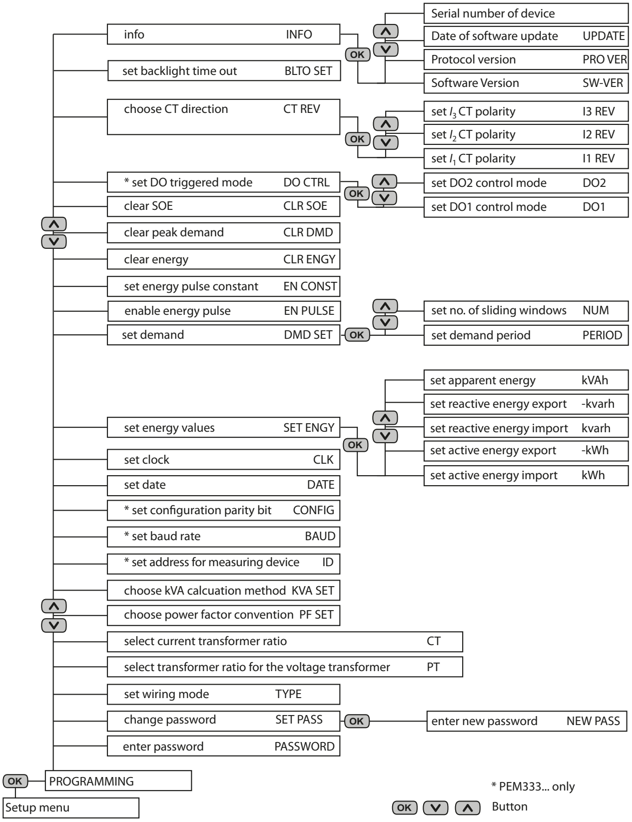


Abb. 6.6: Setup: Setting possibilities

6.10 Setup: Setting possibilities

The table represents the messages indicated on the display, their meaning and their setting possibilities.

Display entry Level 1 / Level 2	Parameters	Description	Setting options	Factory setting
PROGRAM-MING		Setup mode		
PASSWORD	Password	Enter password	/	0
SET PASS		Change pass-word?	YES/NO	NO
NEW PASS	New pass-word	Enter new pass-word	0000…9999	0
TYPE		Select type of connection	WYE/DELTA/ DEMO/1P3W/ 1P2W	WYE
PT		Select transfor-mer ratio for the voltage transfor-mer	1…2200	1
CT		Select CT trans-former ratio	1…30,000 (1 A) 1…6,000 (5 A)	1
PF SET	Power factor convention	Power factor con-vention***	IEC/IEEE/IEEE	IEC
KVA SET		*S* calculation method*	V/S	V
ID	Address for measuring device	Set address for measuring device	1…247	100

Display entry Level 1 / Level 2	Parameters	Description	Setting options	Factory setting
Baud	Baud rate	Set baud rate	1200/2400/ 4800/9600/ 19200 bps	9600
CONFIG	Comm. port configura-tion	Configuration parity bit	8N2/8O1/8E1/ 8N1/8O2/8E2	8E1
DATE	Date	Setting the date	YY-MM-DD	/
CLK	Time	Setting the time	HH:MM:SS	/
SET ENGY	Presetting of energy values	Presetting of energy values	YES/NO	NO
kWh	Active energy import	Presetting of active energy import	0… 99,999,999.99	0
-kWh	Active energy export	Presetting of active energy export	0… 99,999,999.99	0
kvarh	Reactive energy import	Presetting of reactive energy import	0… 99,999,999.99	0
-kvarh	Reactive energy export	Presetting of reactive energy export	0… 99,999,999.99	0
kVAh	Apparent energy	Presetting of apparent energy	0… 99,999,999.99	0
DMD SET	Demand measure-ment	Demand measu-rement on/off	YES/NO	NO

Display entry Level 1 / Level 2	Parameters	Description	Setting options	Factory setting
PERIOD	Measuring time of defined length	Specify the time for demand measurement	1, 2, 3, 5, 10, 15, 30, 60 (minutes)	15
NUM	Number of sliding windows	Set the number of sliding windows	1…15	1
EN PULSE	Energy Pulsing	Activate kWh and kvar energy pulsing	YES/NO	NO
EN CONST	Pulse constant	Number of LED pulses per amount of energy	1K, 3.2K, 5K, 6.4K**, 12.8K**	1K
CLR ENGY	Clear energy values	Clear kWh, kvar and kVAh	YES/NO	NO
CLR DMD	Clear peak demand	Clear peak demand values	YES/NO	NO
CLR SOE	Clear event memory	Clear event memory	YES/NO	NO
DO CTRL	Trigger mode for digital outputs	Change trigger mode for digital outputs	YES/NO	NO
DO1	Operating mode DO1	Set operating mode DO1	NORMAL/ON/OFF	NORMAL
DO2	Operating mode DO2	Set operating mode DO2	NORMAL/ON/OFF	NORMAL
CT REV	Select CT direction	Change CT direction	YES/NO	NO

Display entry Level 1 / Level 2	Parameters	Description	Setting options	Factory setting
I1 REV	I_1 CT	I_1 Change CT polarity	YES/NO	NO
I2 REV	I_2 CT	*I2* Change CT polarity	YES/NO	NO
I3 REV	I_3 CT	I_3 Change CT polarity	YES/NO	NO
BLTO SET	Display lighting	Time duration until the display gets dark	0…59 (minutes)	3
INFO	Information	read only	YES/NO	NO
SW-VER	Software version		/	/
PRO VER	Protocol version	50 means V5.0	/	/
UPDATE	Date of software update	jjmmtt	/	/
	Serial number	Serial number device	/	/

Tab. 6.8: Setup: Setting possibilities

Comments on the table above

* There are various types of calculating the apparent power *S*:

Vector method V:

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

Scalar method S:

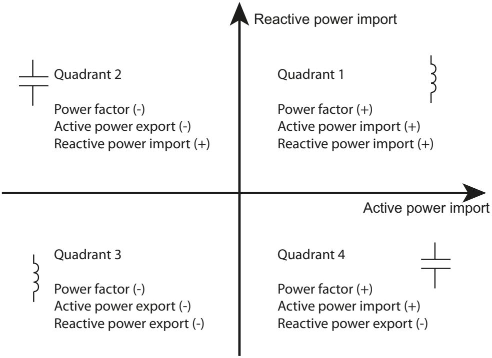
$$S_{ges} = S_{L1} + S_{L2} + S_{L3}$$

The calculation method can be selected:
V = vector method
S = scalar method

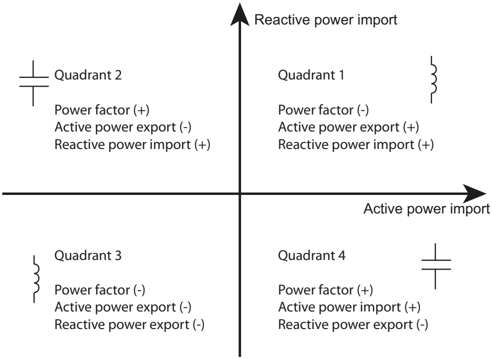
** PEM33x-251 only

***

Power factor λ conventions



IEC



IEEE

Select transformer ratio for the current transformer Example: CT 1000 : 5 (= 200)

Button	Display entry	Description
SETUP > 3 s	PROGRAMMING	
∧	PASSWORD ****	
OK	PASSWORD 0	0 flashes
OK (or Password)	PASSWORD 0	
∧	SET PASS NO	
∧	TYPE WYE	
∧	PT 1	
∧	CT 1	
OK	CT 1	1 flashes
∨	CT ERR 0	0 flashes (units)
<	CT ERR 00	left 0 flashes (tens)
<	CT ERR 0 0	left 0 flashes (hundreds)
∧ ∧	CT 200	2 flashes
OK	CT 200	CT ratio 200 set
SETUP > 3 s	standard display	

7. Application/inputs and outputs

7.1 Digital inputs (PEM333… only)

The device features two digital inputs that are internally operated with DC 24 V.
Digital inputs are typically used for monitoring external states. The switching states of the digital inputs can be read from the LC display or from connected system components. Changes in external states are stored as events in the SOE log in 1 ms resolution.

7.2 Digital outputs (PEM333… only)

The device features two digital outputs. Digital outputs are typically used for setpoint trigger, load control or remote control applications.
Examples:

1. Available via the buttons on the front panel (see "Chapter 6.9 Setup using the "SETUP" button")
2. Operation via communication interface
3. Control setpoints: Control actions in case of setpoint exceedance

7.3 Display Energy pulsing

The two LED pulse outputs are used for kWh and kvarh indication, if the function EN PULSE is enabled. The setting can be carried out in the Setup menu using the buttons on the front or via the communication interface (PEM333… only).

The LEDs flash each time a certain amount of energy is measured (1 kWh resp. 1 kvarh).

In order to determine the actual amount of energy, the flashing frequency can be calculated from the CT ratio and the pulse constant..

$$\text{Pulses per kWh} = \frac{\text{Pulse constant}}{\text{ratio VT x ratio CT}}$$

$$\text{Amount of energy per pulse} = \frac{\text{ratio VT x ratio CT}}{\text{Pulse constant}}$$

Comment:
VT = voltage transformer
CT = current transformer

7.4 Digital pulse outputs (PEM333-…P only)

The device features two digital pulse outputs for kWh and kvarh, which can be activated via the EN PULSE function. They behave like LED pulse outputs: As soon as a specific amount of energy (1 kWh or 1 kvarh) has been measured, a signal for further processing will be emitted via the outputs.
Digital pulse outputs are normally used for accuracy tests.

7.5 Power and energy

7.5.1 Voltage and current phase angles

Phase analysis is used to identify the angle relationship between the three-phase voltages and currents.

7.5.2 Energy

Basic energy parameters include

- Active energy (import and export in kWh)
- Reactive energy (import and export in kvar)
- Apparent energy (S_{ges} in kVAh)

The maximum value to be displayed is ± 99,999,999.9. When the maximum value is reached, the energy register will automatically roll over to zero. The energy register can be edited via software (PEM333… only) and the buttons on the front panel, password required.

7.5.3 Demand DMD

Demand is defined as the approximate average power consumption over a fixed interval. The following values are determined:

- Active power *P*
- Apparent power *S*
- Reactive power *Q*
- I_1
- I_2
- I_3

The time specified for measuring can be set using the buttons on the front panel or via the communication interface. The following options are available:

1, 2, 3, 5, 10, 15, 30, 60 minutes

During the selected measuring period, the power 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 options see "Chapter 6.10 Setup: Setting possibilities".

7.6 Setpoints (PEM333… only)

The device features 6 user programmable control setpoints which provide extensive control by allowing a user to initiate an action in response to a specific condition. The alarm symbol at the bottom of the LC display appears if there are any reached/active control setpoints. When the setpoint is reached it will typically result in alarming and fault detection.

Setpoints are programmed via the **communication interface**
and have the following **setup parameters:**

1. **Setpoint type:** specifies the parameters to be determined and the setpoint type (limit value exceeded/below limit value).

The following settings are possible:

Setpoint type	Parameters
Values exceeded	Phase voltages U_{LN} (x100 V)
	Line-to-line voltages U_{LL}(x100 V)
	I (x1000 A)
	P_{ges}(x1000 kW)
	Q_{ges}(x1000 kvar)
Value below limit	Phase voltages U_{LN} (x100 V)
	Line-to-line voltages U_{LL}(x100 V)
	Power factor λ (×1000)

2. **Setpoint limit**: Specifies the value that the setpoint parameter must go below or exceed for the setpoint to become active. Returns to normal condition in case of:
- the limit value is exceeded 0.95 x setpoint limit
- the value is below the limit value 1.05 x setpoint limit

   For P, Q and λ, also negative values can be entered as setpoint limits.
3. **Setpoint delay**: Specifies the minimum duration
- which the setpoint condition must be met before the setpoint becomes active or
- which the setpoint return condition must be met before the setpoint becomes inactive.

An event will be generated and stored in the SOE Log for any setpoint status changes. The range of the setpoint delay is between 0 and 9,999 seconds.

4. **Setpoint trigger**: Specifies what action the setpoint will take when it becomes active. This action includes "No Trigger" and "Trigger DOx".

7.7 Event log (SOE log)

The device can store up to 32 events. If there are more than 32 events, the newest event will replace the oldest event on a first-in-first-out basis: The 33rd event overwrites the first entry, the 34th the second 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 of 1 ms resolution.
All event records can also be retrieved via communication interface (PEM333… only).
The event log can be cleared using the buttons on the front panel or via communication interface (PEM333… only).

7.8 Power Quality

7.8.1 Total harmonic distortion

The device provides an analysis of the total harmonic distortion. All parameters can be read from the display or are available via communication interface (PEM333… only). The following parameters are provided:

Harmonics	Total harmonic distortion U_{L1}	Total harmonic distortion UL1	Total harmonic distortion U_{L3}
	Total harmonic distortion I_1	Total harmonic distortion *I2*	Total harmonic distortion *I3*
	k-factor I_1	k-factor I_2	k-factor I_3

7.8.2 Unbalance

The device can measure voltage and current unbalance.
The following calculation method is applied:

$$\text{Voltage unbalance} = \frac{[|U_{L1} - \text{Ø}\,U|,|U_{L2} - \text{Ø}\,U|,|U_{L3} - \text{Ø}\,U|]_{max}}{\text{Ø}\,U} \times 100\,\%$$

$$\text{Current unbalance} = \frac{[|I_1 - \text{Ø}\,I|,|I_2 - \text{Ø}\,I|,|I_3 - \text{Ø}\,I|]_{max}}{\text{Ø}\,I} \times 100\,\%$$

Comment: Ø means the average value

8. Modbus Register Map

This chapter provides a complete description of the Modbus register map (protocol version 6.0) for the PEM330/PEM333 series, to facilitate accessing 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).
PEM330/PEM333 supports die 6-digit addressing scheme and the following Modbus functions:

1. Holding Register to read out values
   (Read Holding Register; function code 0x03)
2. Register for setting the DO status
   (Force Single Coil; function code 0x05)
3. Register for device programming
   (Preset Multiple Registers; function code 0x10)

The register addresses are listed without the Modbus Address prefix (4 for Holding Register; 0 for Coil Register). For a complete Modbus protocol specification, please visit www.modbus.org.

8.1 Basic measuring values

Register	Property	Description	Format	Scale/ unit
40000	RO	U_{L1} 1)	UINT32	×100 V 2)
40002	RO	U_{L2} 1)	UINT32	×100 V
40004	RO	U_{L3} 1)	UINT32	×100 V
40006	RO	Ø U_{LN}	UINT32	×100 V
40008	RO	U_{L1L2}	UINT32	×100 V
40010	RO	U_{L2L3}	UINT32	×100 V
40012	RO	U_{L3L1}	UINT32	×100 V
40014	RO	Ø U_{LL}	UINT32	×100 V
40016	RO	I_1	UINT32	×1000 A
40018	RO	I_2	UINT32	×1000 A
40020	RO	I_3	UINT32	×1000 A
40022	RO	Ø I	UINT32	×1000 A
40024	RO	P_{L1} 1)	INT32	×1000 kW
40026	RO	P_{L2} 1)	INT32	×1000 kW
40028	RO	P_{L3} 1)	INT32	×1000 kW

Register	Property	Description	Format	Scale/ unit
40030	RO	P_{ges}	INT32	×1000 kW
40032	RO	Q_{L1} 1)	INT32	×1000 kvar
40034	RO	Q_{L2} 1)	INT32	×1000 kvar
40036	RO	Q_{L3} 1)	INT32	×1000 kvar
40038	RO	Q_{ges}	INT32	×1000 kvar
40040	RO	S_{L1} 1)	INT32	×1000 kVA
40042	RO	S_{L2} 1)	INT32	×1000 kVA
40044	RO	S_{L3} 1)	INT32	×1000 kVA
40046	RO	S_{ges}	INT32	×1000 kVA
40048	RO	λ_{L1} 1)	INT16	×1000
40049	RO	λ_{L2} 1)	INT16	×1000
40050	RO	λ_{L3} 1)	INT16	×1000
40051	RO	λ_{ges}	INT16	×1000
40052	RO	f	UINT16	×100 Hz
40053	RO	I_4	UINT32	x1000 A

Register	Property	Description	Format	Scale/ unit
40055	RO	Voltage unbalance	UINT16	x1000
40056	RO	Current unbalance	UINT16	x1000
40057	RO	Displacement factor L1	INT16	x1000
40058	RO	Displacement factor L2	INT16	x1000
40059	RO	Displacement factor L3	INT16	x1000
40060	RO	Demand *P*	INT32	x1000 kW
40062	RO	Demand *Q*	INT32	x1000 kvar
40064	RO	Demand *S*	INT32	x1000 kVA
40066	RO	Demand I_1	UINT32	x1000 A
40068	RO	Demand I_2	UINT32	x1000 A
40070	RO	Demand I_3	UINT32	x1000 A
40072	RO	Phase angle U_1	UINT16	x100 °
40073	RO	Phase angle U_2	UINT16	x100 °
40074	RO	Phase angle U_3	UINT16	x100 °
40075	RO	Phase angle I_1	UINT16	x100 °

Register	Property	Description	Format	Scale/ unit
40076	RO	Phase angle I_2	UINT16	x100 °
40077	RO	Phase angle I_3	UINT16	x100 °
40078… 40094	Reserved			
40095	RO	Alarm [3)]	Bitmap	
40096	RO	Status digital outputs [4)]	Bitmap	
40097	RO	Status digital inputs [5)]	Bitmap	
40098	RO	SOE pointer [6)]	UNIT32	

Tab. 8.1: Basic measuring values

Comments:

1) Only in the case of wye connection.

2) "x100 V" means that the voltage value in the register is 100 times the actual measured value (therefore, the value of the register must be divided by 100 to obtain the measuring value).

3) The alarm register 40095 shows various alarm states (1 = active, 0 = inactive). The table illustrates details of the alarm register.

Bit in register 40095	**Alarm by event**
B0…B2	Reserved
B3	Setpoint 1
B4	Setpoint 2
B5	Setpoint 3
B6	Setpoint 4
B7	Setpoint 5
B8	Setpoint 6
all other bits	Reserved

Tab. 8.2: Bit sequence alarm register (40095)

4) **Status register 40096:**

Represents the **status of the two digital outputs**

B0 for DO1 (1 = active/closed; 0 = inactive/open)

B1 for DO2 (1 = active/closed; 0 = inactive/open)

5) **Status register 44097**:

Represents the **status of the two digital inputs**

B0 for DI1 (1 = active/closed; 0 = inactive/open)

B1 for DI2 (1 = active/closed; 0 = inactive/open)

6) The event log can store up to 32 events.
It works like a ring buffer according to the FIFO principle: the 33rd value overwrites the first value, the 34th the second and so on. The event log can be reset in the setup parameter menu (see page 53).

8.2 Energy measurement

Register	Characteristics	Description	Format	Unit
40100	RW	Active energy import	UINT32	x0.1 kWh
40102	RW	Active energy export	UINT32	x0.1 kWh
40104	Reserved			
40106	RW	Reactive energy import	UINT32	x0.1 kvarh
40108	RW	Reactive energy export	UINT32	x0.1 kvarh
40110	Reserved			
40112	RW	Apparent energy	UINT32	x0.1 kVAh

Tab. 8.3: Energy measurement

Comment: When the maximum value of 99,999,999 kWh/kvarh/kVAh is reached, the measurement will restart with 0.

8.3 Energy measurement per phase

Register	Charac-teristics	Description	Format	Unit
40200	RW	Import active energy L1	UINT32	x0.1 kWh
40202	RW	Export active energy L1		x0.1 kWh
40204	Reserved			
40206	Reserved			
40208	RW	Import reactive energy L1		x0.1 kvarh
40210	RW	Export reactive energy L1		x0.1 kvarh
40212	Reserved			
40214	Reserved			
40216	RW	Apparent energy L1	UINT32	x0.1 kVAh
40218	RW	Import active energy L2	UINT32	x0.1 kWh
40220	RW	Export active energy L2		x0.1 kWh
40222	Reserved			
40224	Reserved			
40226	RW	Import reactive energy L2		x0.1 kvarh
40228	RW	Export reactive energy L2		x0.1 kvarh
40230	Reserved			

Register	Charac-teristics	Description	Format	Unit
40232	Reserved			
40234	RW	Apparent energy L2	UINT32	x0.1 kVAh
40236	RW	Import active energy L3	UINT32	x0.1 kWh
40238	RW	Export active energy L3		x0.1 kWh
40240	Reserved			
40242	Reserved			
40244	RW	Import reactive energy L3		x0.1 kvarh
40246	RW	Export reactive energy L3		x0.1 kvarh
40248	Reserved			
40250	Reserved			
40252	RW	Apparent energy L3	UINT32	x0.1 kVAh

Tab. 8.4: Energy measurement per phase

8.4 Peak demand

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

Register	Characteristics	Description	Format
40500	RO	Peak demand P	see table 8.6
40504	RO	Peak demand Q	
40508	RO	Peak demand S	
40512	RO	Peak demand I_1	
40516	RO	Peak demand I_2	
40520	RO	Peak demand I_3	

Tab. 8.5: Peak demand

Data structure peak demand

Structure of registers 40500…40520	Description
Register 1	Peak demand HiWord
Register 2	Peak demand LoWord
Register 3	UNIX time HiWord
Register 4	UNIX time LoWord

Tab. 8.6: Data structure peak demand

8.5 Total harmonic distortion (THD) and k-factor

Total harmonic distortion (THD): The value of the THD returned is 10,000 times the actual value.
Example: If the register contains a value of 1031, it means 1031/10.000 = 0.1031 or 10.31 %

k-factor: The value of the k-factor that is returned is ten times the actual measured value.

Register	Property	Description	Format	Factor
40703	RO	k-factor I_1	UINT16	×10
40704	RO	k-factor I_2	UINT16	×10
40705	RO	k-factor I_3	UINT16	×10
40706…40717	Reserved			
40718	RO	THD U_{L1}	UINT16	×10000
40719	RO	THD U_{L2}	UINT16	×10000
40720	RO	THD U_{L3}	UINT16	×10000
40721	RO	THD I_1	UINT16	×10000
40722	RO	THD I_2	UINT16	×10000
40723	RO	THD I_3	UINT16	×10000

Tab. 8.7: Harmonic and k-factor measurements

8.6 Connection fault detection

The universal measuring device not only detects connection faults but also diagnoses the fault type.

Register	Property	Description	Format
40900	RO	Connection fault detection	UINT16

The diagnosis bit indicates the type of connection fault. If the bit value is = 1, a fault has been detected.

Bit	Event
B00	Sum bit (used when no other bit is set)
B01 1)	Frequency range 40…70 Hz exceeded
B02 2)	Diagnosis not possible, since voltage of one phase < 10 % U_{nom}
B03	Diagnosis not possible, since currents of all three phases < 1 % I_{nom}
B04	Reserved
B05	Reserved
B06	Unexpected phase sequence voltage
B07	Unexpected phase sequence current
B08	P_{L1} direction may be wrong
B09	P_{L2} direction may be wrong
B10	P_{L3} direction may be wrong

Bit	Event
B11	Polarity measuring current transformer I_1 interchanged?
B12	Polarity measuring current transformer I_2 interchanged?
B13	Polarity measuring current transformer I_3 interchanged?
B14	Reserved
B15	Reserved

Tab. 8.8: Details diagnosis bit "Connection fault detection"

Comments:

1) If B01 is set to 1, the fault detection cannot be carried out.

2) If the two bits B02 and B03 are set to 1, the fault detection cannot be carried out.

8.7 Setup parameters

Register	Property	Description	Format	Range/unit
41000…41006	Reserved			
41007	RW	activate "ARM before EXECUTING"	UINT16	0 = deactivated 1* = activated
41010	RW	Transformer ratio voltage transformer	UINT16	1…2200 (100*)
41011	RW	Transformer ratio measuring current transformer	UINT16	1…6000 (current input 5 A) 1…30000 (current input 1 A) (1000*)
41012	RW	Connection mode	UINT16	0 = WYE* 1 = DELTA 2 = DEMO 3 = 1P3W 4 = 1P2W
41013	RW	Device address	UINT16	1…247 (100*)
41014	RW	Baud rate	UINT16	1 = 1200 2 = 2400 3 = 4800 4 = 9600* 5 = 19200
41015	RO	Parity	UINT16	0 = 8N2; 1 = 8O1 2 = 8E1* ; 3 = 8N1 4 = 8O2 ; 5 = 8E2

Register	Property	Description	Format	Range/unit
41016… 41018	Reserved			
41019	WO	clear all energy value registers	UINT16	Writing 0xFF00 to the register clears the values for *P*, *Q* and *S*
41020	WO	Resets the event log	UINT16	Writing 0xFF00 to the register resets the SOE pointer of the event log to 0
41021… 41024	Reserved			
41025	RW	Setpoint 1	Data structure setpoint 1)	
41029	RW	Setpoint 2		
41033	RW	Setpoint 3		
41037	RW	Setpoint 4		
41041	RW	Setpoint 5		
41045	RW	Setpoint 6		
41049… 41052	Reserved			
41053	RW	Power factor convention	UINT16	B1B0: 00* = IEC 01 = IEEE 10 = -IEEE

Register	Property	Description	Format	Range/unit
41054	RW	Calculation method *S*	UINT16	B1B0: 00* = vector 01 = scalar
41055	Reserved			
41056	RW	Polarity measuring current transformer L1	UINT16	0* = normal 1 = reversed
41057	RW	Polarity measuring current transformer L2	UINT16	0* = normal 1= reversed
41058	RW	Polarity measuring current transformer L3	UINT16	0 = normal 1 = reversed
41059…41222	Reserved			
41223	RW	Specified time for demand measurement	UINT16	1, 2, 3, 5, 10, 15*, 30, 60 minutes
41224	Reserved			
41225	RW	Rotating field	UINT16	0* = ABC right 1 = CBA left
41226	WO	Clear peak demand value	UINT16	Writing „0xFF00“ to the register resets the peak demand value to 0

Register	Property	Description	Format	Range/unit
41227	WO	Reset Max/Min log	UINT	Writing „0xFF00“ to the register resets the Max/ Min log to 0

Tab. 8.9: Setup parameters

Data structure setpoint

The internal data structure of the 4 registers belonging to each setpoint is described in the table below.

Structure of the registers 41025…41045	Format	Description	
Register 1 (LoByte)	UINT16	>-Setpoint Setpoint exceeded: 1 = U_{LN}, 2 = U_{LL}, 3 = I 4 = P_{ges} 5 = Q_{ges}	<-Setpoint Value below setpoint: 6 = U_{LN} 7 = U_{LL} 8 = λ_{ges}
Register 1 (HiByte)		Setpoint trigger: 0 = No Trigger, 1 = Trigger DO1, 2 = Trigger DO2	
Register 2	UINT32	Setpoint limits	
Register 3			
Register 4	UINT16	Setpoint delay: 0…9999 (seconds)	

Tab. 8.10: Setpoint data structure

The value of the power factor λ displayed is 1000 times the measured value.
Example: desired setpoint is 0.866; value to be set: 0.866 x1000 = 866.

U_{LL}	(x100 V)
U_{LN}	(x100 V)
I	(x1000 A)
P_{ges}	(x1000 kW)
Q_{ges}	(x1000 kvar)
power factor λ	(x1000)

For P, Q and λ, also negative values can be entered as setpoint limits.

8.8 Event log (SOE log)

Each SOE event occupies 7 registers, as shown in the following table. The internal data structure of the event log is listed in table 8.12.

Register	Characteristics	Description	Format
42000…42006	RO	Event 1	see table 8.12
42007…42013	RO	Event 2	
42014…42020	RO	Event 3	
42021…42027	RO	Event 4	
42028…42034	RO	Event 5	
42035…42041	RO	Event 6	
42042…42048	RO	Event 7	
42049…42055	RO	Event 8	
42056…42062	RO	Event 9	
42063…42069	RO	Event 10	
…			
42217…42223	RO	Event 32	

Tab. 8.11: Event log (SOE log)

Event data structure

The internal data structure of the 7 registers belonging to each event in the SOE log is described in the table below.

Register	Characteristics	Description
Register 1	RO	Reserved
Register 2	RO	Event classification (see table 8.13 on page 86)
Register 3	RO	Event value HiWord
Register 4	RO	Event value LoWord
Register 5	RO	Event time (milliseconds) 0…999
Register 6	RO	Event timestamp HiWord (UNIX time in seconds)
Register 7	RO	Event timestamp LoWord (UNIX time in seconds)

Tab. 8.12: Event data structure

Event classification

Event classification	Meaning
1	Digital input 1 closed
2	Digital input 1 open
3	Digital input 2 closed
4	Digital input 2 open
5…10	Reserved
11	Digital output 1 closed
12	Digital output 1 open
13	Digital output 2 closed
14	Digital output 2 open
15…21	Reserved
22	Failure supply voltage
23…30	Reserved
31	Setup changed via device buttons
32	Setup changed via communications
33…59	Reserved
60	Setpoint active: phase voltage exceeded

Event classification	Meaning
61	Setpoint active: line-to-line voltage exceeded
62	Setpoint active: *I* exceeded
63	Setpoint active: P_{ges} exceeded
64	Setpoint active: Q_{ges} exceeded
65	Setpoint active: phase voltage exceeded
66	Setpoint active: line-to-line voltage below setpoint
67	Setpoint active: power factor below setpoint
68	Setpoint inactive: phase voltage exceeded
69	Setpoint inactive: line-to-line voltage exceeded
70	Setpoint inactive: *I* exceeded
71	Setpoint inactive: P_{ges} exceeded
72	Setpoint inactive: Q_{ges} exceeded
73	Setpoint inactive: phase voltage exceeded
74	Setpoint inactive: line-to-line voltage below setpoint
75	Setpoint inactive: power factor below setpoint

Tab. 8.13: Event classification (2nd Event log register)

8.9 Max/Min Log

8.9.1 Maximum values

Register	Property	Description	Format	Range/unit
43000	RO	$U_{L1\ max}$ 1)	see table 8.16	x100 V 2)
43004	RO	$U_{L2\ max}$ 1)		x100 V
43408	RO	$U_{L3\ max}$ 1)		x100 V
43012	RO	Ø $U_{LN\ max}$		x100 V
43016	RO	$U_{L1L2\ max}$		x100 V
43020	RO	$U_{L2L3\ max}$		x100 V
43024	RO	$U_{L3L1\ max}$		x100 V
43028	RO	Ø $U_{LL\ max}$		x100 V
43032	RO	$I_{1\ max}$		x1000 A
43036	RO	$I_{2\ max}$		x1000 A
43040	RO	$I_{3\ max}$		x1000 A
43044	RO	Ø I_{max}		x1000 A
43048	RO	$P_{L1\ max}$ 1)		x1000 kW

Register	Property	Description	Format	Range/unit
43052	RO	$P_{L2\ max}$ 1)		x1000 kW
43056	RO	$P_{L3\ max}$ 1)		x1000 kW
43060	RO	$P_{ges\ max}$		x1000 kW
43064	RO	$Q_{L1\ max}$ 1)		x1000 kvar
43068	RO	$Q_{L2\ max}$ 1)		x1000 kvar
43072	RO	$Q_{L3\ max}$ 1)		x1000 kvar
43076	RO	$Q_{ges\ max}$		x1000 kvar
43080	RO	$S_{L1\ max}$ 1)	see table 8.16	x1000 kVA
43084	RO	$S_{L2\ max}$ 1)		x1000 kVA
43088	RO	$S_{L3\ max}$ 1)		x1000 kVA
43092	RO	$S_{ges\ max}$		x1000 kVA
43096	RO	$\lambda_{L1\ max}$ 1)		x1000
43100	RO	$\lambda_{L2\ max}$ 1)		x1000
43104	RO	$\lambda_{L3\ max}$ 1)		x1000
43108	RO	$\lambda_{ges\ max}$		x1000

Register	Property	Description	Format	Range/unit
43112	RO	f_{max}	see table 8.16	x100 Hz
43116	RO	max. voltage unbalance		x1000
43120	RO	max. current unbalance		x1000
43124	RO	$THD_{UL1\ max}$		x10.000
43128	RO	$THD_{UL2\ max}$		x10.000
43132	RO	$THD_{UL3\ max}$		x10.000
43136	RO	$THD_{I1\ max}$		x10.000
43140	RO	$THD_{I2\ max}$		x10.000
43144	RO	$THD_{I3\ max}$		x10.000

Tab. 8.14: Maximum values

Comments:

1) Only in the case of wye connection.

2) "x100 V" means that the voltage value in the register is 100 times the actual measured value (therefore, the value of the register must be divided by 100 to obtain the measuring value).

8.9.2 Minimum values

Register	Property	Description	Format	Range/unit
43200	RO	$U_{L1\ min}$ 1)	see table 8.16	x100 V 2)
43204	RO	$U_{L2\ min}$ 1)		x100 V
43208	RO	$U_{L3\ min}$ 1)		x100 V
43212	RO	Ø $U_{LN\ min}$		x100 V
43216	RO	$U_{L1L2\ min}$		x100 V
43220	RO	$U_{L2L3\ min}$		x100 V
43224	RO	$U_{L3L1\ min}$		x100 V
43228	RO	Ø $U_{LL\ min}$		x100 V
43232	RO	$I_{1\ min}$		x1000 A
43236	RO	$I_{2\ min}$		x1000 A
43240	RO	$I_{3\ min}$		x1000 A
43244	RO	Ø I_{min}		x1000 A
43248	RO	$P_{L1\ min}$ 1)		x1000 kW
43252	RO	$P_{L2\ min}$ 1)		x1000 kW

Register	Property	Description	Format	Range/unit
43256	RO	$P_{L3\ min}$ 1)	see table 8.16	x1000 kW
43260	RO	$P_{ges\ min}$		x1000 kW
43264	RO	$Q_{L1\ min}$ 1)		x1000 kvar
43268	RO	$Q_{L2\ min}$ 1)		x1000 kvar
43272	RO	$Q_{L3\ min}$ 1)		x1000 kvar
43276	RO	$Q_{ges\ min}$		x1000 kvar
43280	RO	$S_{L1\ min}$ 1)		x1000 kVA
43284	RO	$S_{L2\ min}$ 1)		x1000 kVA
43288	RO	$S_{L3\ min}$ 1)		x1000 kVA
43292	RO	$S_{ges\ min}$		x1000 kVA
43296	RO	$\lambda_{L1\ min}$ 1)		x1000
43300	RO	$\lambda_{L2\ min}$ 1)		x1000
43304	RO	$\lambda_{L3\ min}$ 1)		x1000

Register	Property	Description	Format	Range/unit
43308	RO	$\lambda_{ges\ min}$	see table 8.16	x1000
43312	RO	f_{min}		x100 Hz
43316	RO	min. unbalance U		x1000
43320	RO	min. unbalance I		x1000
43324	RO	$THD_{UL1\ min}$		x10.000
43328	RO	$THD_{UL2\ min}$		x10.000
43332	RO	$THD_{UL3\ min}$		x10.000
43336	RO	$THD_{I1\ min}$		x10.000
43340	RO	$THD_{I2\ min}$		x10.000
43344	RO	$THD_{I3\ min}$		x10.000

Tab. 8.15: Minimum values

Comments:

1) Only in the case of wye connection.

2) "x100 V" means that the voltage value in the register is 100 times the actual measured value (therefore, the value of the register must be divided by 100 to obtain the measuring value).

8.9.3 Data structure Max/Min log

Offset	Property	Description	Format
+0	RO	HiWord: max. resp. min value	UINT16
+1	RO	LoWord: max. resp. min value	UINT16
+2	RO	HiWord: UNIX time	UINT16
+3	RO	LoWord: UNIX time	UINT16

Tab. 8.16: Data structure Max/Min log

8.10 Time setting

The PEM333… provides two time display formats:

1. Year/Month/Day/Hour/Minute/Second register 60000…60002
2. UNIX time register 60004…60005

When sending the time via Modbus communications, make sure to use only one time display format of the two time register sets. All registers within a time register set must be written in a single transaction.

If all the registers **60000…60005** are set, both timestamp registers will display the time as UNIX time. Time specified in the first display format will be ignored.

Optionally, the register **60003** displays milliseconds. For transmitting the timestamp, the function code has to be set to 0x10 (Preset Multiple Register). Invalid date or time values will be rejected by the measuring device.

Register	Property	Description	Format	Comment
60000	RW	Year and month	UINT16	HiWord: year 2000 + (1…69) LoWord: month (1…12)
60001	RW	Day and hour	UINT16	HiWord: day (1…28/29/30/31) LoWord: hour (0…23)
60002	RW	Minute and second	UINT16	HiWord: minute (0…59) LoWord: second (0…59)
60003	RW	Millisecond	UINT16	0…999
60004… 60005	RW	UNIX Time	UINT32	Time in seconds elapsed since January 1, 1970 (00:00:00 h) (0…3155759999)

Tab. 8.17: Timestamp register

8.11 DOx control

The DI control register are implemented as "Write-Only" registers (WO) and are set with the function code 0x05. In order to query the current DO status, the register **40066** has to read out.
PEM executes 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 PEM333… and returned as an exception code 0x04. Register **41007** activates/deactivates the function "**ARM before EXECUTING**".

Register	Property	Format	Description
60064	WO	UINT16	Activate close DO1
60065	WO	UINT16	Execute close DO1
60066	WO	UINT16	Activate open DO1
60067	WO	UINT16	Execute open DO1
60068	WO	UINT16	Activate close DO2
60069	WO	UINT16	Execute close DO2
60070	WO	UINT16	Activate open DO2
60071	WO	UINT16	Execute open DO2
60072…60127	Reserved		
60128	WO	UINT16	Activate reset alarm LED and buzzer
60129	WO	UINT16	Execute reset alarm LED and buzzer

Tab. 8.18: Digital output control register

8.12 Universal measuring device information

Register	Property	Description	Format	Comment
60200… 60219	RO	Model*	UINT16	see "Chapter Tab. 8.20: ASCII coding of "PEM333""
60220	RO	Software version	UINT16	e.g.: 10000 = V1.00.00
60221	RO	Protocol version	UINT16	e.g.: 40 = V4.0
60222	RO	Software update date (year + 2000)	UINT16	e.g.: 080709 = July 9, 2008
60223	RO	Software update Date: month	UINT16	
60224	RO	Software update Date: day	UINT16	
60225	RO	Serial number of device	UINT32	
60227…60229	Reserved			
60230	RO	Measuring current input	UINT16	1 / 5 (A)
60231	RO	U_S	UINT16	100 / 400 (V)

Tab. 8.19: Measuring device information

* The model of the universal measuring device appears in the registers 60200…60219.

A coding example is given in the table below using the "PEM333" by way of example.

Register	Value (Hex)	ASCII
60200	0x50	P
60201	0x45	E
60202	0x4D	M
60203	0x33	3
60204	0x33	3
60205	0x33	3
60206…60219	0x20	Null

Tab. 8.20: ASCII coding of "PEM333"

9. 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 .... 95 . . . 250 V
Frequency range of U_S .... DC, 44 . . . 440 Hz
Power consumption .... ≤ 5 VA

Measuring circuit

Measuring voltage inputs

U_n ($U_{L1-N,L2-N,L3-N}$) .... 230 V
$U_{L1-L2,L2-L3,L3-L1}$ .... 400 V
Measuring range .... 10 . . . 120 % U_n
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
PEM3 . . .-25**5** . . .

I_n .... 5 A
CT transformer ratio .... 1 . . . 6000

PEM3 . . .-25**1** . . .

I_n .... 1 A
CT transformer ratio .... 1 . . . 30.000

Accuracies (of measured value/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 .... 1 % of full scale value
Frequency .... ± 0.02 Hz
Phasing .... ± 1 °
Active energy measurement 0,5 S 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 PEM333…

Interface/protocol .... RS-485/Modbus RTU
Baud rate .... 1.2…19.2 kbit / s
Cable length .... 0…1200 m
Cable shielded (shield connected to SH on one side) .... recommended cable min. J-Y(St)Y min. 2 x 0.8

Switching elements PEM333…

Outputs .... 2 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 .... 2 electrically separated digital inputs
I_{min} .... 2.4 mA
U_{DI} .... DC 24 V

Switching elements PEM333-…P

Outputs .... 2 x electronical
max. valid external voltage .... 80 V
max. switching current .... 50 mA
Inputs .... 2 electrically separated digital inputs
I_{min} .... 2,4 mA
U_{DI} .... DC 24 V

Environment/EMC

EMC .... IEC 61326-1, table 2
Operating temperature .... -25 . . . +55 °C
Climatic class acc. to DIN EN 60721
Stationary use 3K5
Classification of mechanical conditions acc. to DIN EN 60721
Stationary use 3M4

Connection

Connection .... screw-type terminals

Other

Degree of protection, installation IP20
Degree of protection, front IP52
Flammability class UL94V-0
Weight .... ≤ 550 g
Sampling rate .... 1.6 kHz
Total Harmonic distortion THD .... up to the 15th harmonic

Humidity .... 5 . . . 95 % (except condensation)
Air pressure .... 70 kPa . . . 106 kPa
Panel cutout .... 92 x 92 mm (3.62" x 3.62")
Dimensions .... 96 x 96 x 75 mm (3.8" x 3.8" × 3.0")

PEM333-…P only:
PEM333-…P is a class A device.
*If this device is used in a domestic environment, **radio interference** may occur. In this case, the user may be required to take corrective actions.*

9.1 Standards and certifications

PEM330/PEM333… was designed under consideration of 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)
Electrical safety in low voltage distribution systems up to AC 1 000 V and DC 1 500 V – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring device (PMD)

9.2 Ordering information

Type	Current input	Art. No
PEM330		
PEM330	5 A	B 9310 0330
PEM330-251	1 A	B 9310 0331
PEM333, 2 DI, 2 DO, RS-485-interface		
PEM333	5 A	B 9310 0333
PEM333-251	1 A	B 9310 0334
PEM333-…P, 2 DI, 2 pulse outputs, RS-485-interface		
PEM333-255P	5 A	B 9310 0335
PEM333-251P	1 A	B 9310 0336

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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

Email: info@bender.de
www.bender.de

Photos: Bender archives

BENDER Group