Manual

PEM533

Universal measuring device
Software version 2.00.XX

B 9310 0533
B 9310 0534
B 9310 0535
B 9310 0536

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The Power in Electrical Safety©

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Table of Contents

1. Making effective use of this document

1.1 How to use this manual

This operating manual will concern qualified experts in electrical engineering and user 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:

Information intended to assist the user to make optimum use of the product are marked with the Info symbol.

The warning symbol indicates a potential dangerous situation that may result in bodily injury and/or damage to property.
Observe the associated safety instructions.

Although great care has been taken in the drafting of this operating manual, it may nevertheless contain errors and mistakes. The Bender Group cannot accept any liability for injury to persons or damage to property resulting from errors or mistakes in this manual.
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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.de

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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.de

Please send the devices for repair to the following address:

Bender GmbH, Repair Service
Londorfer Strasse 65
35305 Gruenberg
Germany

Field Service
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- 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.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., 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 PEM533 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 PEM533 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 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 PEM533 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 PEM533 for power quality and energy management is characterised by the following features:

- Accuracy class in accordance withIEC 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
- 2 digital outputs
- Power and current demands for particular time frames
- Peak demands with timestamps
- Individual, harmonic components of current and voltage up to the 31st harmonic
- Max and Min values
- Measured quantities
  - Phase voltages U_{L1}, U_{L2}, U_{L3} in V
  - Line-conductor 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	*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* und *I*
– k-factor	for *I*

3.3 Versions

3.3.1 PEM533

230 V / 400 V, current input 5 A

3.3.2 PEM533-251

230 V / 400 V, current input 1 A

3.3.3 PEM533-455

400 V / 690 V, current input 5 A

3.3.4 PEM533-451

400 V / 690 V, current input 1 A

3.4 Application example

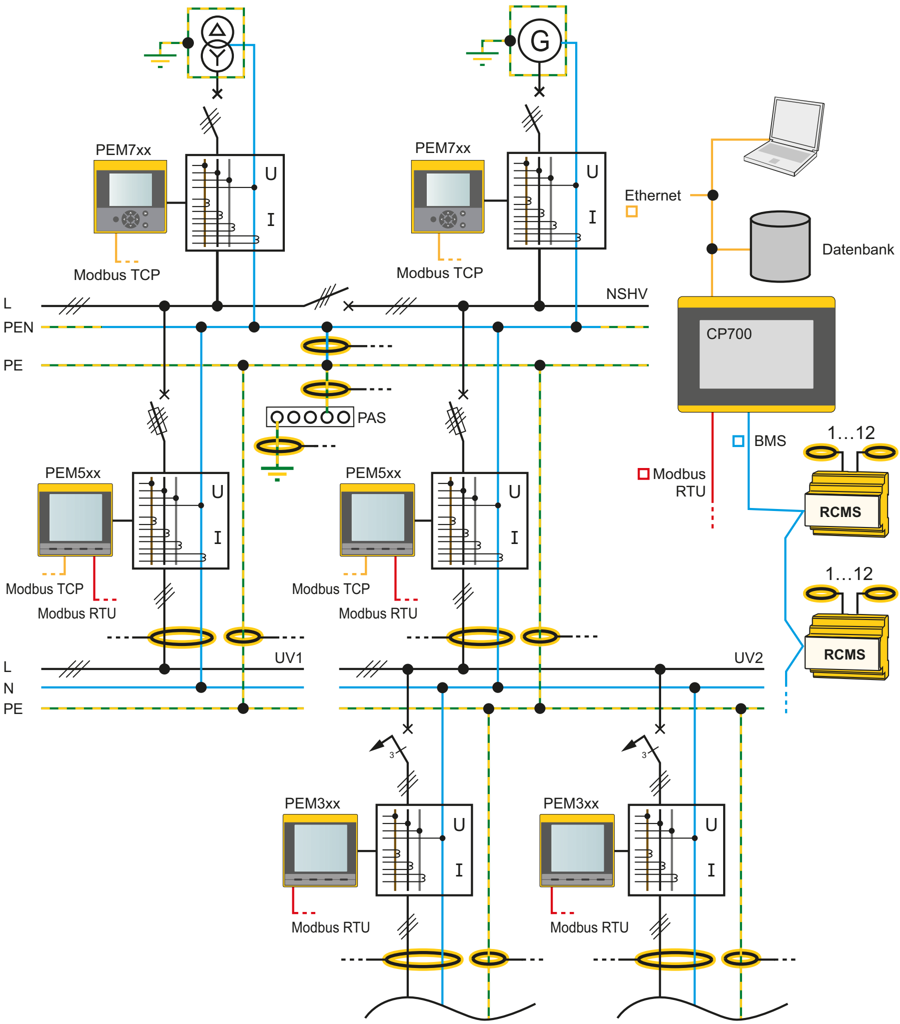


Fig. 3.1: Example of application

3.5 Description of function

The digital universal measuring device PEM533 is suited for measuring and displaying electrical quantities of electricity networks. 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 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

3.6 Front view and rear view

The connecting terminals are located on the rear.

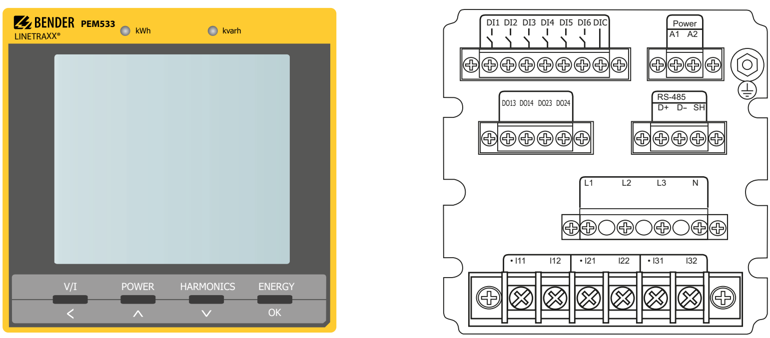


Fig. 3.2: Front view (left) and rear view (right) PEM533

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 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

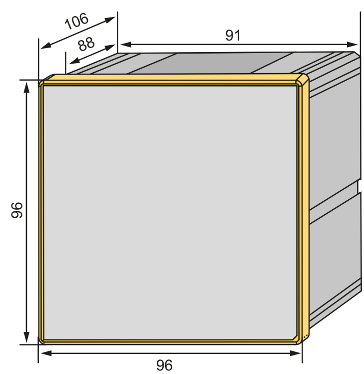


Fig. 4.1: Dimension diagram PEM533 (front view)

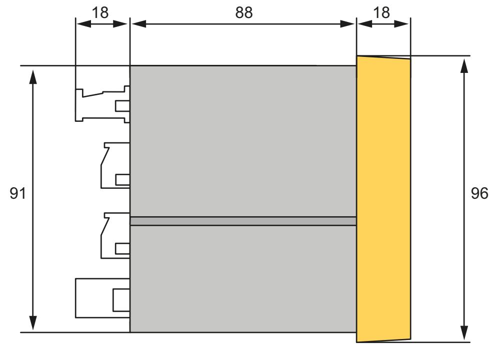


Fig. 4.2: Dimension diagram PEM533 (side view)

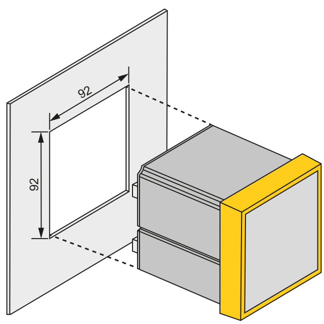


Fig. 4.3: Dimension diagram PEM533 (panel cutout)

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 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

Fuses supply voltage: 6 A
Short-circuit protection Protect the measurement inputs according to the requirements of 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 phase conductors are to be protected*.*

4.4.3 Connection of measuring current transformers

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

4.5 Instructions for connection

- Connect the PEM533 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.

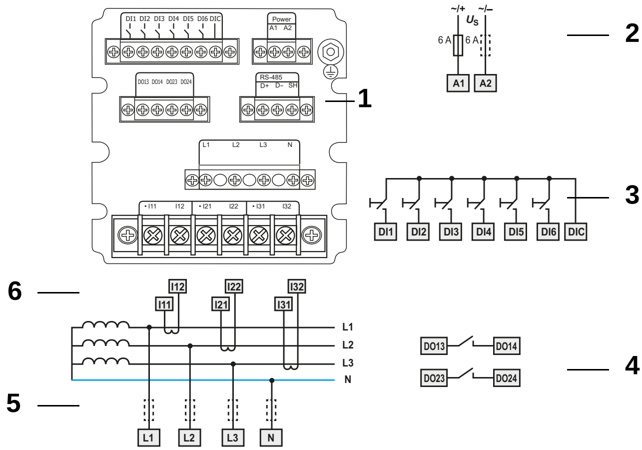


Fig. 4.4: Wiring diagram

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

4.7 Connection diagram voltage inputs

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

The universal measuring device PEM533 can be used in 3-phase-4-wire systems, independent of the type of distribution system (TN, TT, IT system).

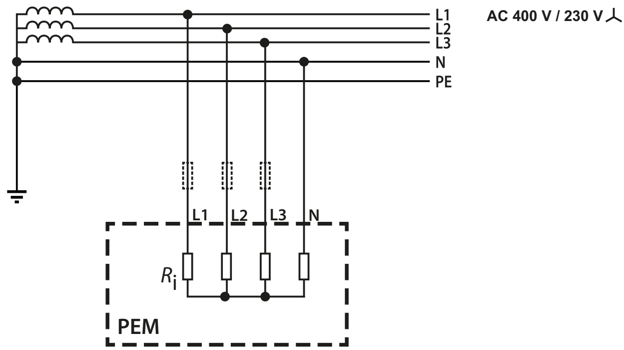


Fig. 4.5: Connection diagram three-phase 4-wire system (e.g. TN-S system)

4.7.2 Three-phase 3-wire system

The PEM can be used in three-phase 3-wire systems. The line conductor voltage must not exceed AC 400 V.

*When used in 3-wire systems, the connection type (**TYPE**) has to be set to delta connection **(DELTA,** page 40).*
*For this purpose, **the measuring inputs L2 and N** are to be **bridged**.*

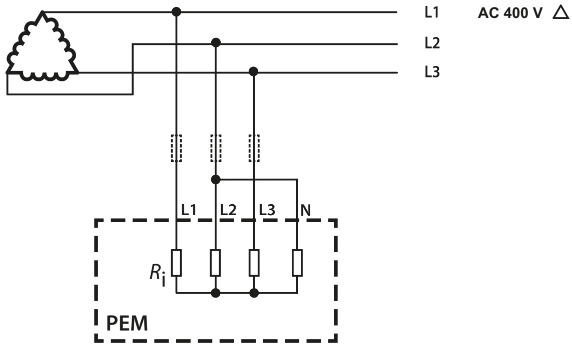


Fig. 4.6: Connection diagram three-phase 3-wire system

4.7.3 Connection via voltage transformers

The coupling via measuring current transformers allows the use of the measuring device in medium and high voltage systems. The transformation ratio can be adjusted in the PEM533 (1…2200).

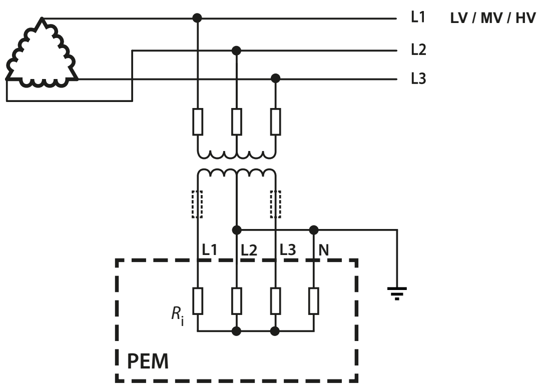
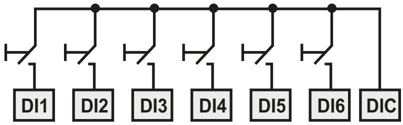


Fig. 4.7: Connection diagram 3-wire system via voltage transformers

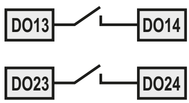
4.8 Digital inputs

The universal measuring device PEM533 provides 6 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.



4.9 Digital outputs

The universal measuring device PEM533 features 2 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

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 US correspond to the nameplates information?
2. Has the nominal insulation voltage of the measuring current transformer 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 transformer ratio (for each channel).
4. Change the measuring current transformer's counting direction, if required.
5. Set the nominal voltage.
6. Select wye connection or delta connection.

5.4 System

The universal measuring device PEM533 can be programmed as well as queried via Modbus RTU. For details refer to "chapter 8. 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 reached.

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

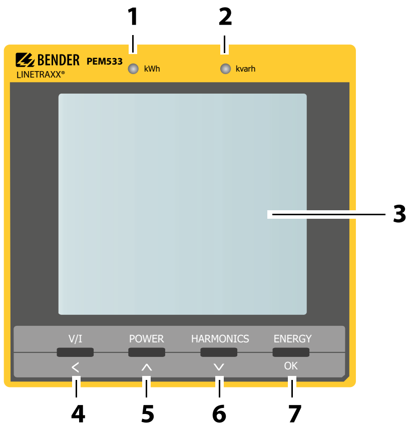


Fig. 6.1: Operating elements

Legend to operating elements

No.	Element	Description
1	LED kWh	Pulse output, See "LED indication" on page 32.
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 position to the left
5	"POWER" button $\wedge$	Display power-related measured quantities in the menu: go up one entry in case of numerical values: increase the value

6	"HARMONICS" button ∨	Display harmonics in the menu: move down one entry in case of numerical values: reduce the value
7	"ENERGY" button OK	Press > 3 s: toggling between setup menu and standard display Display measured values: Active and reactive energy import / active and reactive energy export (line 5) in the menu: selection of the parameter to be edited confirm entry

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 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.

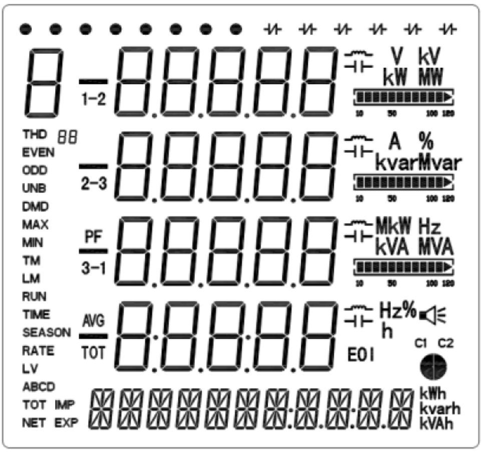


Fig. 6.2: Display during an LCD test

6.3 Getting to know standard display areas

The display can generally be divided into five areas.

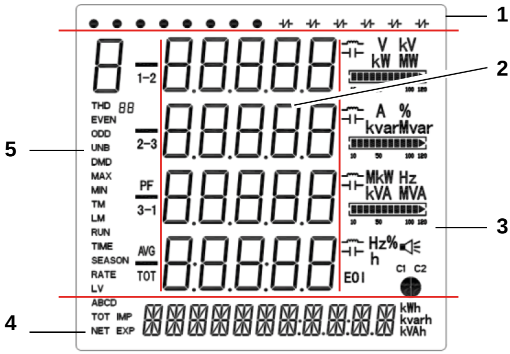


Fig. 6.3: Display areas

Legend to the display areas

1	Displays the indicators for digital input and output status (DI status, 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	Displays parameters relating to voltage, current, fundamental component, power, total harmonic distortion THD, TOHD, TEHD (2^{nd} …31^{st} harmonics) k-factor, unbalance (unb), phase angle for voltages and currents, demands

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

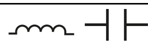
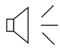
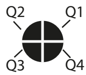
<table>
<tr><th>Area</th><th>Segments</th><th colspan="6">Symbol description</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2"></td><td colspan="3">DI open</td><td colspan="3">DI closed</td></tr>
<tr><td colspan="3">DO open</td><td colspan="3">DO closed</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3"></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
Status commu-nication inter-face</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 kvar
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:

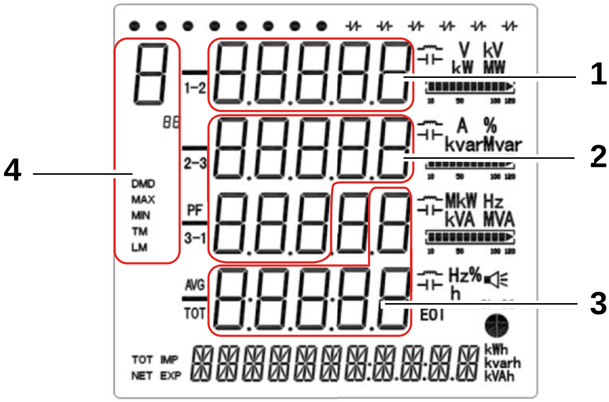


Fig. 6.5: Display: peak demand

No.	Description
1	Peak demand value
2	Peak demand timestamp (date): JJJJ.MM.TT
3	Peak demand timestamp (time): HH:MM:SS
4	Demand displays: **I1**: I1 **I2**: I2 **I3**: I3 **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. The setting can be carried out in the setup menu using the buttons on the front or via the communications interface (only).
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 converted 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.

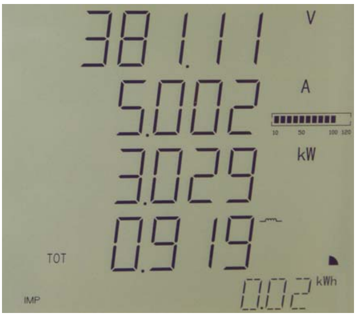


Fig. 6.6: Standard display

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
U1 U2 U3 U_{AVG}	V	U_{L1}	U_{L2}	U_{L3}	Ø U_{LN}
U_{1-2} U_{2-3} U_{3-1} U_{AVG}	V	U_{L1L2}	U_{L2L3}	U_{L3L1}	Ø U_{LL}
I_1 I_2 I_3 I_{AVG}	A	I_1	I_2	I_3	Ø I
I_4	A		I_4		
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	
DMD I1 I_2 I_3 I_{AVG}	A	Demand I_1	Demand I_2	Demand I_3	Ø Demand I
I_1 DMD MAX TM	A	Peak demand I_1 this month	JJJJ.MM.TT hh:mm:ss		
I_2 DMD MAX TM	A	Peak demand I_2 this month	JJJJ.MM.TT hh:mm:ss		
I_3 DMD MAX TM	A	Peak demand I_3 this month	JJJJ.MM.TT hh:mm:ss		

Left column	Right column	First line	Second line	Third line	Fourth line
I_1 DMD MAX LM	A	Peak demand I_1 last month	JJJJ.MM.TT hh:mm:ss		
I_2 DMD MAX LM	A	Peak demand I_2 last month	JJJJ.MM.TT hh:mm:ss		
I_3 DMD MAX LM	A	Peak demand I_3 last month	JJJJ.MM.TT hh:mm:ss		

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

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}		$\lambda_{L1}{}^*$	$\lambda_{L2}{}^*$	$\lambda_{L3}{}^*$	λ_{ges}
*dPF1 dPF2 dPF3 dTOT		Displacement factor $\cos(\varphi)_{L1}{}^*$	Displacement factor $\cos(\varphi)_{L2}{}^*$	Displacement factor $\cos(\varphi)_{L3}{}^*$	
TOT	W var VA	P_{ges}	Q_{ges}	S_{ges}	λ_{ges}
DMD	W var VA	Demand P	Demand Q	Demand S	Demandλ

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

Table 6.2: Display possibilities via the "POWER" button

Note:
* *In "DELTA" mode, the display is skipped.*

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 $_I1$ I_2 I_3 I_{AVG}	%	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 U_1 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 I_1 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
HD3 U_1 U2 U3 U_{AVG}	%	3^{rd} harmonic U_{L1}	3^{rd} harmonic U_{L2}	3^{rd} harmonic U_{L3}	Ø 3^{rd} harmonic U_{LN}
...					

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

Table 6.3: Display possibilities via the "HARMONICS" button

6.7.4 "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 possibilities via the "ENERGY" button

6.8 Setup using the button at the device

Press the "ENERGY" button (> 3 s) to access the Setup mode.
Press the "ENERGY" button again (> 3 s) to return to the display mode.

*To change parameters you must first **enter the password**. (factory setting: 0)*

6.8.1 Setup: Function of the 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 " ∧ " : To move up in the menu or increments a value

"„HARMONICS"
Arrow button " ∨ " : Goes back to the last parameter in the menu or decrements a numeric value.

"ENERGY"
Enter button: To confirm the value entered

6.8.2 Setup: Overview diagram menu

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

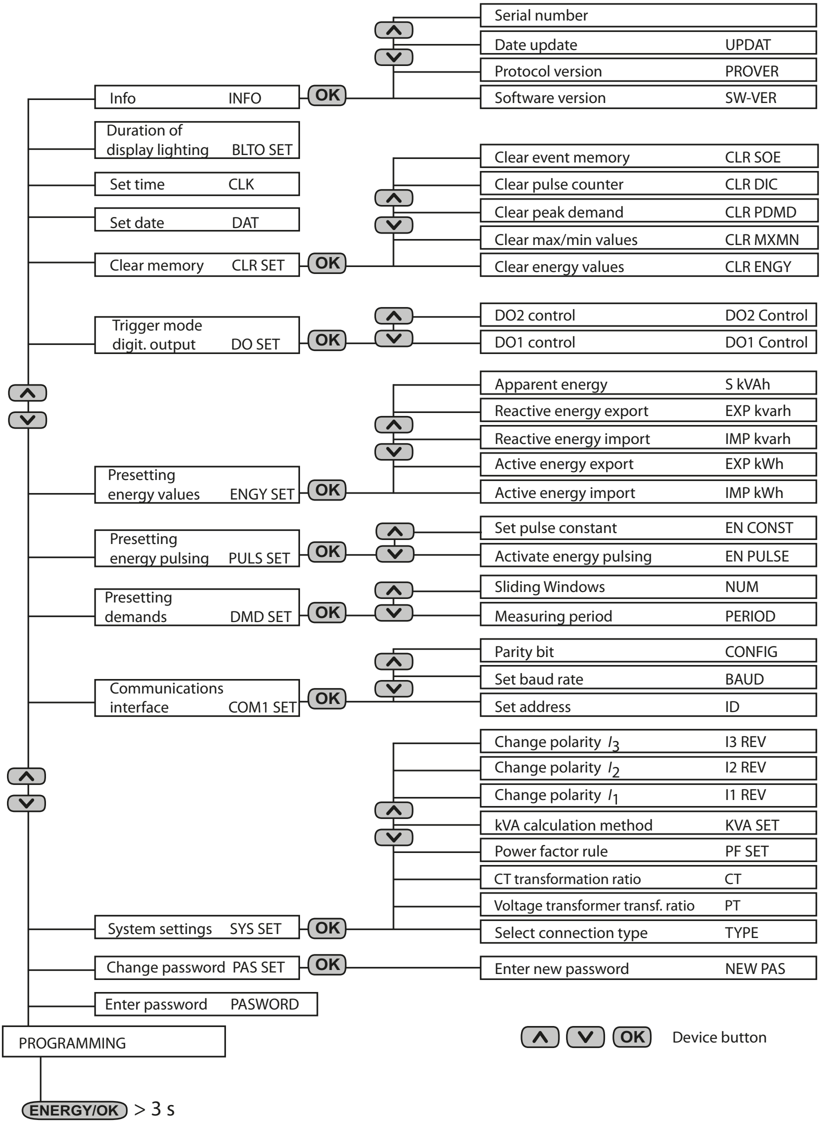


Fig. 6.7: Setup: Adjustment options

6.9 Setup: possibilities

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

Display entry Level 1 / Level 2	Parameters	Description	Setting options	Factory setting
PROGRAM-MING	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	Type of connection	Select type of connection	WYE/DELTA/ DEMO	WYE
PT	Voltage transformer	Select transformer ratio for the voltage transformer	1…2200	1
CT	Measuring current transformers	Select CT transformer ratio	1…30,000 (1 A) 1… 6,000 (5 A)	1
PF SET	Power factor rule	Power factor rule*	IEC/IEEE/-IEEE	IEC
KVA SET		*S* calculation method **	V/S	V
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	I3 CT	I_3 Change CT polarity	YES/NO	NO
COM 1 SET	Configure communications interface		YES/NO	NO
ID	Address for measuring device	Set address for measuring device	1-247	100
Baud	Baud rate	Set baud rate	1200/2400/4800/ 9600/19200 bps	9600
CONFIG	Parity bit	Configuration Parity bit	8N2/8O1/8E1/ 8N1/8O2/8E2	8E1

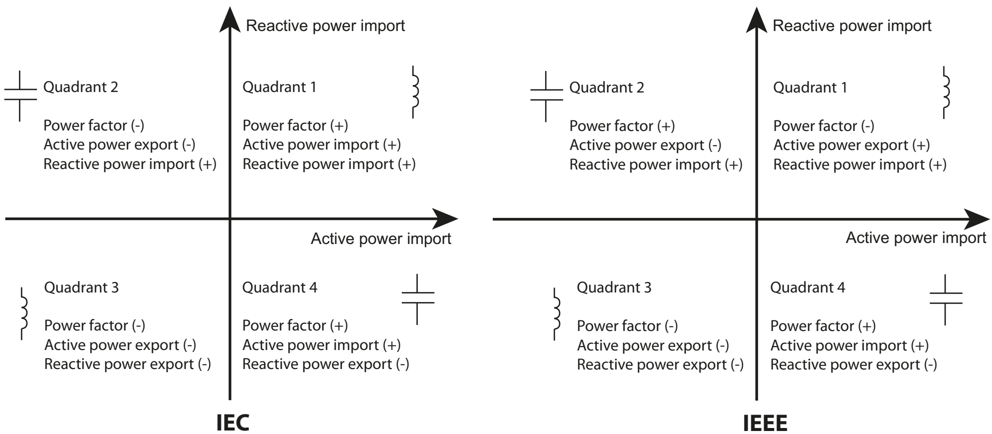
Display entry Level 1 Level 2	Parameters	Description	Setting options	Factory setting
DMD SET	Demand measurement on/off		YES/NO	NO
PERIOD	Length of measurement period	Set the measurement period for demand measurement	1, 2, 3, 5, 10, 15, 30, 60 (minutes)	15
NUM	Number of measurement periods for Sliding Window	Set the number of sliding windows	1…15	1
PULS SET	Set pulse output		YES/NO	NO
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	1K
ENGY SET	Presetting of energy values		YES/NO	NO
IMP kWh	Active energy import	Presetting of active energy import	0… 999,999,999	0
EXP kWh	Active energy export	Presetting of active energy export	0… 999,999,999	0
IMP kvarh	Reactive energy import	Presetting of reactive energy import	0… 999,999,999	0
EXP kvarh	Reactive energy export	Presetting of reactive energy export	0… 999,999,999	0
S kVah	Apparent energy	Presetting of 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	NORMAL
DO2	Operating mode DO2	Set operating mode DO2	NORMAL/ON/OFF	NORMAL
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	Clear Max and Min values of this month	YES/NO	NO

Display entry Level 1 Level 2	Parameters	Description	Setting options	Factory setting
CLR PDMD	Clear peak demand	Clear values peak demand of this month	YES/NO	NO
CLR DIC	Clear pulse coun-ter		YES/NO	NO
CLR SOE	Clear event mem-ory	Clear event memory	YES/NO	NO
DAT	Date	Set current date	YY-MM-DD	/
CLK	Time	Set current time	HH:MM:SS	/
BLTO SET	Display lighting	Time duration until the display gets dark	0…59 (minutes)	3
Info	Device informa-tion	read only	YES/NO	NO
SW-VER	Software version		/	/
PRO VER	Protocol version	50 means V5.0	/	/
UPDAT	Date Software update	jjmmtt	/	/
	Serial number	Serial number device	/	/

Table 6.5: Setup adjustment options

Comments on the table above

* Power factor λ rules



"**IEEE**" and "**–IEEE**" only differ by reversed signs.

** There are two different methods for the calculation of 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

6.10 Configuration example: Setting measuring current transformer

Ratio 1000 : 5 (= 200)

Button	Indication display	Description
ENERGY > 3 s	PROGRAMMING	
⋀	PASWORD ****	
OK (or password)	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	Factory setting
⋀	PT 1	Factory setting
⋀	CT 1	Factory setting
OK	CT 1	1 flashes (units place)
⋁	CTERR 0	0 flashes (units place)
<	CTERR 00	0 on the left flashes (tens place)
<	CTERR 0 0	0 on the left flashes (hundreds place)
⋀⋀	CT 200	2 flashes
OK	CT 200	CT ratio 200 adjusted
OK > 3 s	Standard display	

7. Application/inputs and outputs

7.1 Digital inputs

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 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

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

1. Can be operated via buttons on the front panel (Chapter 6.8 Setup using the button at the device)
2. Operation via communications interface
3. Control setpoints: Control actions in case of setpoint exceedance (Chapter 7.5.1 Control setpoints)
4. Control via digital inputs

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 communications interface.

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

7.4 Power and energy

7.4.1 Voltage and current phase angles

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

7.4.2 Energy

Basic energy parameters include

- Active energy (import, export, net energy and total energy in kWh)
- Reactive energy (import, export, net energy and total energy in kvarh)
- Apparent energy (S_{ges} 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 (only) and the buttons on the front panel, password required.

7.4.3 Demand DMD

The demand is defined as an average consumption value for a defined -measurement period. Values are determined for

- Voltages (U_1, U_2, U_3, $ØU_{LN}$, U_{L1L2}, U_{L2L3}, U_{L3L1}, $ØU_{LL}$)
- Currents (I_1, I_2, I_3, $Ø I$)
- Active power P (P_1, P_2, P_3, $ØP$)
- Apparent power S (S_1, S_2, S_3, $ØS$)
- Reactive energy Q (Q_1, Q_2, Q_3, $ØQ$)
- Power factor λ (λ_1, λ_2, λ_3, $Ø\lambda$)
- 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 **duration of the measurement period** can be adjusted using the buttons on the front panel or via the communications interface. The following options are available:

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

In addition to the duration also the number of the measurement periods between 1 and 15 (**Sliding Window**) is to be specified.

During the total measurement period (duration multiplied by the number) the consumption resp. the imported power is measured. Then the average demand value is indicated on the display and output via the communications interface.

The maximum demand value determined over the whole recording period (peak demand) will be stored and displayed. The peak demand can be reset manually. Setting possibilities See “Setup: possibilities” on page 40.

7.5 Setpoints

The device supports two different types of setpoints:

1. Control setpoints for the general control applications and alarming.
2. Setpoints of the digital inputs and outputs: Provides control output actions in response to changes in digital input status.

7.5.1 Control setpoints

The device features 9 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 is lit if there are any reached/active control 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 deactivated.
2. **Setpoint parameter**

Key	Parameters	Factor; Unit	Key	Parameters	Factor; Unit	Key	Parameters	Factor; Unit
0	—	—	**6**	λ_{ges}	x1,000	**12**	$\mathrm{TOHD_I}$	x10,000
1	U_{LN}	x 100; V	**7**	$\mathrm{THD_U}$	x10,000	**13**	Demand P_{ges}	x 1,000; kW
2	U_{LL}	x 100; V	**8**	$\mathrm{THD_I}$	x10,000	**14**	Demand Q_{ges}	x 1,000; kvar
3	I	x 1000; A	**9**	$\mathrm{TEHD_U}$	x10,000	**15**	Demand S	x 1,000; kVA
4	P_{ges}	x 1,000; kW	**10**	$\mathrm{TEHD_I}$	x10,000	**16**	Ø Demand I	x 1,000; A
5	Q_{ges}	x 1,000; kvar	**11**	$\mathrm{TOHD_U}$	x10,000			

Table 7.1: Setpoint parameters

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 threshold value).
4. **Setpoint limit (inactive limit)**: Specifies the
   lower limits (under setpoint) resp.
   upper limits (over setpoint)
   that have to be violated before the setpoint becomes inactive, e.g. return condition (release threshold value).
5. **Response delay:** Specifies the minimum period that a limit value must have been violated before an action is triggered.
   Each status change generates an event which is stored in the event log. The range of the response delay can be between 0 and 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 generates an event which is stored in the event log. The range of the delay on release can be between 0 and 9,999 seconds.
7. **Setpoint trigger**: Specifies what action the setpoint will take when it becomes active. This action includes "No Trigger" and "Trigger DOx".

7.5.2 Setpoints of the digital inputs and outputs (DI setpoint)

Each of the six digital inputs can be programmed to trigger a digital output via the setpoints when it becomes active. The setpoints for the digital inputs are used for monitoring external status and to trigger alarming and control reactions in case of a limit value violation. The digital input setpoints can be programmed via the communications interface.
One digital output can control one or both of the digital outputs. The following events are stored in the event log

- Status change of the digital output (open or close)
- Digital input channel triggers the output actions
- The digital output is operated by the digital input

7.6 Logging

7.6.1 Peak demand log

The PEM533 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.

7.6.2 Max/Min log

The PEM533 stores each new maximum and minimum value of this month and last month. 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}
$P_{L1\ max}$	$P_{L1\ min}$	$P_{L1\ max}$	$P_{L1\ min}$
$P_{L2\ max}$	$P_{L2\ min}$	$P_{L2\ max}$	$P_{L2\ min}$
$P_{L3\ max}$	$P_{L3\ min}$	$P_{L3\ max}$	$P_{L3\ min}$
$P_{ges\ max}$	$P_{ges\ min}$	$P_{ges\ max}$	$P_{ges\ min}$
$Q_{L1\ max}$	$Q_{L1\ min}$	$Q_{L1\ max}$	$Q_{L1\ min}$
$Q_{L2\ max}$	$Q_{L2\ min}$	$Q_{L2\ max}$	$Q_{L2\ min}$
$Q_{L3\ max}$	$Q_{L3\ min}$	$Q_{L3\ max}$	$Q_{L3\ min}$

This month		Last month	
Maximum values	**Minimum values**	**Maximum values**	**Minimum values**
$Q_{\text{ges max}}$	$Q_{\text{ges min}}$	$Q_{\text{ges max}}$	$Q_{\text{ges min}}$
$S_{\text{L1 max}}$	$S_{\text{L1 min}}$	$S_{\text{L1 max}}$	$S_{\text{L1 min}}$
$S_{\text{L2 max}}$	$S_{\text{L2 min}}$	$S_{\text{L2 max}}$	$S_{\text{L2 min}}$
$S_{\text{L3 max}}$	$S_{\text{L3 min}}$	$S_{\text{L3 max}}$	$S_{\text{L3 min}}$
$S_{\text{ges max}}$	$S_{\text{ges min}}$	$S_{\text{ges max}}$	$S_{\text{ges min}}$
$\lambda_{\text{1 max}}$	$\lambda_{\text{1 min}}$	$\lambda_{\text{1 max}}$	$\lambda_{\text{1 min}}$
$\lambda_{\text{2 max}}$	$\lambda_{\text{2 min}}$	$\lambda_{\text{2 max}}$	$\lambda_{\text{2 min}}$
$\lambda_{\text{3 max}}$	$\lambda_{\text{3 min}}$	$\lambda_{\text{3 max}}$	$\lambda_{\text{3 min}}$
$\lambda_{\text{ges max}}$	$\lambda_{\text{ges min}}$	$\lambda_{\text{ges max}}$	$\lambda_{\text{ges min}}$
f_{max}	f_{min}	f_{max}	f_{min}
max. voltage unbalance	min. voltage unbalance	max. voltage unbalance	min. voltage unbalance
max. current unbalance	min. current unbalance	max. current unbalance	min. current unbalance
THD $U_{\text{L1 max}}$	THD $U_{\text{L1 min}}$	THD $U_{\text{L1 max}}$	THD $U_{\text{L1 min}}$
THD $U_{\text{L2 max}}$	THD $U_{\text{L2 min}}$	THD $U_{\text{L2 max}}$	THD $U_{\text{L2 min}}$
THD $U_{\text{L3 max}}$	THD $U_{\text{L3 min}}$	THD $U_{\text{L3 max}}$	THD $U_{\text{L3 min}}$
THD $I_{\text{1 max}}$	THD $I_{\text{1 min}}$	THD $I_{\text{1 max}}$	THD $I_{\text{1 min}}$
THD $I_{\text{2 max}}$	THD $I_{\text{2 min}}$	THD $I_{\text{2 max}}$	THD $I_{\text{2 min}}$
THD $I_{\text{3 max}}$	THD $I_{\text{3 min}}$	THD $I_{\text{3 max}}$	THD $I_{\text{3 min}}$

Table 7.2: Measured values in Max/Min log for this month and last month

7.6.3 Event log (SOE log)

The device can store up to 64 events. If there are more than 64 events, the newest event will replace the oldest event on a first-in-first-out basis: The 65th event will replace the first entry, 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.
The event log can be cleared using the buttons on the front panel or via communications interface.

7.7 Power Quality

7.7.1 Harmonic distortion

The device provides an analysis
- Total Harmonic Distortion (THD)
- Even Total Harmonic Distortion (TEHD)
- Odd Total Harmonic Distortion (TOHD)
- k-factor
- All harmonics up to the 31st order

The evaluation of the harmonic components is carried out when a current of at least 150 mA (current input 1 A) resp. 750 mA (current input 5 A) flows.
All parameters are available on the display or the communications interface.

The following parameters are provided:

	L1	L2	L3
Harmonics **voltage**	THD	THD	THD
	TEHD	TEHD	TEHD
	TOHD	TOHD	TOHD
	2nd harmonic	2nd harmonic	2nd harmonic
	…	…	…
	31st harmonic	31st harmonic	31st harmonic

	L1	L2	L3
Harmonics **current**	THD	THD	THD
	TEHD	TEHD	TEHD
	TOHD	TOHD	TOHD
	k-factor	k-factor	k-factor
	2nd harmonic	2nd harmonic	2nd harmonic
	…	…	…
	31st harmonic	31st harmonic	31st harmonic

7.7.2 unbalance

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

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

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

Note: Ø means the average value

8. Modbus Register Map

This chapter provides a complete description of the Modbus register (protocol version 6.0) for the PEM533 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).
PEM533 supports the 6-digit addressing scheme and the following Modbus functions:

1. Holding register for reading 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)

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

8.1 Basic measurements

Register	Property	Description	Format	Scale/ unit
0000	RO	U_{L1} [1)]	UINT32	×100, V [2)]
0002	RO	U_{L2} [1)]	UINT32	×100, V
0004	RO	U_{L3} [1)]	UINT32	×100, V
0006	RO	Ø U_{LN}	UINT32	×100, V
0008	RO	U_{L1L2}	UINT32	×100, V
0010	RO	U_{L2L3}	UINT32	×100, V
0012	RO	U_{L3L1}	UINT32	×100, V
0014	RO	Ø U_{LL}	UINT32	×100, V
0016	RO	*I1*	UINT32	×1000, A
0018	RO	*I2*	UINT32	×1000, A
0020	RO	*I3*	UINT32	×1000, A
0022	RO	Ø *I*	UINT32	×1000, A

Register	Property	Description	Format	Scale/ unit
0024	RO	P_{L1} 1)	INT32	×1000, kW
0026	RO	P_{L2} 1)	INT32	×1000, kW
0028	RO	P_{L3} 1)	INT32	×1000, kW
0030	RO	P_{ges}	INT32	×1000, kW
0032	RO	Q_{L1} 1)	INT32	×1000, kvar
0034	RO	Q_{L2} 1)	INT32	×1000, kvar
0036	RO	Q_{L3} 1)	INT32	×1000, kvar
0038	RO	Q_{ges}	INT32	×1000, kvar
0040	RO	S_{L1} 1)	INT32	×1000, kVA
0042	RO	S_{L2} 1)	INT32	×1000, kVA
0044	RO	S_{L3} 1)	INT32	×1000, kVA
0046	RO	S_{ges}	INT32	×1000, kVA
0048	RO	λ_{L1} 1)	INT16	×1000, -
0049	RO	λ_{L2} 1)	INT16	×1000, -
0050	RO	λ_{L3} 1)	INT16	×1000, -
0051	RO	λ_{ges}	INT16	×1000, -
0052	RO	*F*	UINT16	×100, Hz
0053	RO	*I4*	UINT32	x1000, A
0055…0064	Reserved			
0065	RO	Voltage unbalance	UINT16	x1000
0066	RO	Current unbalance	UINT16	x1000
0067	RO	Displacement factor L1	INT16	x1000
0068	RO	Displacement factor L2	INT16	x1000
0069	RO	Displacement factor L3	INT16	x1000
0070	RO	Phase angle $_{U}L1$	UINT16	x100, °
0071	RO	Phase angle $_{U}L2$	UINT16	x100, °
0072	RO	Phase angle $_{U}L3$	UINT16	x100, °

Register	Property	Description	Format	Scale/ unit
0073	RO	Phase angle I_1	UINT16	x100, °
0074	RO	Phase angle I_2	UINT16	x100, °
0075	RO	Phase angle I_3	UINT16	x100, °
0076…0079	Reserved			
0080	RO	Status digital inputs 3)	UINT16	
0081	RO	Status digital outputs 4)	UINT16	
0082	RO	Alarm 5)	UINT16	
0083	RO	SOE Pointer 6)	UINT32	
0085…0119	Reserved			

Table 8.1: Basic measurements

Notes:

1) Only in the case of wye connection.

2) "x 100, V" means that the voltage value returned 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) **Status register 0080**:
Represents the **states of the two digital inputs**
B0 B5 for DI1 DI6 (1 = active/closed; 0 = inactive/open)

4) Status register 0081:
Represents the **states of the two digital outputs**
B0 for DO1 (1 = active/closed; 0 = inactive/open)
B1 for DO2 (1 = active/closed; 0 = inactive/open)

5) The **alarm register 0082** indicates the various alarm states (1 = active, 0 = inactive).
Table 8.2 on page 56 illustrates details of the alarm register.

Bit in register 0082	Alarm event
B0…B2	Reserved
B3	Setpoint 1
B4	Setpoint 2
B5	Setpoint 3
B6	Setpoint 4
B7	Setpoint 5
B8	Setpoint 6
B9	Setpoint 7
B10	Setpoint 8
B11	Setpoint 9
all other bits	Reserved

Table 8.2: Bit sequence alarm register (0082)

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 65rd 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 42).

8.2 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

Table 8.3: Energy measurements

Note: After reaching the maximum value of 999.999.999 kWh/kvarh/kVAh, the measurement starts again with 0.

8.3 Harmonic measurements

Register	Property	Description	Format	Unit
0400…0402	Reserved			
0403	RO	k-factor I_1	UINT16	x10
0404	RO	k-factor I_2	UINT16	x10
0405	RO	k-factor I_3	UINT16	x10
0406	RO	$TOHD_{UL1}$	UINT16	x10,000
0407	RO	$TOHD_{UL2}$	UINT16	x10,000
0408	RO	$TOHD_{UL3}$	UINT16	x10,000
0409	RO	$TOHD_{I1}$	UINT16	x10,000
0410	RO	$TOHD_{I2}$	UINT16	x10,000
0411	RO	$TOHD_{I3}$	UINT16	x10,000
0412	RO	$TEHD_{UL1}$	UINT16	x10,000
0413	RO	$TEHD_{UL2}$	UINT16	x10,000
0414	RO	$TEHD_{UL3}$	UINT16	x10,000
0415	RO	$TEHD_{I1}$	UINT16	x10,000
0416	RO	$TEHD_{I2}$	UINT16	x10,000
0417	RO	$TEHD_{I3}$	UINT16	x10,000
0418	RO	THD_{UL1}	UINT16	x10,000
0419	RO	THD_{UL2}	UINT16	x10,000
0420	RO	THD_{UL3}	UINT16	x10,000
0421	RO	THD_{I1}	UINT16	x10,000
0422	RO	THD_{I2}	UINT16	x10,000
0423	RO	THD_{I3}	UINT16	x10,000
0424	RO	U_{L1} 2nd harmonic	UINT16	x10,000
0425	RO	U_{L2} 2nd harmonic	UINT16	x10,000
0426	RO	U_{L3} 2nd harmonic	UINT16	x10.000

Register	Property	Description	Format	Unit
0427	RO	I_1 2nd harmonic	UINT16	x10,000
0428	RO	I_2 2nd harmonic	UINT16	x10,000
0429	RO	I_3 2nd harmonic	UINT16	x10,000
...	RO	...	UINT16	x10.000
0598	RO	U_{L1} 31st harmonic	UINT16	x10,000
0599	RO	U_{L2} 31st harmonic	UINT16	x10,000
0600	RO	U_{L3} 31st harmonic	UINT16	x10,000
0601	RO	I_1 31st harmonic	UINT16	x10,000
0602	RO	I_2 31st harmonic	UINT16	x10,000
0603	RO	I_3 31st harmonic	UINT16	x10,000

Table 8.4: Harmonic measurements

8.4 Demand

Register	Property	Description	Format	Unit
1000	RO	Demand U_{L1}	INT32	x100, V
1002	RO	Demand U_{L2}	INT32	x100, V
1004	RO	Demand U_{L3}	INT32	x100, V
1006	RO	Ø Demand U_{LN}	INT32	x100, V
1008	RO	Demand U_{L1L2}	INT32	x100, V
1010	RO	Demand U_{L2L3}	INT32	x100, V
1012	RO	Demand U_{L3L1}	INT32	x100, V
1014	RO	Ø Demand U_{LL}	INT32	x100, V
1016	RO	Demand I_1	INT32	x1000, A
1018	RO	Demand I_2	INT32	x1000, A
1020	RO	Demand I_3	INT32	x1000, A
1022	RO	Ø Demand I	INT32	x1000, A
1024	RO	Demand P_{L1}	INT32	x1000, kW
1026	RO	Demand P_{L2}	INT32	x1000, kW
1028	RO	Demand P_{L3}	INT32	x1000, kW
1030	RO	Demand P_{ges}	INT32	x1000, kW
1032	RO	Demand Q_{L1}	INT32	x1000, kvar
1034	RO	Demand Q_{L2}	INT32	x1000, kvar
1036	RO	Demand Q_{L3}	INT32	x1000, kvar
1038	RO	Demand Q_{ges}	INT32	x1000, kvar
1040	RO	Demand S_{L1}	INT32	x1000, kVA
1042	RO	Demand S_{L2}	INT32	x1000, kVA
1044	RO	Demand S_{L3}	INT32	x1000, kVA
1046	RO	Demand S_{ges}	INT32	x1000, kVA
1048	RO	Demand λ_1	INT32	x1000
1050	RO	Demand λ_2	INT32	x1000

Register	Property	Description	Format	Unit
1052	RO	Demand λ_3	INT32	x1000
1054	RO	Demand λ_{ges}	INT32	x1000
1056	RO	Demand *f*	INT32	x100, Hz
1058	RO	Demand voltage unbal-ance	INT32	x1000
1060	RO	Demand current unbalance	INT32	x1000
1062	RO	Demand THD_{UL1}	INT32	x10,000
1064	RO	Demand THD_{UL2}	INT32	x10.000
1066	RO	Demand THD_{UL3}	INT32	x10,000
1068	RO	Demand THD_{I1}	INT32	x10,000
1070	RO	Demand THD_{I2}	INT32	x10,000
1072	RO	Demand THD_{I3}	INT32	x10,000

Table 8.5: Register demands

8.5 Extreme values per demand measurement time frame

8.5.1 Maximum values demand

Register	Property	Description	Format	Unit
1400	RO	$U_{L1\ max}$	INT32	x100, V
1402	RO	$U_{L2\ max}$	INT32	x100, V
1404	RO	$U_{L3\ max}$	INT32	x100, V
1406	RO	Ø $U_{LN\ max}$	INT32	x100, V
1408	RO	$U_{L1L2\ max}$	INT32	x100, V
1410	RO	$U_{L2L3\ max}$	INT32	x100, V
1412	RO	$U_{L3L1\ max}$	INT32	x100, V
1414	RO	Ø $U_{LL\ max}$	INT32	x100, V
1416	RO	$I_{1\ max}$	INT32	x1000, A
1418	RO	$I_{2\ max}$	INT32	x1000, A

Register	Property	Description	Format	Unit
1420	RO	$I_{3\ \mathrm{max}}$	INT32	x1000, A
1422	RO	Ø I_{max}	INT32	x1000, A
1424	RO	$P_{\mathrm{L1\ max}}$	INT32	x1000, kW
1426	RO	$P_{\mathrm{L2\ max}}$	INT32	x1000, kW
1428	RO	$P_{\mathrm{L3\ max}}$	INT32	x1000, kW
1430	RO	$P_{\mathrm{ges\ max}}$	INT32	x1000, kW
1432	RO	$Q_{\mathrm{L1\ max}}$	INT32	x1000, kvar
1434	RO	$Q_{\mathrm{L2\ max}}$	INT32	x1000, kvar
1436	RO	$Q_{\mathrm{L3\ max}}$	INT32	x1000, kvar
1438	RO	$Q_{\mathrm{ges\ max}}$	INT32	x1000, kvar
1440	RO	$S_{\mathrm{L1\ max}}$	INT32	x1000, kVA
1442	RO	$S_{\mathrm{L2\ max}}$	INT32	x1000, kVA
1444	RO	$S_{\mathrm{L3\ max}}$	INT32	x1000, kVA
1446	RO	$S_{\mathrm{ges\ max}}$	INT32	x1000, kVA
1448	RO	$\lambda_{1\ \mathrm{max}}$	INT32	x1000
1450	RO	$\lambda_{2\ \mathrm{max}}$	INT32	x1000
1452	RO	$\lambda_{3\ \mathrm{max}}$	INT32	x1000
1454	RO	$\lambda_{\mathrm{ges\ max}}$	INT32	x1000
1456	RO	f_{max}	INT32	x100, Hz
1458	RO	max. voltage unbalance	INT32	x1000
1460	RO	max. current unbalance	INT32	x1000
1462	RO	$\mathrm{THD}_{\mathrm{UL1\ max}}$	INT32	x10.000
1464	RO	$\mathrm{THD}_{\mathrm{UL2\ max}}$	INT32	x10.000
1466	RO	$\mathrm{THD}_{\mathrm{UL3\ max}}$	INT32	x10.000
1468	RO	$\mathrm{THD}_{\mathrm{I1\ max}}$	INT32	x10.000
1470	RO	$\mathrm{THD}_{\mathrm{I2\ max}}$	INT32	x10.000
1472	RO	$\mathrm{THD}_{\mathrm{I3\ max}}$	INT32	x10,000

Fig. 8.1: Maximum values per demand period

8.5.2 Minimum values demand

Register	Property	Description	Format	Unit
1600	RO	$U_{L1\ min}$	INT32	x100, V
1602	RO	$U_{L2\ min}$	INT32	x100, V
1604	RO	$U_{L3\ min}$	INT32	x100, V
1606	RO	Ø $U_{LN\ min}$	INT32	x100, V
1608	RO	$U_{L1L2\ min}$	INT32	x100, V
1610	RO	$U_{L2L3\ min}$	INT32	x100, V
1612	RO	$U_{L3L1\ min}$	INT32	x100, V
1614	RO	Ø $U_{LL\ min}$	INT32	x100, V
1616	RO	$I_{1\ min}$	INT32	x1000, A
1618	RO	$I_{2\ min}$	INT32	x1000, A
1620	RO	$I_{3\ min}$	INT32	x1000, A
1622	RO	Ø I_{min}	INT32	x1000, A
1624	RO	$P_{L1\ min}$	INT32	x1000, kW
1626	RO	$P_{L2\ min}$	INT32	x1000, kW
1628	RO	$P_{L3\ min}$	INT32	x1000, kW
1630	RO	$P_{ges\ min}$	INT32	x1000, kW
1632	RO	$Q_{L1\ min}$	INT32	x1000, kvar
1634	RO	$Q_{L2\ min}$	INT32	x1000, kvar
1636	RO	$Q_{L3\ min}$	INT32	x1000, kvar
1638	RO	$Q_{ges\ min}$	INT32	x1000, kvar
1640	RO	$S_{L1\ min}$	INT32	x1000, kVA
1642	RO	$S_{L2\ min}$	INT32	x1000, kVA
1644	RO	$S_{L3\ min}$	INT32	x1000, kVA
1646	RO	$S_{ges\ min}$	INT32	x1000, kVA
1648	RO	$\lambda_{1\ min}$	INT32	x1000
1650	RO	$\lambda_{2\ min}$	INT32	x1000
1652	RO	$\lambda_{3\ min}$	INT32	x1000

Register	Property	Description	Format	Unit
1654	RO	$\lambda_{ges\ min}$	INT32	x1000
1656	RO	f_{min}	INT32	x100, Hz
1658	RO	min. voltage unbalance	INT32	x1000
1660	RO	min. current unbalance	INT32	x1000
1662	RO	$THD_{UL1\ min}$	INT32	x10.000
1664	RO	$THD_{UL2\ min}$	INT32	x10.000
1666	RO	$THD_{UL3\ min}$	INT32	x10,000
1668	RO	$THD_{I1\ min}$	INT32	x10,000
1670	RO	$THD_{I2\ min}$	INT32	x10,000
1672	RO	$THD_{I3\ min}$	INT32	x10,000

Table 8.6: Minimum values per demand period

8.6 Peak demand

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

8.6.1 Peak demand this month

Register	Prope rty	Description	Format	
1800…1804	RO	Peak demand *P* of this month	see Table 8. 9 on page 64	x1000, kW
1805…1809	RO	Peak demand *Q of this month*		x1000, kvar
1810…1814	RO	Peak demand *S* of this month		x1000, kVA
1815…1819	RO	Peak demand I_1 of this month		x1000, A
1820…1824	RO	Peak demand I_2 of this month		x1000, A
1825…1829	RO	Peak demand I_3 of this month		x1000, A

Table 8.7: Peak demand of this month

8.6.2 Peak demand last month

Register	Property	Description	Format	
1850…1854	RO	Peak demand *P* last month	see Table 8. 9 on page 64	x1000, kW
1855…1859	RO	Peak demand *Q* last month		x1000, kvar
1860…1864	RO	Peak demand *S last month*		x1000, kVA
1865…1869	RO	Peak demand I_1 last month		x1000, A
1870…1874	RO	Peak demand I_2 last month		x1000, A
1875…1879	RO	Peak demand I_3 last month		x1000, A

Table 8.8: Peak demand last month

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: Date: Day	UINT16	1…28/29/30/31
	RO	LoWord: Hour		0…23
+ 4	RO	HiWord: Minute	UINT16	0…59
	RO	LoWord: Second		0…59

Table 8.9: Peak demand data structure

8.7 Max/Min log

8.7.1 Maximum log of this month

Register	Eigenschaft	Beschreibung	Format	Einheit
2000…2004	RO	$U_{L1\ max}$	see Table 8.14 on page 71	x100, V
2005…2009	RO	$U_{L2\ max}$		x100, V
2010…2014	RO	$U_{L3\ max}$		x100, V
2015…2019	RO	Ø $U_{LN\ max}$		x100, V
2020…2024	RO	$U_{L1L2\ max}$		x100, V
2025…2029	RO	$U_{L2L3\ max}$		x100, V
2030…2034	RO	$U_{L3L1\ max}$		x100, V
2035…2039	RO	Ø $U_{LL\ max}$		x100, V
2040…2044	RO	$I_{1\ max}$		x1000, A
2045…2049	RO	$I_{2\ max}$		x1000, A
2050…2054	RO	$I_{3\ max}$		x1000, A
2055…2059	RO	Ø I_{max}		x1000, A
2060…2064	RO	$P_{L1\ max}$		x1000, kW
2065…2069	RO	$P_{L2\ max}$		x1000, kW
2070…2074	RO	$P_{L3\ max}$		x1000, kW
2075…2079	RO	$P_{ges\ max}$		x1000, kW
2080…2084	RO	$Q_{L1\ max}$		x1000, kvar
2085…2089	RO	$Q_{L2\ max}$		x1000, kvar
2090…2095	RO	$Q_{L3\ max}$		x1000, kvar
2096…2099	RO	$Q_{ges\ max}$		x1000, kvar
2100…2104	RO	$S_{L1\ max}$		x1000, kVA
2105…2109	RO	$S_{L2\ max}$		x1000, kVA
2110…2114	RO	$S_{L3\ max}$		x1000, kVA
2115…2119	RO	$S_{ges\ max}$		x1000, kVA

Register	Eigenschaft	Beschreibung	Format	Einheit
2120…2124	RO	$\lambda_{1\ max}$	see Table 8.14 on page 71	x1000
2125…2129	RO	$\lambda_{2\ max}$		x1000
2130…2134	RO	$\lambda_{3\ max}$		x1000
2135…2139	RO	$\lambda_{ges\ max}$		x1000
2140…2144	RO	f_{max}		x100, Hz
2145…2149	RO	min. voltage unbalance		x1000
2150…2154	RO	min. current unbalance		x1000
2155…2159	RO	$THD_{UL1\ max}$		x10.000
2160…2164	RO	$THD_{UL2\ max}$		x10.000
2165…2169	RO	$THD_{UL3\ max}$		x10.000
2170…2174	RO	$THD_{I1\ max}$		x10.000
2175…2179	RO	$THD_{I2\ max}$		x10.000
2180…2184	RO	$THD_{I3\ max}$		x10.000

Table 8.10: Max log of this month

8.7.2 Min log of this month

Register	Property	Description	Format	
2300…2304	RO	$U_{L1\ min}$	see Table 8.14 on page 71	x100, V
2305…2309	RO	$U_{L2\ min}$		x100, V
2310…2314	RO	$U_{L3\ min}$		x100, V
2315…2319	RO	Ø $U_{LN\ min}$		x100, V
2320…2324	RO	$U_{L1L2\ min}$		x100, V
2325…2329	RO	$U_{L2L3\ min}$		x100, V
2330…2334	RO	$U_{L3L1\ min}$		x100, V
2335…2339	RO	Ø $U_{LL\ min}$		x100, V
2340…2344	RO	$I_{1\ min}$		x1000, A
2345…2349	RO	$I_{2\ min}$		x1000, A
2350…2354	RO	$I_{3\ min}$		x1000, A

Register	Property	Description	Format	
2355…2359	RO	$\varnothing I_{min}$	see Table 8.14 on page 71	x1000, A
2360…2364	RO	$P_{L1\ min}$		x1000, kW
2365…2369	RO	$P_{L2\ min}$		x1000, kW
2370…2374	RO	$P_{L3\ min}$		x1000, kW
2375…2379	RO	$P_{ges\ min}$		x1000, kW
2380…2384	RO	$Q_{L1\ min}$		x1000, kvar
2385…2389	RO	$Q_{L2\ min}$		x1000, kvar
2390…2395	RO	$Q_{L3\ min}$		x1000, kvar
2396…2399	RO	$Q_{ges\ min}$		x1000, kvar
2400…2404	RO	$S_{L1\ min}$		x1000, kVA
2405…2409	RO	$S_{L2\ min}$		x1000, kVA
2410…2414	RO	$S_{L3\ min}$		x1000, kVA
2415…2419	RO	$S_{ges\ min}$		x1000, kVA
2420…2424	RO	$\lambda_{1\ min}$		x1000
2425…2429	RO	$\lambda_{2\ min}$		x1000
2430…2434	RO	$\lambda_{3\ min}$		x1000
2435…2439	RO	$\lambda_{ges\ min}$		x1000
2440…2444	RO	f_{min}		x100, Hz
2445…2449	RO	min. voltage unbalance		x1000
2450…2454	RO	min. current unbalance		x1000
2455…2459	RO	$THD_{UL1\ min}$		x10,000
2460…2464	RO	$THD_{UL2\ min}$		x10,000
2465…2469	RO	$THD_{UL3\ min}$		x10,000
2470…2474	RO	$THD_{I1\ min}$		x10,000
2475…2479	RO	$THD_{I2\ min}$		x10,000
2480…2484	RO	$THD_{I3\ min}$		x10,000

Table 8.11: Min log of this month

8.7.3 Max log of last month

Register	Property	Description	Format	
2600…2604	RO	$U_{L1\ max}$	see Table 8.14 on page 71	x100, V
2605…2609	RO	$U_{L2\ max}$		x100, V
2610…2614	RO	$U_{L3\ max}$		x100, V
2615…2619	RO	Ø $U_{LN\ max}$		x100, V
2620…2624	RO	$U_{L1L2\ max}$		x100, V
2625…2629	RO	$U_{L2L3\ max}$		x100, V
2630…2634	RO	$U_{L3L1\ max}$		x100, V
2635…2639	RO	Ø $U_{LL\ max}$		x100, V
2640…2644	RO	$I_{1\ max}$		x1000, A
2645…2649	RO	$I_{2\ max}$		x1000, A
2650…2654	RO	$I_{3\ max}$		x1000, A
2655…2659	RO	Ø I_{max}		x1000, A
2660…2664	RO	$P_{L1\ max}$		x1000, kW
2665…2669	RO	$P_{L2\ max}$		x1000, kW
2670…2674	RO	$P_{L3\ max}$		x1000, kW
2675…2679	RO	$P_{ges\ max}$		x1000, kW
2680…2684	RO	$Q_{L1\ max}$		x1000, kvar
2685…2689	RO	$Q_{L2\ max}$		x1000, kvar
2690…2695	RO	$Q_{L3\ max}$		x1000, kvar
2696…2699	RO	$Q_{ges\ max}$		x1000, kvar
2700…2704	RO	$S_{L1\ max}$		x1000, kVA
2705…2709	RO	$S_{L2\ max}$		x1000, kVA
2710…2714	RO	$S_{L3\ max}$		x1000, kVA
2715…2719	RO	$S_{ges\ max}$		x1000, kVA

Register	Property	Description	Format	
2720…2724	RO	$\lambda_{1\ max}$	see Table 8.14 on page 71	x1000
2725…2729	RO	$\lambda_{2\ max}$		x1000
2730…2734	RO	$\lambda_{3\ max}$		x1000
2735…2739	RO	$\lambda_{ges\ max}$		x1000
2740…2744	RO	f_{max}		x100, Hz
2745…2749	RO	max. voltage unbalance		x1000
2750…2754	RO	max. current unbalance		x1000
2755…2759	RO	$THD_{UL1\ max}$		x10,000
2760…2764	RO	$THD_{UL2\ max}$		x10,000
2765…2769	RO	$THD_{UL3\ max}$		x10,000
2770…2774	RO	$THD_{I1\ max}$		x10,000
2775…2779	RO	$THD_{I2\ max}$		x10,000
2780…2784	RO	$THD_{I3\ max}$		x10,000

Table 8.12: Max log of last month

8.7.4 Min log last month

Register	Property	Description	Format	
2900…2904	RO	$U_{L1\ min}$	see Table 8.14 on page 71	x100, V
2905…2909	RO	$U_{L2\ min}$		x100, V
2910…2914	RO	$U_{L3\ min}$		x100, V
2915…2919	RO	Ø $U_{LN\ min}$		x100, V
2920…2924	RO	$U_{L1L2\ min}$		x100, V
2925…2929	RO	$U_{L2L3\ min}$		x100, V
2930…2934	RO	$U_{L3L1\ min}$		x100, V
2935…2939	RO	Ø $U_{LL\ min}$		x100, V
2940…2944	RO	$I_{1\ min}$		x1000, A
2945…2949	RO	$I_{2\ min}$		x1000, A
2950…2954	RO	$I_{3\ min}$		x1000, A

Register	Property	Description	Format	
2955…2959	RO	$\varnothing I_{min}$	see Table 8.14 on page 71	x1000, A
2960…2964	RO	$P_{L1\ min}$		x1000, kW
2965…2969	RO	$P_{L2\ min}$		x1000, kW
2970…2974	RO	$P_{L3\ min}$		x1000, kW
2975…2979	RO	$P_{ges\ min}$		x1000, kW
2980…2984	RO	$Q_{L1\ min}$		x1000, kvar
2985…2989	RO	$Q_{L2\ min}$		x1000, kvar
2990…2995	RO	$Q_{L3\ min}$		x1000, kvar
2996…2999	RO	$Q_{ges\ min}$		x1000, kvar
3000…3004	RO	$S_{L1\ min}$		x1000, kVA
3005…3009	RO	$S_{L2\ min}$		x1000, kVA
3010…3014	RO	$S_{L3\ min}$		x1000, kVA
3015…3019	RO	$S_{ges\ min}$		x1000, kVA
3020…3024	RO	$\lambda_{1\ min}$		x1000
3025…3029	RO	$\lambda_{2\ min}$		x1000
3030…3034	RO	$\lambda_{3\ min}$		x1000
3035…3039	RO	$\lambda_{ges\ min}$		x1000
3040…3044	RO	f_{min}		x100, Hz
3045…3049	RO	min. voltage unbalance		x1000
3050…3054	RO	min. current unbalance		x1000
3055…3059	RO	$THD_{UL1\ min}$		x10,000
3060…3064	RO	$THD_{UL2\ min}$		x10,000
3065…3069	RO	$THD_{UL3\ min}$		x10,000
3070…3074	RO	$THD_{I1\ min}$		x10,000
3075…3079	RO	$THD_{I2\ min}$		x10,000
3080…3084	RO	$THD_{I3\ min}$		x10,000

Table 8.13: Memory minimum values last month

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: Date: Day	UINT16	1…28/29/30/31
	RO	LoWord: Hour		0…23
+ 4	RO	HiWord: Minute	UINT16	0…59
	RO	LoWord: Second		0…59

Table 8.14: Max/Min log data structure

8.8 Setup parameters

Register	Property	Description	Format	Range/unit
6000	RW	Voltage transformer ratio	UINT16	1*…2200
6001	RW	Measuring current trans-former ratio	UINT16	1*…6000 (current input 5 A) 1*…30000 (current input 1 A)
6002	RW	Wiring mode	UINT16	0 = WYE* 1 = DELTA 2 = DEMO
6003	RW	Device address Modbus RTU	UINT16	1…247 (100*)
6004	RW	Modbus RTU baud rate	UINT16	0 = 1200 1 = 2400 2 = 4800 3 = 9600* 4 = 19200
6005	RW	Modbus RTU parity	UINT16	0 = 8N2; 1 = 8O1 2 = 8E1*; 3 = 8N1 4 = 8O2 ; 5 = 8E2
6006…6014	Reserved			
6015	RW	Power factor λ rule	UINT16	B1B0: 00* = IEC 01= IEEE 10 = -IEEE
6016	RW	Calculation method *S*	UINT16	B1B0: 00* = vector 01 = scalar
6017	RW	Polarity measuring current transformer L1	UINT16	0* = normal 1 = reversed
6018	RW	Polarity measuring current transformer L2	UINT16	0* = normal 1=reversed
6019	RW	Polarity measuring current transformer L3	UINT16	0=normal 1=reversed
6020	RW	Demand measurement period	UINT16	1, 2, 3, 5, 10, 15*, 60 minutes
6021	RW	Number of sliding windows	UINT16	1*…15
6022…6045	Reserved			

Register	Property	Description	Format	Range/unit
6046	RW	Setpoints DI1/ DI2	See "Digital input setpoint data structure (register 6046, 6047 and 6048)" on page 74.	
6047	RW	Setpoints DI3 / DI4		
6048	RW	Setpoints DI5 / DI6		
6049…6071	Reserved			
6072…6080	RW	Setpoint 1	See "Control setpoints data structure" on page 75.	
6081…6089	RW	Setpoint 2		
6090…6098	RW	Setpoint 3		
6099…6107	RW	Setpoint 4		
6108…6016	RW	Setpoint 5		
6117…6125	RW	Setpoint 6		
6126…6134	RW	Setpoint 7		
6135…6143	RW	Setpoint 8		
6144…6152	RW	Setpoint 9		
6153…6271	Reserved			
6272	RW	Enable energy pulse	UINT16	0* = disabled 1 = enabled
6273	RW	Pulse constant	UINT16	0* = 1000 imp/kxh
6274	RW	Read time	UINT16	0*
6275…6289	Reserved			
6290	WO	Clear all energy registers	UINT16	Writing 0xFF00 to the register clears the energy values
6291	WO	Clear event log	UINT16	Writing 0xFF00 to the register resets the pointer of the event log to 0
6292	WO	Clear demand of this month	UINT16	Writing 0xFF00 to the register clears the demand values of this month
6293	WO	Clear Max/Min log	UINT16	Writing 0xFF00 to the register clears the values of the Max/Min log
6294…6329	Reserved			

Table 8.15: Setup parameters

8.8.1 Digital input setpoint data structure (register 6046, 6047 and 6048)

Digital inputs DI1 and DI2

DI2				DI1		
Bit	15…10	9	8	7…2	1	0
Triggers digital output	Reserved	DO2	DO1	Reserved	DO2	DO1

Table 8.16: Register 6046

Digital inputs DI3 and DI4

DI4				DI3		
Bit	15…10	9	8	7…2	1	0
Triggers digital output	Reserved	DO2	DO1	Reserved	DO2	DO1

Table 8.17: Register 6047

Digital inputs DI5 and DI6

DI6				DI5		
Bit	15…10	9	8	7…2	1	0
Triggers digital output	Reserved	DO2	DO1	Reserved	DO2	DO1

Table 8.18: Register 6048

Example:
If register 6046 contains a value of 0x101, it means the following:
After being enabled

- DI1 controls output DO2
- DI2 controls output DO1.

Control setpoints data structure

Offset	Property	Description	Format	Range/options
+ 0	RW	Type	UINT16	0 = disabled 1 = over setpoint 2 = under setpoint
+ 1	RW	Parameters [1)]	UINT16	1…16
+ 2	RW	Threshold value exceeded	INT32	/
+ 4	RW	Value below release threshold	INT32	/
+ 6	RW	Response thresh-old value delay delay	UINT16	0…9999 (s)
+ 7	RW	Release thresh-old value delay	UINT16	0…9999 (s)
+ 8	RW	Trigger [2)]	UINT16	0…21

Table 8.19: Control setpoints data structure

Comments relating to the table above

[1)] Parameter

Key	Parameters	Scale/ unit	Key	Parameters	Scale/ unit
0	—	—	9	$TEHD_U$	x10,000
1	U_{LN}	x100, V	10	$TEHD_I$	x10,000
2	U_{LL}	x100, V	11	$TOHD_U$	x10,000
3	I	x 1,000, A	12	$TOHD_I$	x10,000
4	P_{ges}	x1,000, kW	13	Demand P_{ges}	x1,000, kW
5	S_{ges}	x1,000, kvar	14	Demand Q_{ges}	x1,000, kvar
6	λ_{ges}	x1,000	15	Demand S_{ges}	x1,000, kVA
7	THD_U	x10,000	16	Ø Demand I	x1,000, A
8	THD_I	x10,000			

Table 8.20: Setpoint parameter

[2)] **Trigger**

Key	0	1	2	3…21
Action	/	DO1	DO2	Reserved

Table 8.21: Setpoint trigger

8.9 Event log (SOE log)

Each SOE event occupies 8 registers, as shown in the following table. The internal data structure of the event log is listed in Table 8.23 on page 77.

Register	Property	Description	Format
10000…10007	RO	Event 1	see Table 8.23 on page 77
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 8.22: Event log (SOE log)

Event data structure (SOE log)

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

Offset	Property	Description
+ 0	RO	Reserved
+ 1	RO	Event classification (see Table 8.24 on page 82)
+ 2	RO	HiWord: Year-2000 LoWord: Month (1…12)
+ 3	RO	HiWord: Day (0…31) LoWord: Hour (1…23)
+ 4	RO	HiWord: Minute (0…59) LoWord: Second (0…59)
+ 5	RO	Millisecond (0…999)
+ 6	RO	HiWord: Event value
+ 7	RO	LoWord: Event value

Table 8.23: Event data structure

Event classification (SOE log)

Event classification	Event sub-classification	Event value option	Description
1	1	1/0	Digital input 1 closed/open
	2	1/0	Digital input 2 closed/open
	3	1/0	Digital input 3 closed/open
	4	1/0	Digital input 4 closed/open
	5	1/0	Digital input 5 closed/open
	6	1/0	Digital input 6 closed/open
2	1	1/0	Digital output 1 closed/open by Modbus access
	2	1/0	Digital output 2 closed/open by Modbus access
	3…4	Reserved	
	5	1/0	Digital output 1 closed/open by setpoint
	6	1/0	Digital output 2 closed/open by setpoint
	7…8	Reserved	
	9	1/0	Digital output 1 closed/open by button on the front

Event classification	Event sub-classification	Event value option	Description
2	10	1/0	Digital output 2 closed/open by button on the front
	11…14	Reserved	
	15	1/0	Digital output 1 closed/open by DI setpoint
	16	1/0	Digital output 2 closed/open by DI setpoint
	17…18	Reserved	
3	1	Trigger value x 100	>-Setpoint U_{LN} exceeded
	2	Trigger value x 100	>-Setpoint U_{LL} exceeded
	3	Trigger value x 1000	>-Setpoint I exceeded
	4	Trigger value	>-Setpoint P_{ges} exceeded
	5	Trigger value	>-Setpoint Q_{ges} exceeded
	6	Trigger value x 1000	>-Setpoint λ_{ges} exceeded
	7	Trigger value x 10,000	>-Setpoint THD_U exceeded
	8	Trigger value x 10,000	>-Setpoint THD_I exceeded
	9	Trigger value x 10,000	>-Setpoint $TEHD_U$ exceeded
	10	Trigger value x 10,000	>-Setpoint $TEHD_I$ exceeded
	11	Trigger value x 10,000	>-Setpoint $TOHD_U$ exceeded
	12	Trigger value x 1000	>-Setpoint $TOHD_I$ exceeded
	13	Trigger value x 1000	>-Setpoint demand P_{ges} exceeded
	14	Trigger value x 1000	>-Setpoint demand Q_{ges} exceeded
	15	Trigger value x 1000	>-Setpoint demand S_{ges} exceeded
	16	Trigger value x 100	>-Setpoint demand I exceeded
	17	Return value x 100	>-Setpoint U_{LN} return

Event classification	Event sub-classification	Event value option	Description
3	18	Return value x 100	>-Setpoint U_{LL} return
	19	Return value x 1000	>-Setpoint *I* return
	20	Return value	>-Setpoint P_{ges} return
	21	Return value	>-Setpoint Q_{ges} return
	22	Return value x 1000	>-Setpoint λ_{ges} return
	23	Return value x 10,000	>-Setpoint THD_U return
	24	Return value x 10.000	>-Setpoint THD_I return
	25	Return value x 10.000	>-Setpoint $TEHD_U$ return
	26	Return value x 10.000	>-Setpoint $TEHD_I$ return
	27	Return value x 10.000	>-Setpoint $TOHD_U$ return
	28	Return value x 1000	>-Setpoint $TOHD_I$ return
	29	Return value x 1000	>- Setpoint demand P_{ges} return
	30	Return value x 1000	>-Setpoint demand Q_{ges} return
	31	Return value x 1000	>-Setpoint demand S_{ges} return
	32	Return value x 100	>-Setpoint demand*Ireturn*
	33	Trigger value x 100	Under <-Setpoint U_{LN}
	34	Trigger value x 100	Under <-Setpoint U_{LL}
	35	Trigger value x 1000	Under <-Setpoint *I*
	36	Trigger value	Under <-Setpoint P_{ges}
	37	Trigger value	Under <-setpoint Q_{ges}
	38	Trigger value x 1000	Under <-Setpoint λ_{ges}

Event classification	Event sub-classification	Event value option	Description
3	39	Trigger value x 10.000	Under <-Setpoint THD_U
	40	Trigger value x 10.000	Under <-Setpoint THD_I
	41	Trigger value x 10.000	Under <-Setpoint TEHD_U
	42	Trigger value x 10.000	Under <-Setpoint TEHD_I
	43	Trigger value x 10.000	Under <-Setpoint TOHD_U
	44	Trigger value x 1000	Under <-Setpoint TOHD_I
	45	Trigger value x 1000	Under <-Setpoint demand P_{ges}
	46	Trigger value x 1000	Under <-Setpoint demand Q_{ges}
	47	Trigger value x 1000	Under <-Setpoint demand S_{ges}
	48	Trigger value x 100	Under <-Setpoint demand I
	49	Return value x 100	<-Setpoint U_{LN} return
	50	Return value x 100	<-Setpoint U_{LL} return
	51	Return value x 1000	<-Setpoint I return
	52	Return value	<-Setpoint P_{ges} return
	53	Return value	<-Setpoint Q_{ges} return
	54	Return value x 1000	<-Setpoint λ_{ges} return
	55	Return value x 10.000	<-Setpoint THD_U return
	56	Return value x 10.000	<-Setpoint THD_I return
	57	Return value x 10.000	<-Setpoint TEHD_U return
	58	Return value x 10.000	<-Setpoint TEHD_I return

Event classification	Event sub-classification	Event value option	Description
3	59	Return value x 10,000	<-Setpoint $TOHD_U$ return
	60	Return value x 1000	<-Setpoint $TOHD_I$ return
	61	Return value x1000	<-Setpoint demand P_{ges} return
	62	Return value x1000	<-Setpoint demand Q_{ges} return
	63	Return value x 1000	<-Setpoint demand S_{ges} return
	64	Return value x 100	<-Setpoint demand I return
	65	Bit 31	Shows which DO is being triggered by DI setpoint 0 = open 1 = closed
		Bits 16…30	Shows which DI is being triggered by DO 1 = DI1 2 = DI2 3 = DI3 4 = DI4 5 = DI5 6 = DI6
		Bits 2…15	Reserved
		Bits 0…1	Shows which DO is being triggered by the associated DI: Bit 0 = DO1/ Bit 1 = DO2
	66…69	Reserved	
4	1	0	Supply voltage on
	2	0	Supply voltage off
	3	0	Setup changed via device buttons
	4	0	Setup changed via communications
	5	0	Counter DI cleared via communication
	6	0	Event log cleared via device buttons
	7	0	Event log cleared via communications
	8	0	Energy values cleared via device buttons
	9	0	Energy values cleared via communications
	10	0	Peak demand of this month cleared via device buttons
	11	0	Peak demand of this month cleared via communications

Event classification	Event sub-classification	Event value option	Description
4	12	0	Max/Min value log of this month cleared via device buttons
	13	0	Max/Min log of this month cleared via communications
	14	Reserved	
5	1…6	Reserved	
6	1…17	Reserved	

Table 8.24: Event classification

8.10 Time setting

There are two time register formats supported by PEM533:

1. Year/Month/Day/Hour/Minute/Secondregister 9000…9002
2. UNIX-timeregister 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 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…28/29/30/31) 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) (0…4102444799)

Table 8.25: Timestamp register

8.11 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 **0081** have to be read out.
PEM533 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 that is to be sent to an output not being activated before will be ignored by the PEM533 and instead will be returned as exception code 0x04.

Register	Property	Format	Description
9100	WO	UINT16	Activate DO1 close
9101	WO	UINT16	Execute DO1 close
9102	WO	UINT16	Activate open DO1 open
9103	WO	UINT16	Execute DO1 open
9104	WO	UINT16	Activate DO2 close
9105	WO	UINT16	Execute DO2 close
9106	WO	UINT16	Activate DO2 open
9107	WO	UINT16	Execute DO2 open
9108…9165	Reserved		

Table 8.26: Digital output control register

8.12 Universal measuring device information

Register	Property	Description	Format	Note
9800… 9819	RO	Model*	UINT16	see Table 8.28 on page 85
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	Software update date: Month	UINT16	
9824	RO	Software update date: Date: day	UINT16	
9825	RO	Serial number		
9827…9829	Reserved			
9830	RO	Measuring current input	UINT16	1 / 5 (A)
9831	RO	U_S	UINT16	100/400 (V)

Table 8.27: 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 "PEM533" by way of example.

Register	Value (Hex)	ASCII
9800	0x50	P
9801	0x45	E
9802	0x4D	M
9803	0x35	5
9804	0x33	3
9805	0x33	3
9806…9819	0x20	Null

Table 8.28: ASCII coding of "PEM533"

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

$U_{L1-N,L2-N,L3-N}$	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
PEM533	
I_N	5 A
CT transformer ratio	1 . . . 6,000
PEM533-251	
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 °
Measurement of the active energy 0.5S .... acc. to DIN EN 62053-22 (VDE 0418 Teil 3-22)
Measurement of the voltage r.m.s. values .... acc. to DIN EN 61557-12 (VDE 0413-12), Kap. 4.7.6
Measurement of the phase current r.m.s. values ....
.... acc. to DIN EN 61557-12 (VDE 0413-12), chapter 4.7.5
Measurement of the frequency .... acc. to DIN EN 61557-12 (VDE 0413-12), chapter4.7.4

Interface

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

Switching elements

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 .... 6 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

Connection

Connection .... screw terminals

Other

Degree of protection, installation IP20
Degree of protection, front IP65
Weight .... ≤ 1100 g

9.1 Standards and certifications

PEM533 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)

9.2 Ordering information

Type	**Current input**	**Article number**
PEM533 230/400 V, 50 Hz	5 A	B 9310 0533
PEM533-251 230/400 V, 50 Hz	1 A	B 9310 0534
PEM533-455 400/690 V, 50 Hz	5 A	B 9310 0535
PEM533-451 400/690 V, 50 Hz	1 A	B 9310 0536

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