EN Manual

PEM735

Universal measuring device

100…690 V, 50 Hz

Software version 2.00.xx

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

DANGER

*The signal word indicates that there is a **high risk of danger,**, that will result in **death** or **serious injury** if not avoided.*

WARNING

*This signal word indicates a **medium risk of danger** that can lead to **death** or **serious injury** if not avoided.*

CAUTION

*This signal word indicates a **low level risk** that can result in **minor or moderate injury** or **damage to property** if not avoided.*

*This symbol denotes information intended to assist the user in making **optimum use** of the product.*

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

- Question about specific customer applications
- Commissioning
- Troubleshooting

Telephone+49 6401 807-760*
Fax: +49 6401 807-259
In Germany only: 0700BenderHelp (Tel. and Fax)
E-msupport@bender-service.de

Repair Service

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

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

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

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

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

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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.

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

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.com -> Know-how -> Seminars.

1.4 Delivery conditions, guarantee, warranty and liability

The conditions of sale and delivery set out by Bender apply.
For software products the "Softwareklausel zur Überlassung von Standard-Software als Teil von Lieferungen, Ergänzung und Änderung der Allgemeinen Lieferbedingungen für Erzeugnisse und Leistungen der Elektroindustrie" (software clause in respect of the licensing of standard software as part of deliveries, modifications and changes to general delivery conditions for products and services in the electrical industry) set out by the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e. V.) (German Electrical and Electronic Manufacturer's 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 PEM735 is suitable for

- the analysis of energy and power (Power Analyser)
- monitoring of the power supply quality (Power Quality)
- data recording for energy management (Energy Management).

As a compact device for front panel mounting, it is suitable to replace analogue indicating instruments. PEM735 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 measuring current and voltage transformers.

Use for the intended purpose 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 devices or other property.

DANGER

Danger of electric shock!
Touching live parts will result in electric shock which can be fatal.
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 devices:
  - 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.
- Reference signs must always be clearly legible. Replace damaged or illegible signs 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, power demand measurements or the quality of the supply voltage are to be made visible.
The PEM735 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 PEM735 for power quality and energy management is characterised by the following features:

- Class A power analyser, certified according to DIN EN 61000-4-30
- Monitoring the power quality in accordance with DIN EN 50160
- Accuracy class according to IEC 62053-22: 0.2 S
- TFT colour display (640 x 480) 5,7“
- Modbus/RTU and Modbus/TCP
- Memory: 2 GB (1 GB for data recording)
- Panel mounting 138x138
- Integrated web server
- Flicker measurement
- Detection and recording of transient events (40 µs)
- Sampling rate: 512 samples/cycle
- Freely configurable recorders for waveform, consumption and long-term recording
- Sampling rate of the measuring channels: 25.6 kHz
- Calculation of the total harmonic distortion THDU/THDI: harmonics up to the order 63
- Individual current/voltage harmonics
- Password protection
- History memory for minimum and maximum values of current, voltage, energy,

power etc. for each month.

- Inputs and outputs:
  - 2 digital outputs,
  - 4 relay outputs,
  - 8 digital inputs (sampling: 1 kHz)
  - 2 LED pulse outputs for active and reactive energy:
- Setpoints: 32 configurable setpoints (24 Standard, 8 Highspeed)
- System protocol:
  - 1024 entries
  - Setup changes
  - Setpoints
  - DI status changes
  - DO switching operations
- Communication:
  - Galvanically isolated RS-485 interface (1,200 to 19,200 bit/s)
  - Modbus/RTU protocol
  - Modbus/TCP (10/100 Mbit/s)

Measurements at a glance

- Measuring quantities
  - Phase voltages — U_{L1}, U_{L2}, U_{L3} in V
  - Line-to-line voltage — U_{L1L2}, U_{L2L3}, U_{L3L1} in V
  - U4 — in V
  - Phase currents — I_1, I_2, I_3 in A
  - Neutral current (calculated) — I_0 in A
  - Neutral current (measured) — I_4 in A
  - Frequency — f in Hz
  - Phase angle — for U and I in °
  - Power per phase conductor — P in kW, Q in kvar, S in kVA
  - Total power — P in kW, Q in kvar, S in kVA
  - Displacement factor — cos (φ)
  - Power factor — λ
  - Active and reactive energy import — in kWh, kvarh
  - Active and reactive energy export — in kWh, kvarh
  - Voltage unbalance — in %
  - Current unbalance — in %
  - Harmonic distortion

(THD, TOHD, TEHD)	for *U* and *I*
– k-factor	for *I*
– Minimum and maximum values	for *U*, *I*, r.m.s., fundamental component

- Measuring quantities PQ
  - k-factor for *I*
  - THD, TOHD and TEHD for *U* and *I*
  - Harmonic analysis for P, Q and S for harmonics of the order 2…63.
  - Fundamental component for *U, I, P, Q, S* and λ
  - Fundamental component for active and reactive energy (import and export)
  - Total harmonics for active energy.
  - Individual harmonics 2…31 for active energy import
- Report in accordance with EN 50160
  - Power Frequency
  - Supply voltage variations
  - Rapid voltage changes
  - Flicker severity
  - Voltage Unbalance
  - Harmonic voltage for harmonics up the order 63 in % or r.m.s. value
  - Interharmonic voltage for harmonics up to the order 63 in % or r.m.s. value
  - Mains signaling
  - Swell overvoltages
  - Dips
  - Interruptions
  - Transient overvoltages

3.3 Versions

PEM735 100/690 V;
Current input 5 A

3.4 Application example

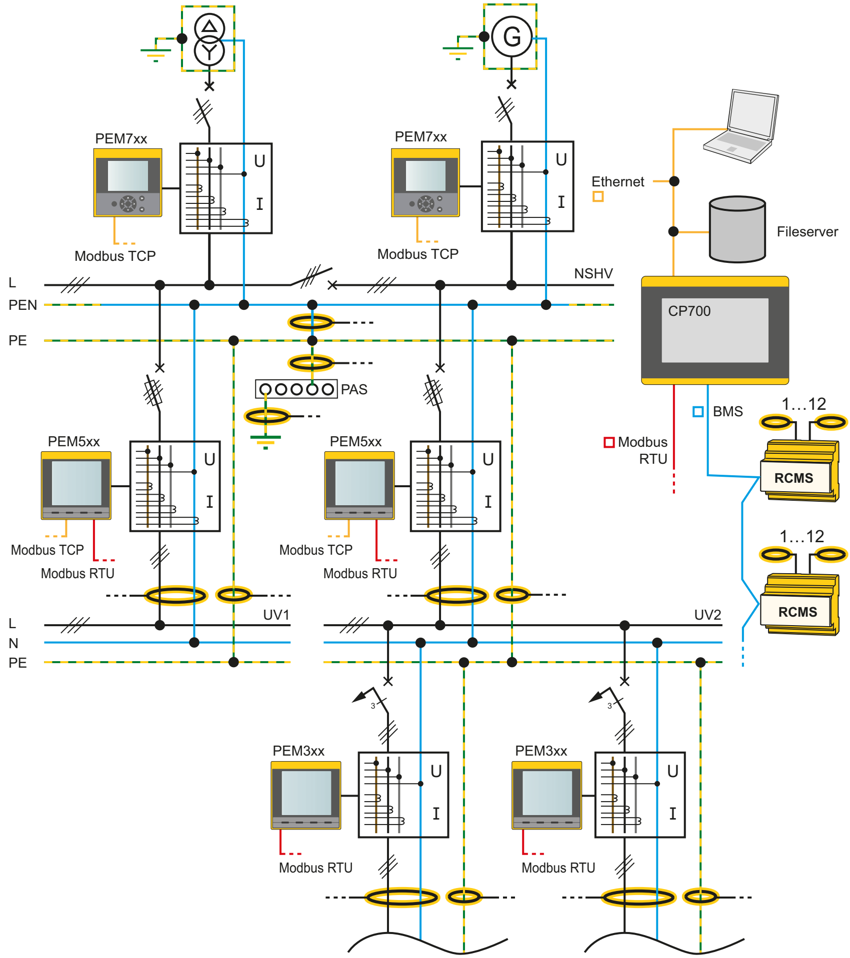


Fig. 3.1: Application example

3.5 Description of function

The digital universal measuring device PEM735 is suited for measuring and displaying electrical quantities of electricity networks. The PEM735 can measure currents, voltages, energy consumption and power as well as representing individual harmonic components of current voltage for the voltage and current quality assessment in accordance with DIN EN 50160.

The accuracy of the active energy metering corresponds to class 0.2 S, which is in compliance with the DIN EN 62053-22 (VDE 0418 Part 3-22):2003-11.
The current inputs 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 threshold value is exceeded).

The universal measuring device PEM735 provides the following functions:

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

4. Installation and connection

4.1 Project planning

For any questions associated with project planning, please contact Bender:
Internet: www.bender-de.com
Telephone+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.
Refer to the rated and supply voltage values *as specified in the technical data!*

4.3 Installing the device

4.3.1 Dimension diagrams

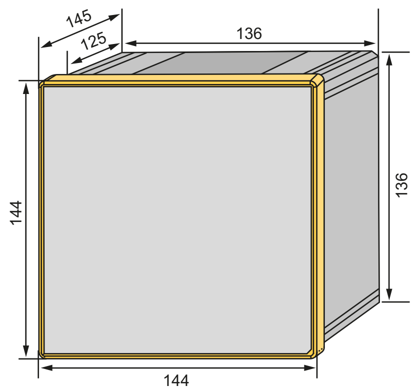


Fig. 4.1: Dimension diagram PEM735 (front view)

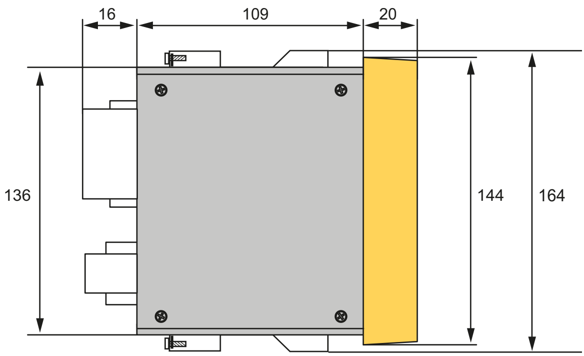


Fig. 4.2: Dimension diagram PEM735 (side view)

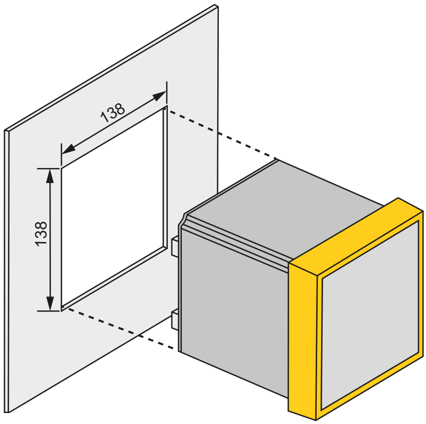


Fig. 4.3: Dimension diagram PEM735 (panel cutout)

4.3.2 Front panel mounting

A front-panel cutout of 138 mm x 138 mm is required for the device.

1. Loosen the screws of the fixing brackets.
2. Slide the fixing brackets along the grooves provided in the enclosure and remove them.
3. Insert the device into the installation opening of the front panel.
4. Refit the brackets in the reverse order.

5. Tighten the screws of the brackets.
6. 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 instructions

DANGER

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

4.4.2 Back-up fuses

Back-up fuse supply voltage: 6 A
Back-up fuse measuring inputs:
Voltage 6 A
Current inputs without a fuse

"The breaking capacity of the overcurrent protection device should be compatible with the current rating of the installation". (DIN EN 61010-1(VDE 0411-1):2011-07 9.6.1 Overcurrent protection).

A suitable separator must be provided. For details refer to the operating manuals of the measuring current transformers currently used.

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

4.4.3 Measuring current transformer connection

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

4.5 Connection details

- Connect the PEM735 to the supply voltage (terminals A1 and A2 resp. +/-). Connect terminal "⏚" to the protective conductor.
- Power protection by a 6 A fuse. 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 back of the device.

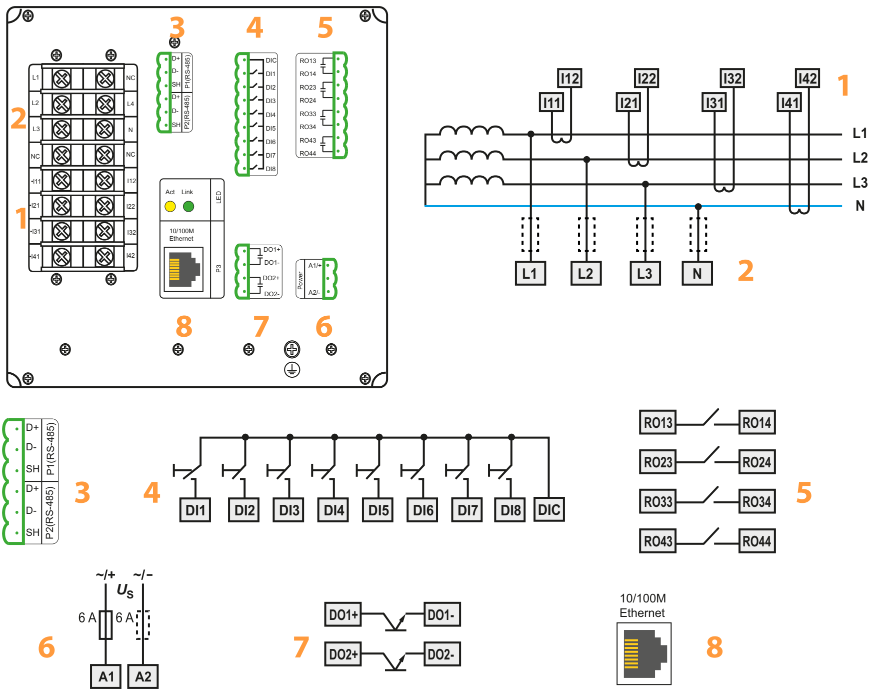


Fig. 4.4: Wiring diagram

Legend to wiring diagram

1	Connection to the system to be monitored
2	Measuring voltage inputs: The measuring leads should be protected with appropriate fuses.
3	RS-485 bus connection
4	Digital inputs
5	Relay outputs
6	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.
7	Digital outputs (N/O contacts "Solid state")
8	Connection Modbus TCP

4.7 Connection diagram voltage inputs

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

The universal measuring device PEM735 can be used in three-phase-4-wire systems, independent of the type of distribution system (TN, TT, IT system).

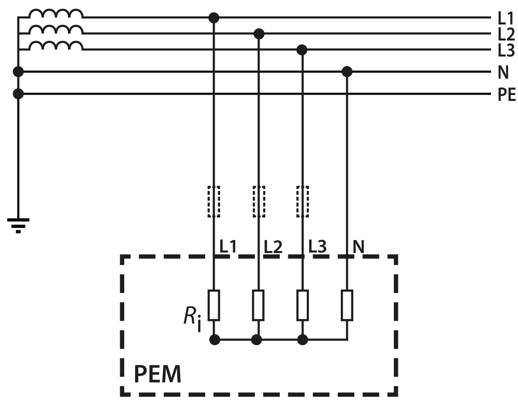


Fig. 4.5: Connection diagram three-phase 4-wire system (e.g. TN-S system)

4.7.2 Three-phase 3-wire system

The universal measuring device PEM735 can be used in three-phase-3-wire systems.

When used in a three-wire system the ***wiring mode DELTA*** *is required. For this purpose,* ***the measuring inputs L2 and N*** *are to be* ***bridged****.*

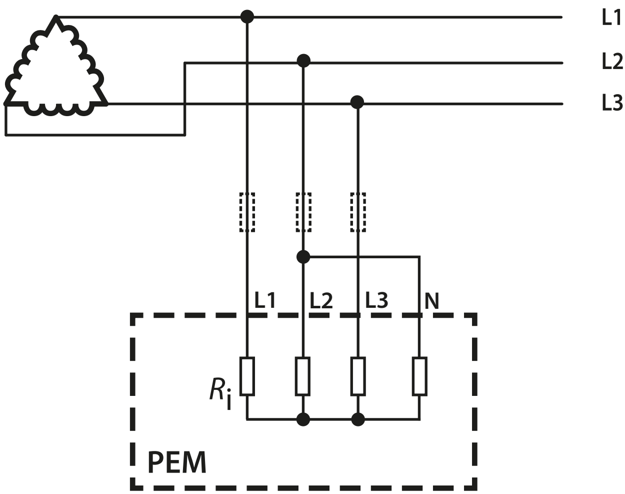


Fig. 4.6: Connection diagram three-phase-3-wire system

4.7.3 Connection via voltage transformers

The coupling of the voltage transformers allows the use of the measuring device in medium and high-voltage systems.
The transformation ratio can be adjusted in the PEM735 (1…1.000.000).

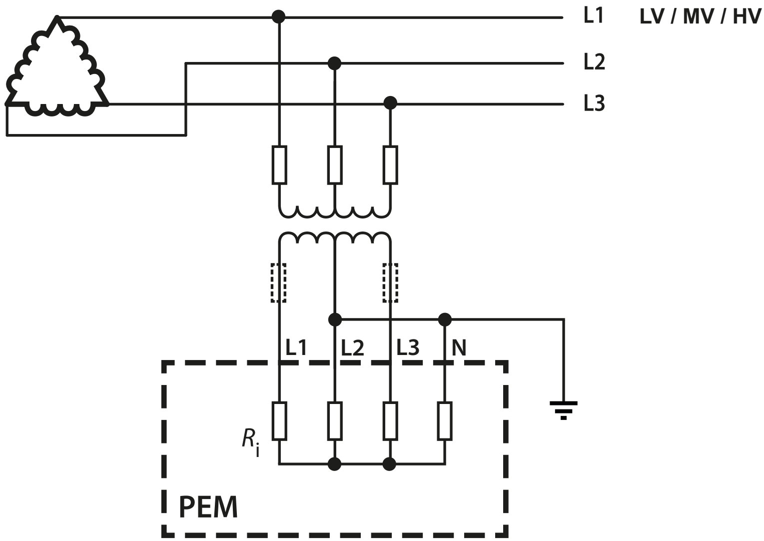


Fig. 4.7: Connection diagram 3-wire system via voltage transformers

4.8 Digital inputs

The universal measuring device PEM735 provides 8 digital inputs. The inputs are supplied by a galvanically isolated DC 24 V voltage. An external circuit providing at least a current of I_{min} > 2.4 mA is required for triggering the inputs.

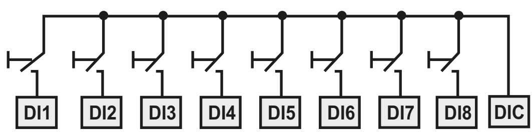


Fig. 4.8: Digital inputs

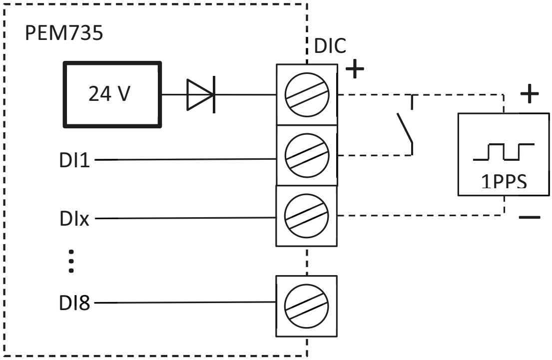
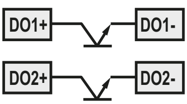


Fig. 4.9: Digital inputs (internal connection diagram)

Note: PPS = pulse per second, pulse/s

4.9 Digital outputs DO1…2

The universal measuring device PEM735 features two configurable outputs (N/O contacts „"Solid State Relay").

	**Rated operational voltage**	max. 30 V
	Rated operational current	50 mA

Tab. 4.1: Digital outputs

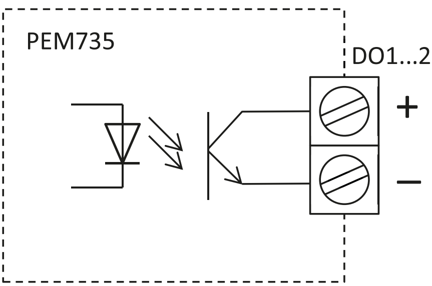
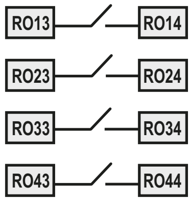


Fig. 4.10: Digital outputs (internal connection diagram)

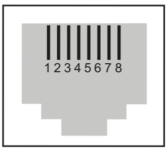
4.10 Relay outputs RO1…4

The universal measuring device PEM735 features four relay outputs.

	**Rated operational voltage**	250 V AC/DC
	Rated operational current	3 A

Tab. 4.2: Relay outputs

4.11 Modbus TCP (connector pin assignment)

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

Tab. 4.3: Modbus TCP (connector pin assignment)

5. Commissioning

5.1 Check proper connection

Observe the relevant standards and regulations for installation and connection as well as the operating manual of the respective device.

5.2 Before switching on

Consider the following questions before switching on:

1. Does the connected supply voltage correspond to the information on the nameplate?
2. Has the nominal insulation voltage of the measuring current transformers been exceeded?
3. Does the measuring current transformer's maximum current correspond to the nameplate information of the connected device?

5.3 Switching on

To switch the device on, follow the steps below:

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 (line-to-line voltage U_{LL}).
6. Select wye connection or delta connection.

5.4 System

The universal measuring device PEM735 can be programmed and queried via Modbus RTU/Modbus TCP. For details refer to the Annex "PEM735-Modbus".
In addition, it is possible to integrate the device into Bender's own bus protocol BMS bus (**B**ender **M**essgeräte **S**chnittstelle) via additional communication modules. In this way, communication with (already existing) Bender devices for device parameterisation and visualisation of measured values and alarms can be achieved.

Help and examples of system integration can be found on the Bender homepage www.bender.de or you can contact our Bender Service for personal advice (see chapter " 1.2 Technical support: Service and support").

6. Operation

6.1 Getting to know the operating elements

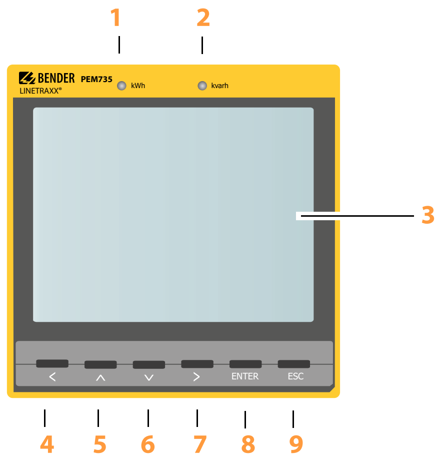


Fig. 6.1: Operating elements

Legend to operating elements

No.	Element	Description
1	LED kWh	Pulse output, see "LED indication (Energy pulsing)" on page 32.
2	LED kvarh	
3	LC display	
4	<	Back; Submenu: scroll; move left on display
5	Λ	Main menu: move upwards in the menu; increase number/selection
6	V	Main menu: move down in the menu; Decrease number/selection
7	>	Select menu item; Submenu: scroll; move right on display

8	"ENTER" button	ok; switch to the submenu "freeze" waveform recorder depending on the submenu other function (information on the display)
9	"ESC" button	Leave submenu; "Unfreeze" waveform recorder depending on the submenu other function (information on the display)

Tab. 6.1: Legend to operating elements

6.2 LED indication (Energy pulsing)

The universal measuring device features two red LEDs on the front side to display active and reactive energy measurements: kWh and kvarh. The LEDs flash each time a certain energy value is reached (1 kWh or 1 kvarh).

The amount of energy displayed corresponds to the amount of energy measured by the measuring device. In order to relate the flashing frequency to the amount of energy, the transformation ratios and the pulse constant have to be considered.

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

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

Note:
VT = voltage transformer
CT = measuring current transformer

6.3 Overview diagram

The following diagram will help you navigate through the menus.

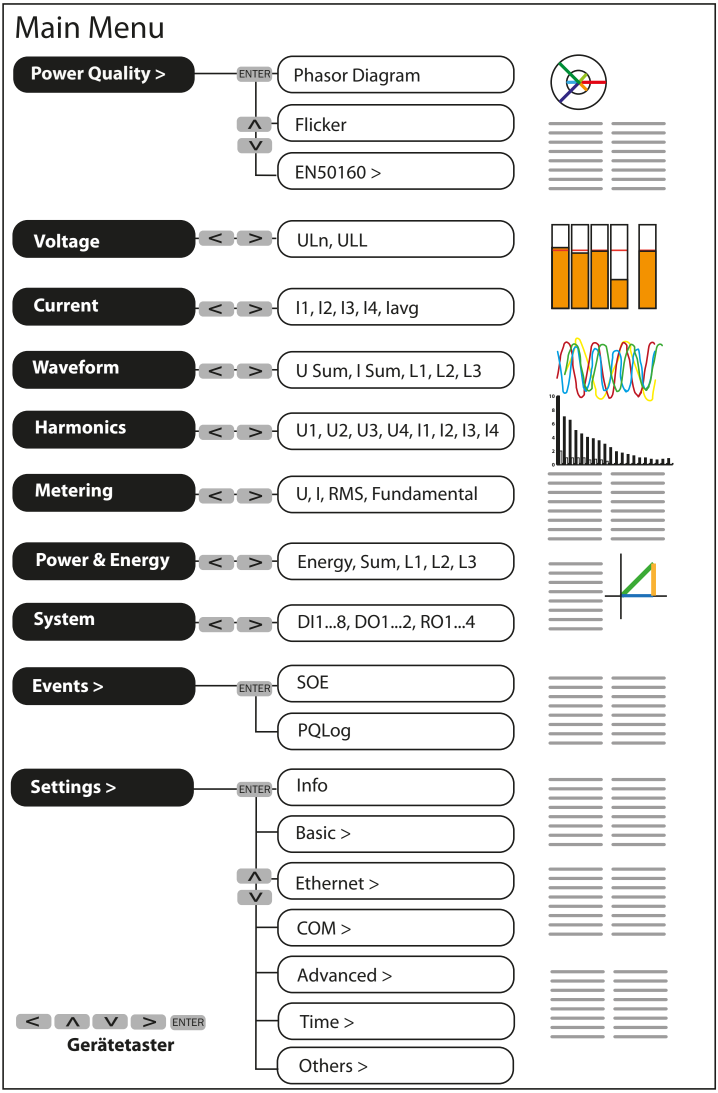


Fig. 6.2: Overview: Display representation menu

7. Power Quality

The PEM735 offers the possibility of evaluating different power quality measurement results directly at the device. Here, both the actual measured values and graphic illustrations can be displayed.

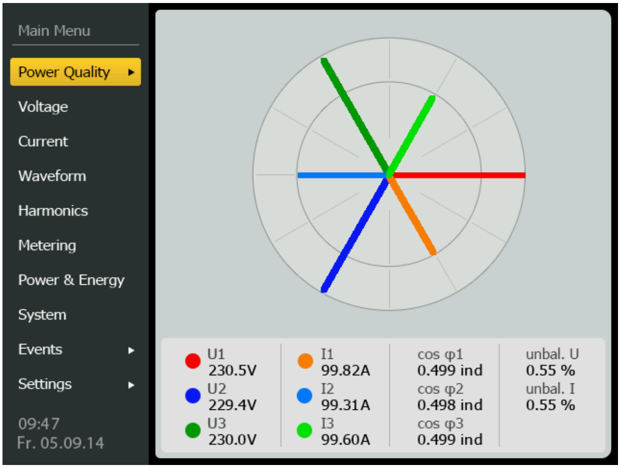


Fig. 7.1: Display "Power Quality" (default display screen)

In addition to the phasor diagram, an overview of the flicker events and the starting point for the report (according to DIN EN 50160) are displayed under the menu "Power Quality".

Press "ENTER" to go back a menu level. You can navigate between the individual views of a menu level using the ⋀ and ⋁ buttons.
Press the "ESC" button to escape from the submenu.

7.1 Phasor diagram

The phasor diagram shows voltages and currents in relation to each other. The voltages and currents that belong together are depicted in similar colours (light-blue and dark-blue, light-green and dark-green, red and orange). In this way, the phase angles between the sinusoidal curves can easily be assigned. The currents are depicted within the inner circle while the voltages are shown within the outer circle.

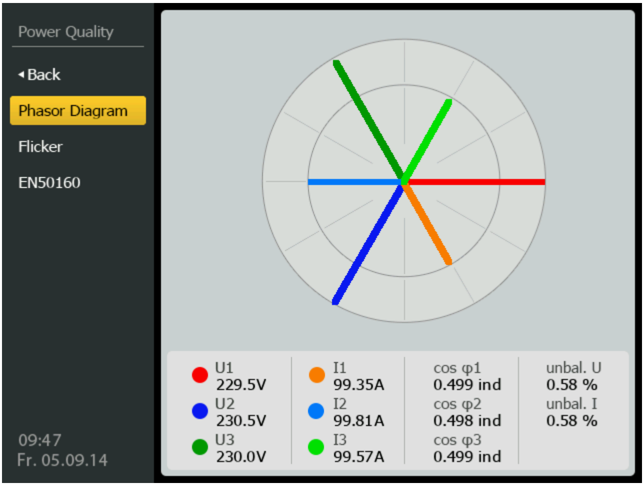


Fig. 7.2: Display "Phasor diagram"

The display shows:

Display text	Description
U1…U3	Voltages U_{L1}, U_{L2}, U_{L3}
I1…I3	Currents I_1, I_2, I_3
cos φ 1…3	Phase angle cosφ between current and voltage
unbal U	Voltage unbalance
unbal I	Current unbalance

7.2 Flicker

Flicker can be caused by short-term operating voltage fluctuations. Every occurrence of flicker is recorded for each phase and represented in tabular form on the display.
For detailed description refer to the standard DIN EN 61000-4-15.

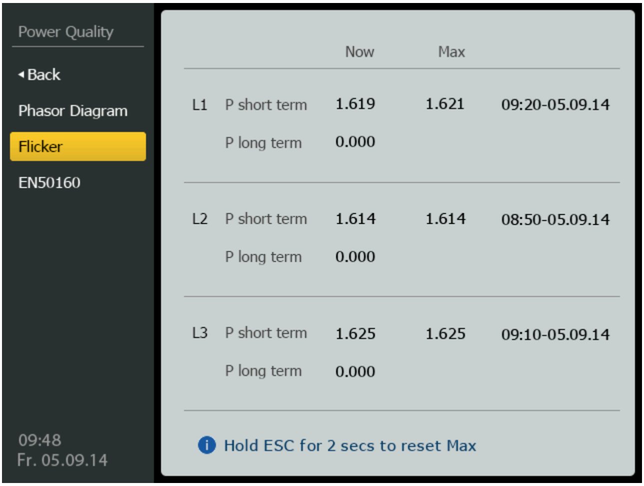


Fig. 7.3: Display "Flicker"

The display shows:

Display text	Description	Note
now	Actual measured value	
max	Maximum measured value over an observation period	
P short-term	PST, short-term flicker	10-minute value
P long-term	Plt, long-term flicker	2-hour value, cubic average of 12 Pst
Timestamp	Timestamp of the maximum value.	

To ***reset the maximum values****, keep the "ESC" button pressed for at least two seconds.*

7.3 DIN EN 50160 report

The evaluation according to DIN EN 50160 (Voltage characteristics of electricity supplied by public distribution systems) contains the following items:

- Power frequency
- Voltage variations
- Rapid voltage changes [1)]
- Flicker severity
- Supply voltage unbalance
- Harmonic voltage
- Interharmonic voltage [1)]
- Mains signaling voltages (ripple control signals)
- Voltage interruptions [1)]
- Voltage dips [1)]
- Voltage swells [1)]
- Transient overvoltages [1)]

Note:

[1)] These values are recorded and, when applicable, subdivided into classes. But the DIN EN 50160 does not specify threshold values.

The DIN EN 50160 report clearly represents the measured values of frequencies, voltages, waveforms and the symmetry of the line voltages directly at the device. Since there are a large number of measurement values, you have to switch between the different display representations using the arrow buttons.

The start page of the DIN EN 50160 report provides an overview of the measurements and the errors occurred. In this way you can see at a glance if the conditions of DIN EN 50160 are complied with or not. On the occurrence of errors the parameters are marked with and can be further analysed on a subpage.

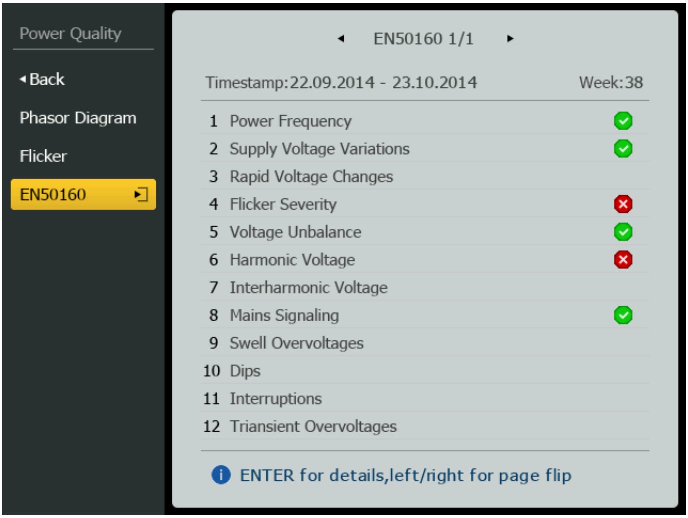


Fig. 7.4: Display "DIN EN 50160" (start page: report

The display shows:

Display text	Description	Note
Timestamp	Observation period for the report	
	Measured values comply with the specified threshold values	
	Measured values do not comply with the specified threshold values	
Detail	Results are shown on several sub-pages;	Scroll with arrow buttons; Press "ENTER" or "ESC" to return to the start page.

When several reports are stored, navigate through the reports using the < and > buttons.
To navigate through individual parameters in the report use the ∧ and ∨ buttons. Press "ENTER" to go to the respective subpage.
Press the "ESC" or "ENTER" button to leave the subpage.

7.3.1 Power Frequency

The power frequency is 50 Hz.
For systems with a synchronous connection to an interconnected system, the DIN EN 50160 requires a nominal frequency f_n interval of 49.5…50.5 Hz during 99.5 % of a year (narrow limits).

All measured values of a year must be in the interval of 47…52 Hz (f_n -6 /+ 4 %).

Measurement overview

f_n	50 Hz
f_n ± 1 % (during min. 99.5 % of a year)	49.5…50.5 Hz
f_n –6/+4 % (for all measured values of a year)	47…52 Hz
Basic value	Mean value
Integration interval	10 s
Observation period	1 week
Number of intervals	60480

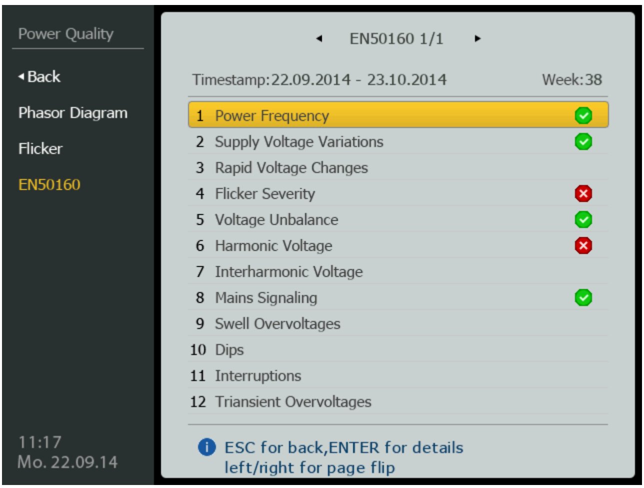


Fig. 7.5: "Power Frequency" (selection of the parameters)

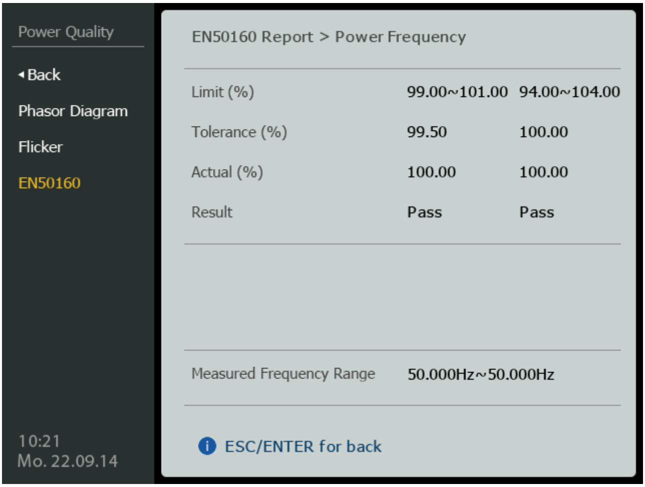


Fig. 7.6: "Power Frequency" (subpage)

The display shows:

Display text	Description	Note
Limit (%)	Permissible deviations from the nominal frequency (tolerance band).	**Left column**: max. ±1 % permissible deviation for 99.5% of the measured values (narrow limits) **Right column**: max. -6 %/ +4 % for all measured values (wide limits)
Tolerance (%)	Number [%] of the measured values, which must be in the tolerance band within one measurement period.	
Actual (%)	Number of measured values [%] within the tolerance band of one measurement period.	The average value derived from 10-second observation periods.
Result	Limit values complied with?	Pass: Specifications complied with. Fail: Specifications not complied with.

Applies to a system in an interconnected system.

7.3.2 Supply Voltage Variations

The voltage must not differ from the nominal voltage U_n by more than 10% during 95% of the observation time (= one week) (narrow limits).

All measured values of a year must be in the interval of 195.5…253.0 V (wide limits).

To consider the voltage level, 10 minute mean r.m.s. values of the voltage are applied.

Measurement overview

Nominal voltage U_n	230 V
U_n ±10 % (for at least 95 % of a year)	207.0…253.0 V
U_n −15 % / +10 % for all measured values of a year	195.5…253.0 V
Basic value	r.m.s. value
Integration interval	10 minutes
Observation period	1 week
Number of measurement intervals	1008

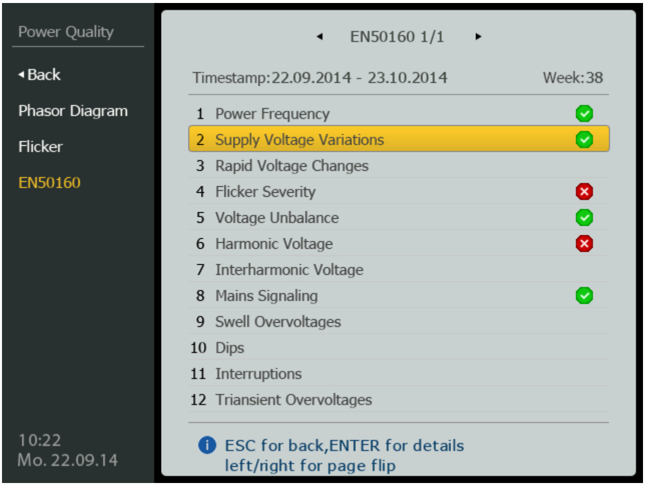


Fig. 7.7: Supply voltage variations (selection of the parameters)

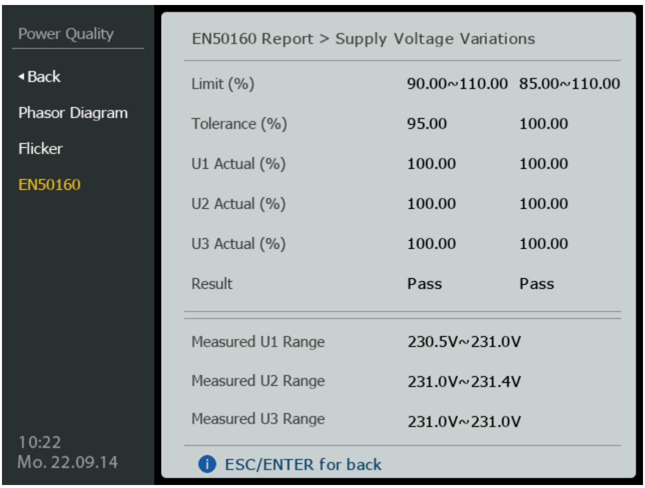


Fig. 7.8: Supply voltage variations (subpage)

The display shows

Display text	Description	Note
Limit (%)	Permissible deviations from the nominal voltage U_n (tolerance band)	**Left column**: max. 10 % permissible deviation for 95 % of the measured values (narrow limits) **Right column**: -15/+10 % for all measured values (wide limits)
Tolerance (%)	Number of measured values [%] which must be within the tolerance band of one measurement period.	
U1…3 Actual (%)	Number of measured values [%] within the tolerance band of one measurement period.	
Result	Limit values complied with?	
Measured U1…3 range	Range of measured values for $U_{L1...3}$	Absolute values in V

7.3.3 Rapid Voltage Changes

Rapid voltage changes are rapid variations of the r.m.s. value between two consecutive voltage values. These changes are distinguishable by definite but unspecified durations.

Rapid voltage changes can be due to load variations in the network users' installation or switching in the system, or by faults.

If in the case of rapid voltage changes the conditions of voltage dips or swells are met, the occurring events are often considered as voltage dips or swells rather than rapid voltage changes.

Measurement overview

U_n	230 V
Rapid voltage changes	5…10 %
Basic value	r.m.s. value
Integration interval	10 ms
Observation period	1 day

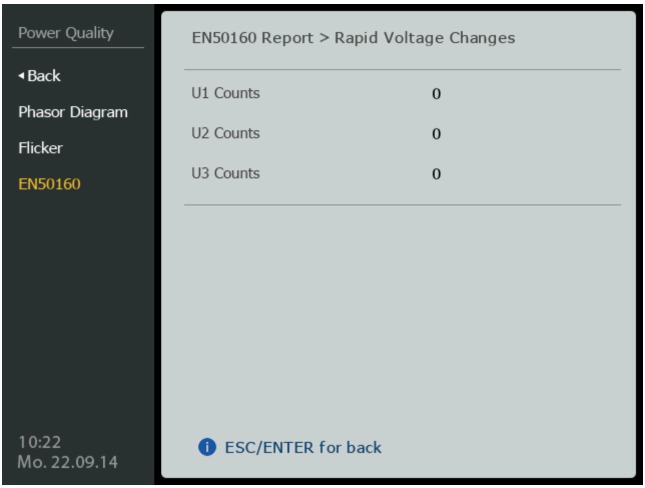


Fig. 7.9: Rapid voltage changes (subpage)

The display shows

Display text	Description
U1…3 counts	Counts the number of rapid voltage changes for $U_{L1...3}$

DIN EN 50160 does not specify limits for these measured values.

7.3.4 Flicker Severity
(according to DIN EN 50160)

Voltage fluctuations cause changes in the luminance of lamps which can create the visual phenomenon called flicker. Above a certain threshold flicker becomes annoying. The annoyance grows very rapidly with the amplitude of the fluctuation. At certain repetition rates even very small amplitudes can be annoying.
The intensity of flicker annoyance can be evaluated by the following quantities:

- Short-term flicker severity (perceptibility unit short term **Pst**), measured over a period of 10 minutes;
- Long-term flicker severity (perceptibility unit long term **Plt**), calculated from a sequence of 12 Pst values (= two-hour interval) according to the following expression

$$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{{P_{sti}}^3}{12}}$$

P_{lt} must be ≤ 1 during each period of one week for 95% of the time.

The reaction to flicker is subjective and can vary depending on the perceived cause of the flicker and the period over which it persists. In some cases Plt = 1 gives rise to annoyance, whereas in other cases higher levels of Plt are noticed without annoyance.

Measurement overview

U_n	230 V
Flicker	≤ 1 for 95 % of the time
Basic value	Flicker algorithm
Integration interval	2 h
Observation period	1 week
Number of measurement intervals	84

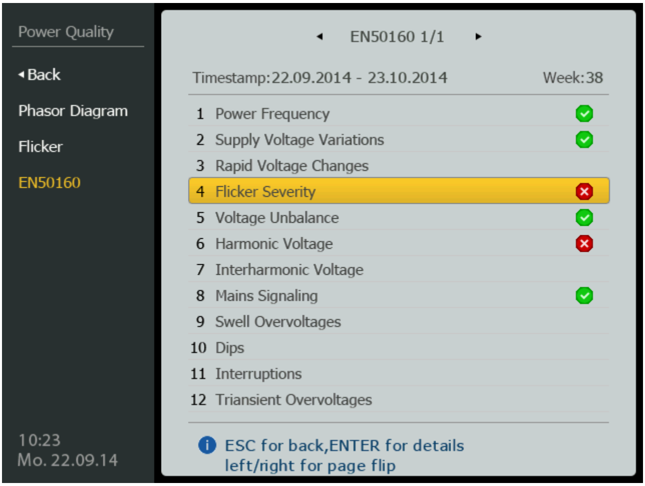


Fig. 7.10: Flicker severity (selection of the parameters)

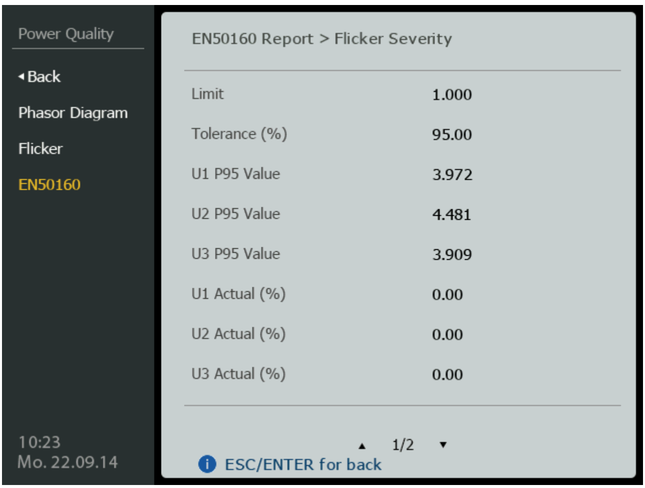


Fig. 7.11: Flicker severity (subpage1)

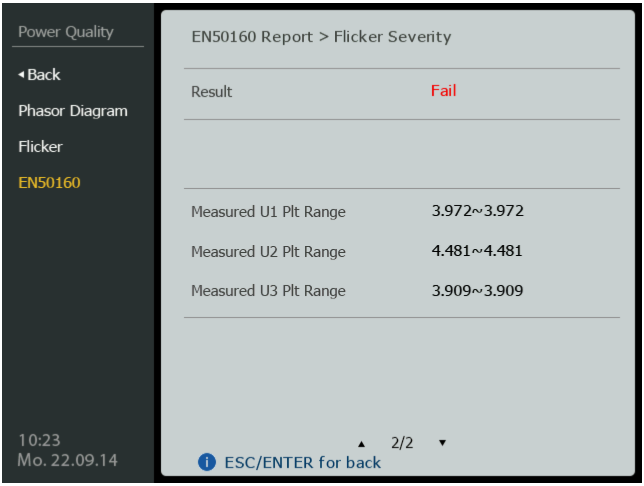


Fig. 7.12: Flicker severity (subpage 2)

The display shows:

Display text	Description
Limit	Permissible limit
Tolerance (%)	Number [%] of the measured values, which must be in the tolerance band within one measurement period (≤ 1)
U1…3 P95 value	Measured flicker value of the 95th percentile (P95) during an observation period
U1…3 Actual (%)	Number of measured values [%] within the tolerance band of one measurement period
Result	Specifications complied with? (Pass: Specifications complied with. Fail: Specifications not complied with)
Measured U1…3 Plt range	Range of measured values for long-term flicker $U_{L1...3}$

7.3.5 Voltage Unbalance

(according to DIN EN 50160)
Under normal operating conditions, during each period of one week, 95 % of the 10 min mean r.m.s. values of the negative phase sequence component (fundamental) of the supply voltage must be within the range of 0…2 % of the positive phase sequence component (fundamental).

In some areas with partly single phase or two phase connected network users' installations, unbalances up to about 3 % at three-phase supply terminals occur. In this European standard only values for the negative phase sequence component are given because this component is the relevant one for the possible interference of appliances connected to the system.

Measurement overview

Voltage unbalance (ratios of the negative to the positive phase sequence component)	2 % , in special cases 3 %
Percentage	95 % of the measured values in the measurement period
Basic value	r.m.s. value
Integration interval	10 minutes
Observation period	1 week
Number of measurement intervals	1008

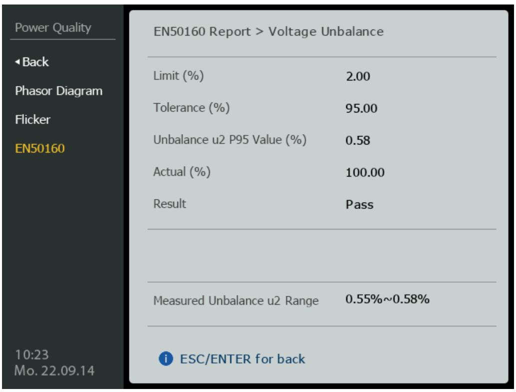


Fig. 7.13: Voltage unbalance

The display shows:

Display text	Description	Note
Limit (%)	Permissible deviations from the nominal supply voltage (unbalance tolerance band)	
Tolerance (%)	Number [%] of the measured values, which must be in the tolerance band within one measurement period.	
Unbalance u2 P95 Value (%)	Measured value of the 95th percentile (P95) during an observation period	unbalance u_2 is the voltage value for the unbalance of the negative phase sequence
Actual (%)	Number of measured values [%] within the tolerance band of one measurement period.	
Result	Specifications complied with?	Pass: Specifications complied with. Fail: Specifications not complied with.
Measured Unbalance u2 Range	Range of measured values for unbalance u2	

Measurement interval: 10 min mean values

PEM735 can determine the unbalance for the zero sequence and the negative sequence component.
Unbalance u_2 = (negative sequence/positive sequence component) x 100 %
Unbalance u_0 = (zero sequence/positive sequence component) x 100 %

7.3.6 Harmonic Voltage

(according to DIN EN 50160)

Under normal operating conditions, during each period of one week, 95% of the 10 min mean r.m.s. values of each individual harmonic voltage must be less than or equal to the values given in table 7.1 . Resonances may cause higher voltages for an individual harmonic.

Moreover, the THD of the supply voltage (including all harmonics up to the order 40) must be ≤ 8 %.

Overview of the limits for individual harmonics

Harmonic order	Percentage [%]	Harmonic order	Percentage [%]
2	2.0	**3**	5.0
4	1.0	**5**	6.0
6	0.5	**7**	5.0
8	0.5	**9**	1.5
10	0.5	**11**	3.5
12	0.5	**13**	3.0
14	0.5	**15**	0.5
16	0.5	**17**	2.0
18	0.5	**19**	1.5
20	0.5	**21**	0.5
22	0.5	**23**	1.5
24	0.5	**25**	1.5
No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable due to resonance effects.			

Tab. 7.1: Limits for individual harmonics

Note table 7.1: The **3n harmonics** are highlighted. They contribute significantly to the unwanted heating of the neutral conductor.

Measurement overview

Total harmonic distortion THD (including harmonics up to the order 40)	max. 8 %
Percentage	95 % of the measured values must be smaller than or equal to the limit.
Basic value	r.m.s. value
Integration interval	10 minutes
Observation period	1 week
Number of measurement intervals	1008

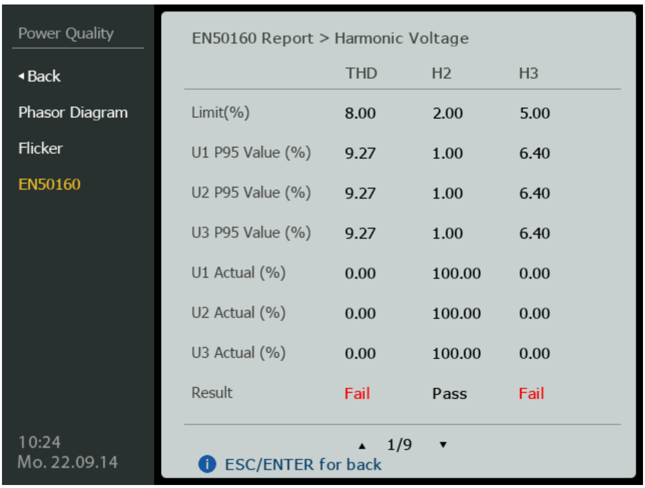


Fig. 7.14: Harmonic voltage (subpage 1)

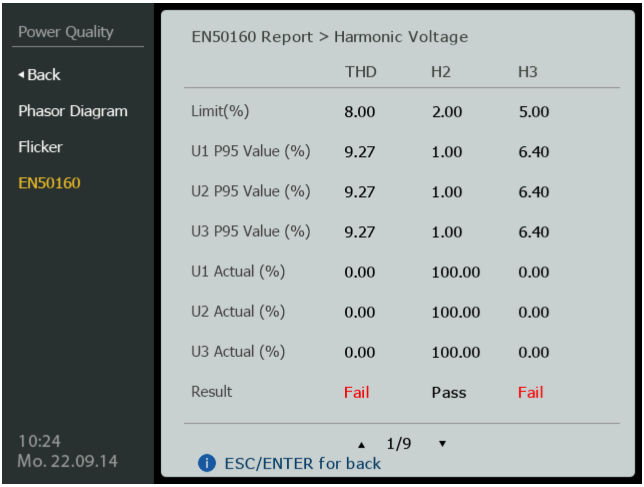


Fig. 7.15: Harmonic voltage (subpage 2)

The display shows:

Display text	Description
THD	Total harmonic distortion
H1…25	Harmonics 1…25
Limit (%)	Permissible limit
U1…3 P95 Value (%)	Measured value of the 95th percentile (P95) during an observation period
U1…3 Actual (%)	Number of measured values [%] within the tolerance band of one measurement period
Result	Specifications complied with? (Pass: Specifications complied with. Fail: Specifications not complied with)

Use the ∧ and ∨ buttons to navigate between the individual pages of the harmonics.
Press the "ENTER" or the "ESC" button to return to the report overview.

7.3.7 Interharmonic Voltage

according to DIN EN 50160

An interharmonic voltage is a sinusoidal voltage with a frequency not equal to an integer multiple of the fundamental frequency (e. g. f_n = 50 Hz).

Interharmonic voltages at closely adjacent frequencies can appear at the same time forming a wide band spectrum. The level of interharmonics is increasing due to the development of frequency converters and similar control equipment. Levels are under consideration, pending more experience.
In certain cases interharmonics, even at low levels, give rise to flicker, or cause interference in ripple control systems.

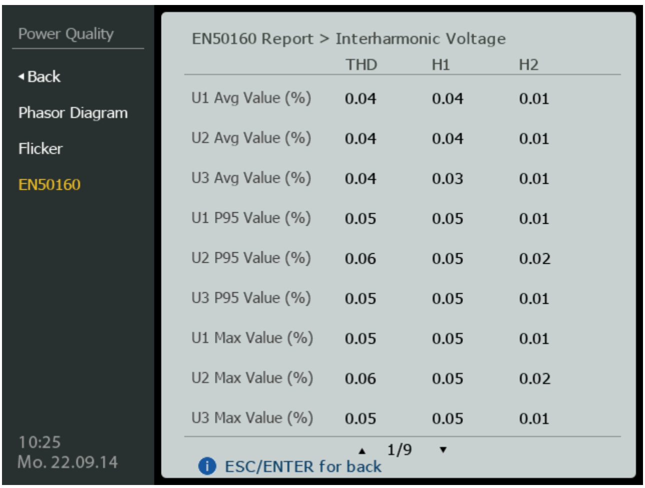


Fig. 7.16: Interharmonic Voltage (subpage 1)

The display shows:

Display text	Description	Note
U1…3 Avg Value (%)	Ø -measured value per phase	Percentage
U1…3 P95 Value (%)	Measured value of the 95^{th} percentile (P95) during an observation period	Percentage
U1…3 Max Value (%)	Maximum measured value per phase	Percentage

Use the ⋀ and ⋁ buttons to navigate between the individual pages of the interharmonics.
Press the "ENTER" or the "ESC" button to return to the report overview.

DIN EN 50160 does not specify limits for these measured values.

7.3.8 Mains Signaling (ripple control signals)

Mains signaling voltages.

Ripple control signals are signals superimposed on the supply voltage for the purpose of transmission of information in the public supply network and to network users' premises.

Signals in the public supply network can be classified as follows:

- Ripple control signals: Superimposed sinusoidal voltage signals in the frequency range 110…3 000 Hz;
- Mains marking signals: Superimposed short time alterations (transients) at selected points of the voltage waveform.

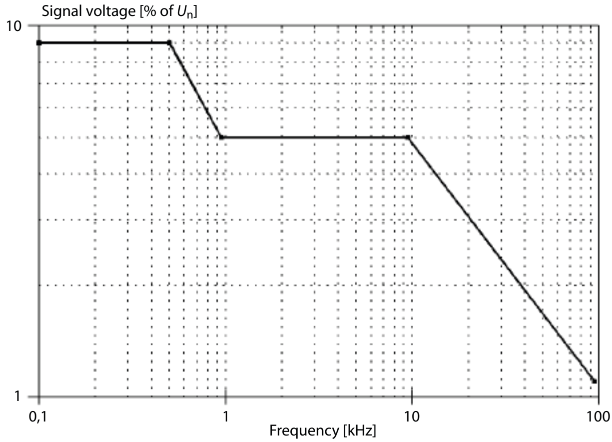


Fig. 7.17: Voltage levels of signal frequencies in percent U_n used in public LV networks (according to DIN EN 50160)

In some countries the public networks may be used by the network operators for the transmission of signals. For 99 % of a day the 3 s mean value of the signal voltages must be less or equal to the values given in Fig. 7.17.

PEM735 can detect the voltage of the signals in three different frequency ranges. The limits of the frequency ranges can be specified by the user. The frequency range is limited to 3 kHz.

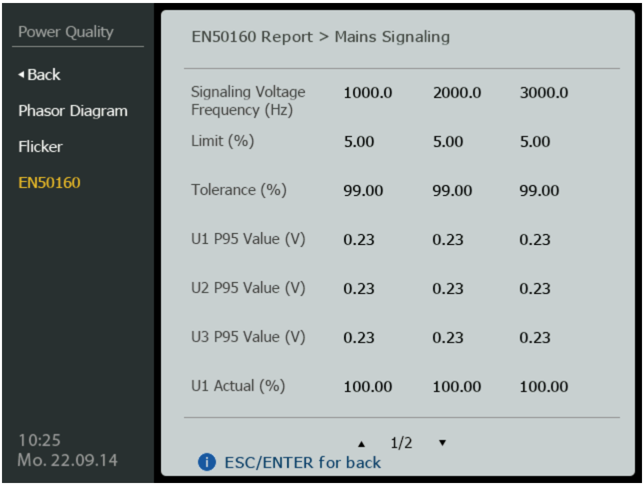


Fig. 7.18: Mains signaling (subpage 1)

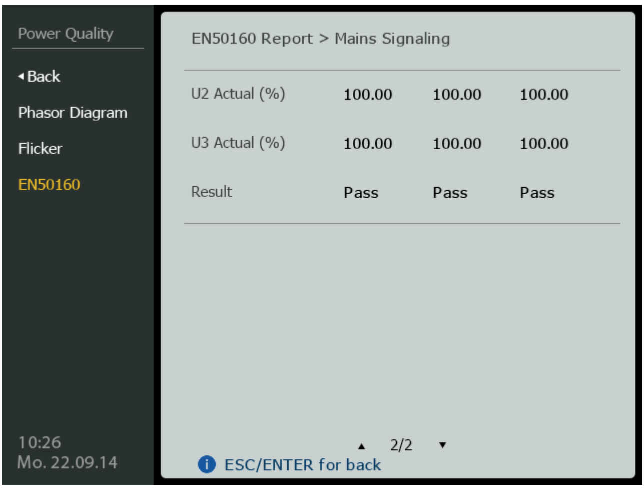


Fig. 7.19: Mains signaling (subpage 2)

The display shows:

Display text	Description	Note
Signaling voltage frequency (Hz)	Frequency of the ripple control signals	The three frequencies used can be adjusted via Modbus.
Limit (%)	Permissible deviations (tolerance band)	
Tolerance (%)	Number [%] of the measured values, which must be in the tolerance band within one measurement period.	
U1…3 P95 Value (V)	Measured value of the 95th percentile (P95) during an observation period	
U1…3 Actual (%)	Latest measured value $U_{L1...3}$	
Result	Specifications complied with?	Pass: Specifications complied with Fail: Specifications not complied with

Use the ⋀ and ⋁ buttons to navigate between the individual pages of the mains signaling.
Press the "ENTER" or the "ESC" button to return to the report overview.

7.3.9 Swell Overvoltages

Voltage swells are typically caused by switching operations and load disconnections. The nominal supply voltage U_n is used as reference. The swell start threshold is equal to 110 % of U_n , the hysteresis is 2 %.
In addition to the threshold, the duration of the voltage swell is also determined. Voltage swells can trigger up to two of the following:

- Relay outputs
- Digital outputs
- PQ-Log
- Waveform recorder
- Data recorder

These settings can only be made via the communication interface. For detailed information refer to the annex "Modbus".

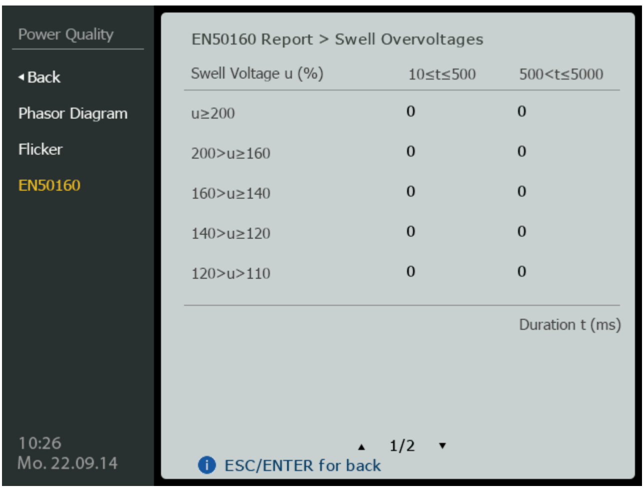


Fig. 7.20: Voltage swells (subpage1)

The display shows:

Display text	Description
t	Time (ms)
Voltage swell u	Voltage swell level in % of the sliding value (U_{sr}) or of the nominal value (U_{din}).

For voltage swells classification the percentages of the voltage levels u are summarized as follows:

u ≥ 200
200 > u ≥ 160
160 > u ≥ 140
140 > u ≥ 120
120 > u >110

Use the ⋀ and ⋁ buttons to navigate between the individual pages of the voltage swells.
Press the "ENTER" or the "ESC" button to return to the report overview.

DIN EN 50160 does not specify limits for these measured values.

7.3.10 Dips

according to DIN EN 50160

Voltage dips are typically originated by faults occurring in the public network or in network users' installations. The nominal supply voltage U_n is used as reference. The voltage dip start threshold is equal to 90 % of the U_n , the hysteresis is 2 %.
The ratio (as a percentage) between the residual voltage U_{res} and the nominal supply voltage U_n is displayed.

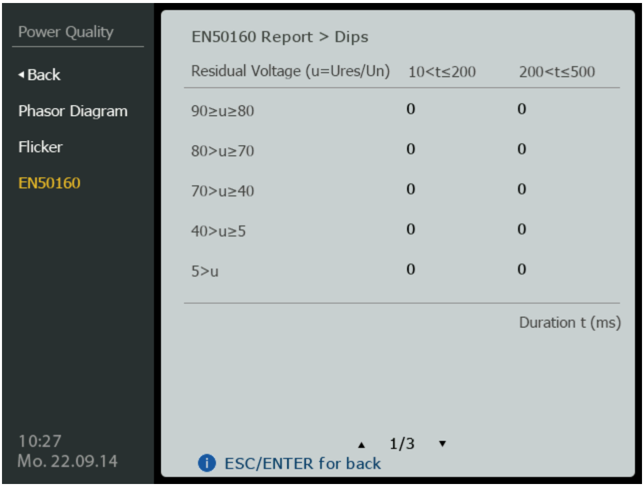


Fig. 7.21: Dips (subpages 1 of 3)

For voltage dips classification the percentages of the voltage levels u are summarized as follows:

$90 \geq u \geq 80$
$80 > u \geq 70$
$70 > u \geq 40$
$40 > u \geq 5$
$5 > u$

The display shows:

Display text	Description
Residual Voltage U res	Residual voltage level U_{res}
t	Duration of the voltage dip (ms)
Un	Nominal supply voltage U_n
90>u>=80	Classification of the voltage dip (% of the residual voltage)
10<t<=200	Classification of the voltage dip (duration *t* in ms)

Note: If the "Sliding Reference Voltage U_{sr}" detection method is used, the calculation should be made using a first order and a constant set to one minute.

$$U_{sr(n)} = 0.9967 \times U_{sr(n-1)} + 0.0033 \times U_{(10/12)rms}$$

Use the ∧ and ∨ buttons to navigate through the individual pages of the voltage dips.
Press the "ENTER" or the "ESC" button to return to the report overview.

DIN EN 50160 does not specify limits for these measured values.

7.3.11 Interruptions

according to DIN EN 50160

Interruptions are, by their nature, very unpredictable and variable from place to place and from time to time. For the time being, it is not possible to give fully representative statistical results of measurements of interruption frequency covering the whole of European networks. The voltage interruptions measured are counted and classified according to duration.

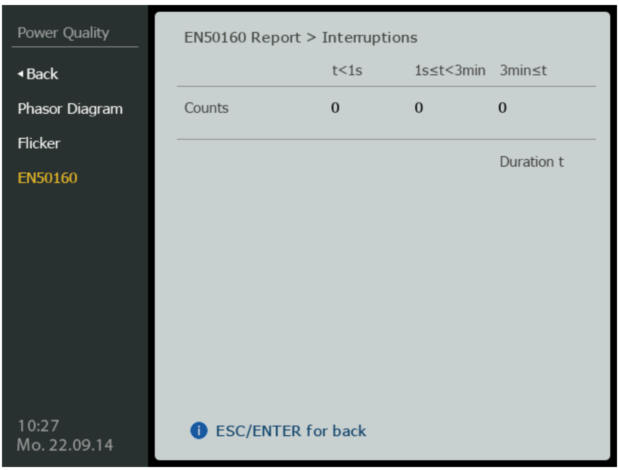


Fig. 7.22: Interruptions (subpage)

The time periods *t* are differentiated as follows:

$t < 1$ s
1 s ≤ $t < 180$ s (3 minutes)
180 s ≤ t

The display shows:

Display text	Description
Counts	Quantity
1s ≤ t < 3 min	Classification of voltage interruption according to duration (in this case it varies between 1 second and 3 minutes)

Voltage interruption evaluation

On polyphase systems, a voltage interruption begins when the r.m.s. value $U_{L1/2\ (rms)}$ of all channels falls below the voltage interruption threshold. A voltage interruption ends when the voltage on any one channel is equal to, or greater than, age interruption threshold plus the hysteresis.

The voltage interruption threshold and the hysteresis voltage are both set by the user according to the application. The voltage interruption threshold should not be set below the uncertainty of the residual voltage U_{res} measurement plus the value of the hysteresis. Typically, the hysteresis is 2 % of U_s (U_{din}). The voltage interruption threshold can, for example, be set to 5 % or 10 % of U_s (U_{din}). Voltage interruptions can trigger the following outputs or records:

- digital outputs
- Relay outputs RO1…4
- Highspeed data recorder HS-DR1…4
- Data recorders
- Waveform recorders WFR1…2

These settings can only be carried out via the communication interface (see Annex "Modbus").

DIN EN 50160 does not specify limits for these measured values.

7.3.12 Transient Overvoltages
according to DIN EN 50160

Transient overvoltages at the supply terminals are generally caused by lightning (induced overvoltage) or by switching in the system.

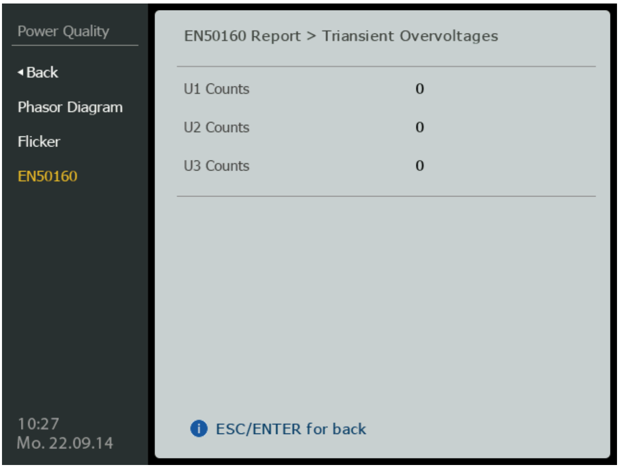


Fig. 7.23: Transient overvoltages

The display shows:

Display text	Description
Counts	Number of counts during the observation period.

When the transient measurement is activated, transients can trigger the following actions:

- Switching of outputs (digital outputs DO1…2, relay outputs RO1…4)
- Starting waveform recorders WFR1…2
- Sending alarm e-mails

These settings can only be carried out via the communication interface (see Annex "Modbus"). This also applies for the setting of limits for the transient measurement.

DIN EN 50160 does not specify limits for these measured values.

Note 1*: The rise time can cover a wide range from milliseconds down to much less than a microsecond. However, for physical reasons, transients of longer durations usually have much lower amplitudes. Therefore, the coincidence of a high amplitude and a long rise time is extremely unlikely.*

Note 2*: The energy content of a transient overvoltage varies considerably according to the origin. An induced overvoltage due to lightning generally has a higher amplitude but lower energy content than an overvoltage caused by switching, because of the generally longer duration of such switching overvoltages.*

Note 3: *For withstanding transient overvoltages in the vast majority of cases, LV installations and end user appliances are designed according to EN 60664-1. Where necessary (see IEC 60364-4-44) surge protective devices should be selected according to IEC 60364-5-53, to take account of the actual situations. This is assumed to cover also induced overvoltages due to both lightning and switching.*

8. Voltage

Overview of the voltages measured U_{LL} or U_{Ln} as well as the average voltage ØU (U_{avg}) from U1…U3 as a bar graph.

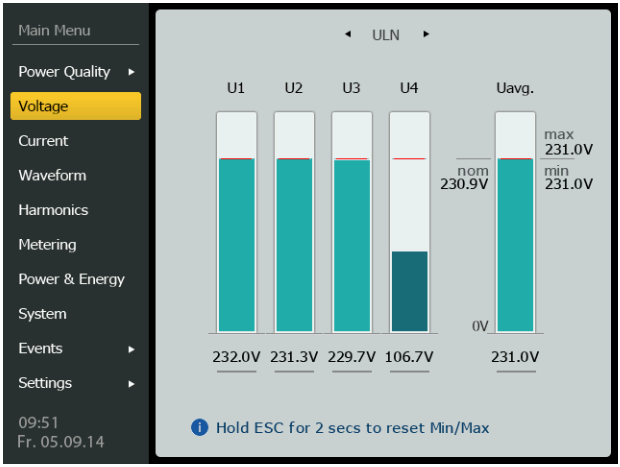


Fig. 8.1: Display "Voltage" (voltage measurement)

Use the < and > buttons to switch between the individual displays.

*To reset the **minimum and maximum values**, keep the "ESC" button pressed for at least two seconds.*

9. Current

Overview of measured and calculated currents $I_{0...4}$ as well as the average current ØI (I_{avg}) as a bar graph.

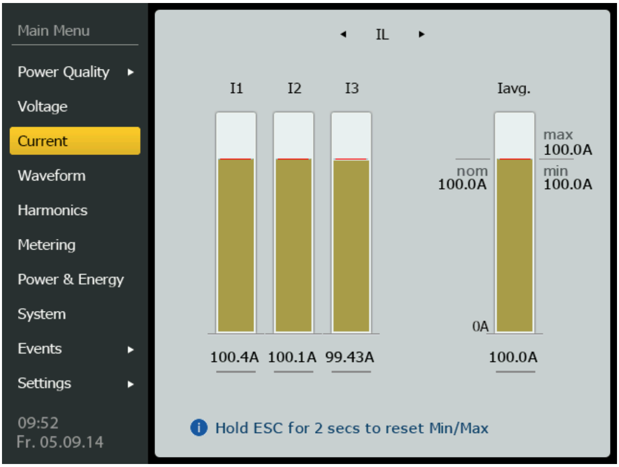


Fig. 9.1: Display "Current" (current measurement)

Use the < and > buttons navigate between the displays IL and I0/I4.

To reset the maximum value, keep the "ESC" button pressed for at least two seconds.

10. Waveform

In addition to the numeric values, the waveform recorder represents the waveforms of the measured voltages and currents on the display. Here, a comprehensive view of all voltages $U_{L1...3}$ and currents $I_{1...3}$ and the consideration of individual waves is possible.

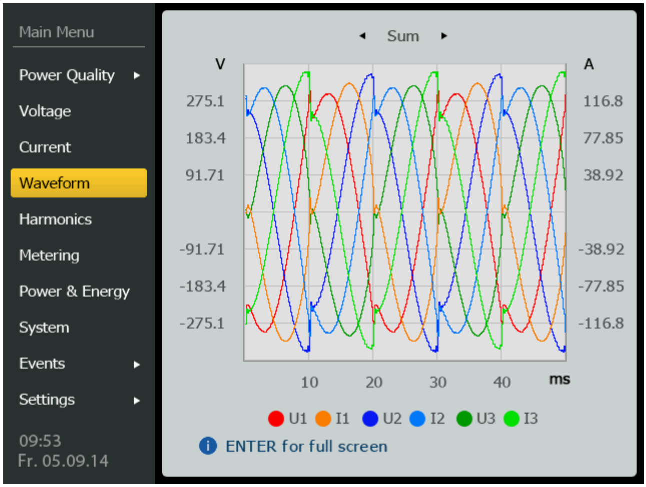


Fig. 10.1: Display "Waveform" (overall presentation)

Use the "ENTER" button to enable full screen display:

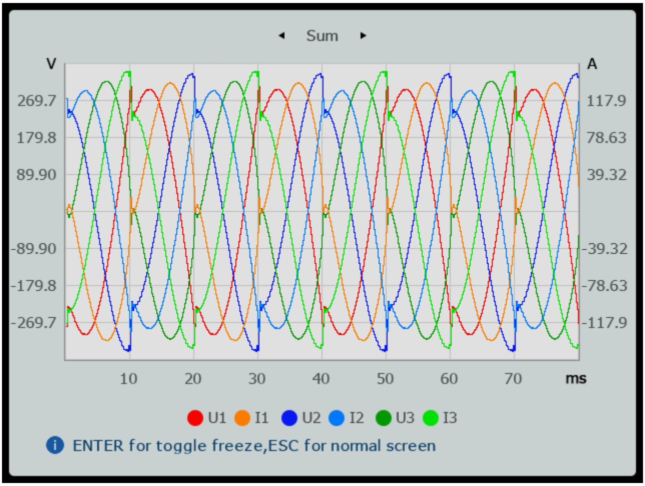


Fig. 10.2: Display "Waveform" (full screen display)

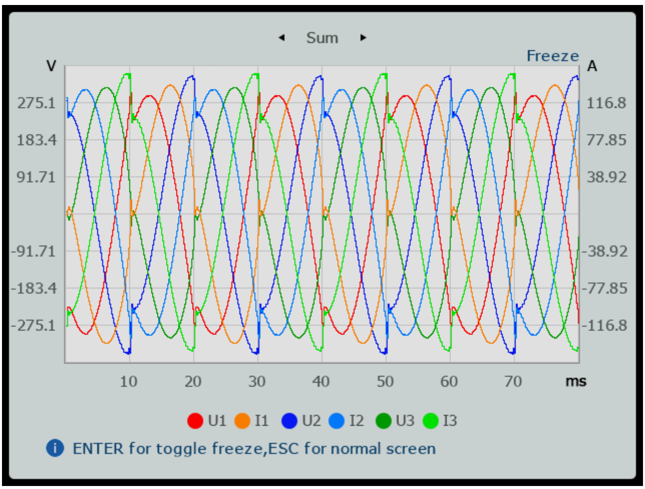


Fig. 10.3: Display "Waveform" (frozen)

In full screen mode the latest waves can be "frozen" using the "Enter" button so that you can analyse the graphs in more detail. By pressing the "Enter" button once more, the display will unfreeze and return to the full screen display mode.
Leave the frozen display mode and return directly to the standard mode by pressing the "ESC" button.

Display "Waveform" (Presentation of current and voltage of one phase)

11. Harmonics

Overview of the measured harmonics as bar graphs. Use the < and > buttons to navigate between the individual displays.

There are two possibilities to calculate the harmonic distortion. This setting can be carried out directly on the device.
Settings > Advanced > HD Calculation

% U_k/ U_{FUND}
"Fundamental"

THD calculation of an individual harmonic (related to the fundamental U_1 or I_1)

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

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

% of RMS
"Root Mean Square", r.m.s. value:

Harmonic distortion calculation of an individual harmonic (THF, related to the total value U_{ges} or I_{ges})

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

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

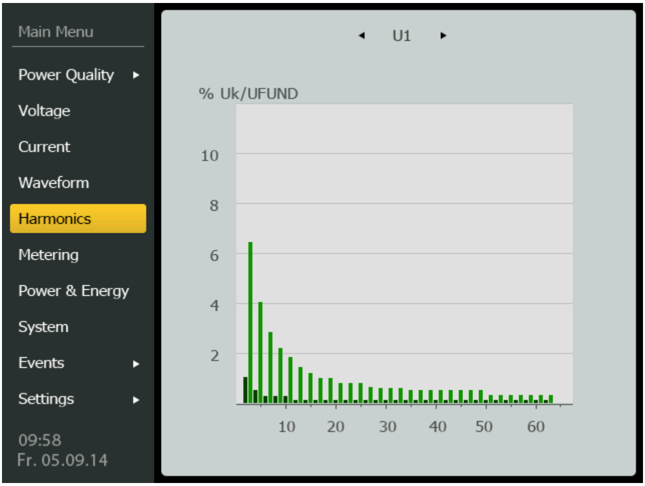


Fig. 11.1: Display "Harmonics" (voltages of one phase)

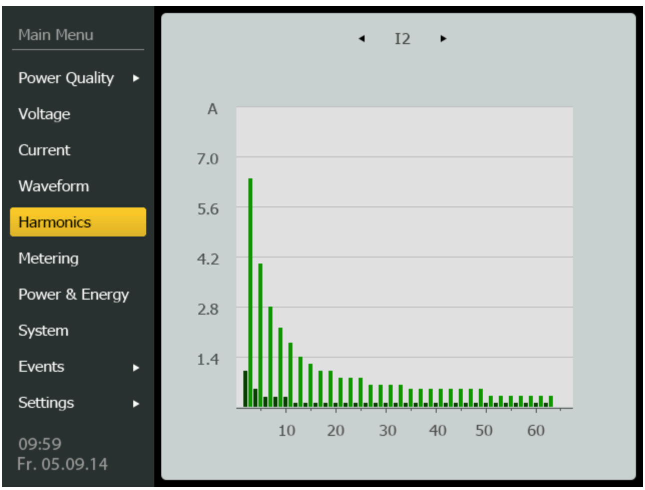


Fig. 11.2: Display „Harmonics“ (currents of one phase

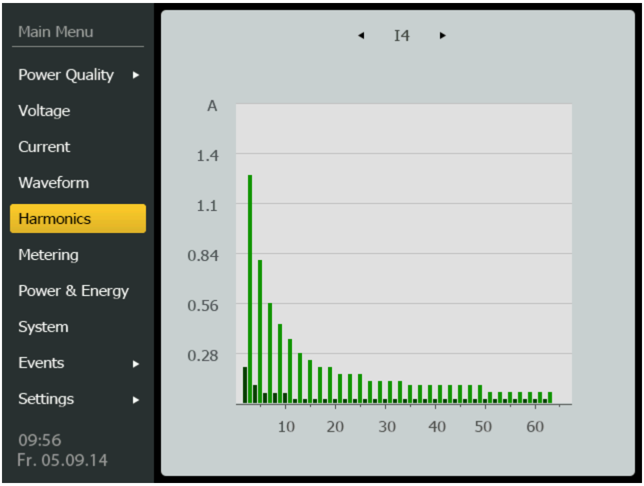


Fig. 11.3: Display „Harmonics" (currents I4)

Settings > Advanced: Harmonics Calc. Type Sub_Group a

Settings > Advanced > Current K^{th} Harmonic. Calc.: RMS or distortion
Settings > Advanced > Voltage K^{th} Harmonic. Calc.: RMS or distortion

When "RMS" is selected, the harmonics are displayed as r.m.s. values (V or A).
When "Distortion" is selected, the harmonics are indicated as a percentage based on the set "HD calculation", that means as a percentage related to the fundamental (% of FUND), or as a percentage related to the r.m.s. value of all harmonics (% of RMS).

Specify the number of harmonics that should be used to determine THD, TEHD and TOHD:
Settings > Advanced > THD Harmonic Bound: orders 2…63.

12. Metering

Measured values for voltages, currents, r.m.s. values and fundamentals in tabular form. Use the < and > buttons to navigate between the individual displays.

Display	Parameters	Measured values	Note
U	$U_{L1\ldots3}$	Actual, min, max	only shows r.m.s. voltages
	$U_{L1L2\ldots L3L1}$	Actual, min, max	
	F	Actual	
	U4	Actual	
I	$I_{1\ldots3}$	Actual, min, max	only shows r.m.s. current
	I_4	Actual, min, max	
	I_0	Actual, min, max	
RMS	$U_{L1\ldots3}$	Actual	shows a combination of RMS voltage, RMS current and power, incl. all harmonics
	$U_{L1L2\ldots L3L1}$	Actual	
	$I_{1\ldots3}$	Actual	
	P	for L1, L2, L3 and the total value	
	Q		
	S		
	λ		
Fundamental	$U_{L1\ldots3}$	Actual	shows a combination of RMS voltage, RMS current and power for fundamental only
	$U_{L1L2\ldots L3L1}$	Actual	
	$I_{1\ldots3}$	Actual	
	P	for L1, L2, L3 and the total value	
	Q		
	S		
	λ		

Tab. 12.1: Overview of measured values in the "Metering" menu

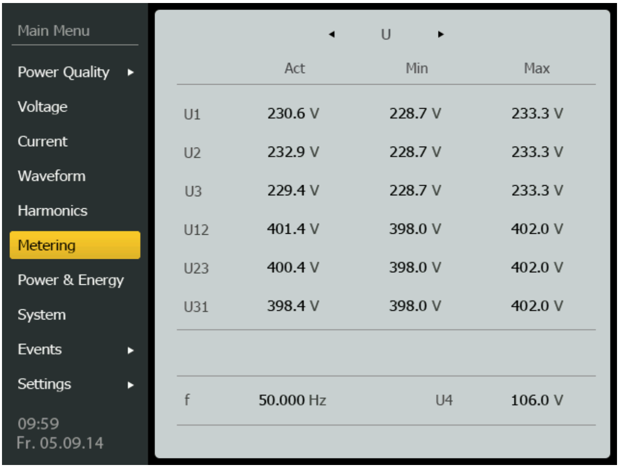


Fig. 12.1: Display „Metering“ (voltages)

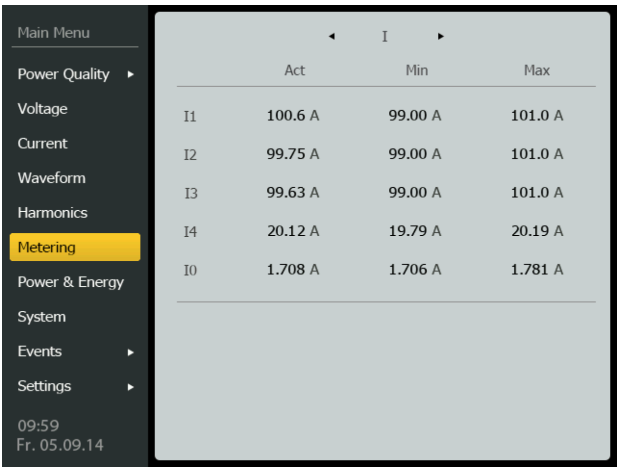


Fig. 12.2: Display: "Metering" (currents)

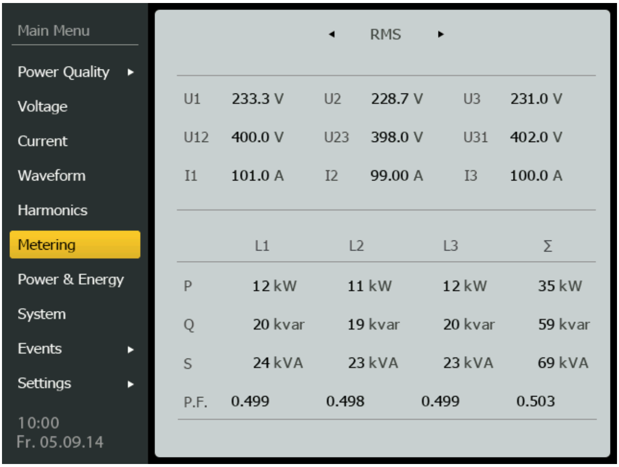


Fig. 12.3: Display: "Metering" (r.m.s. values)

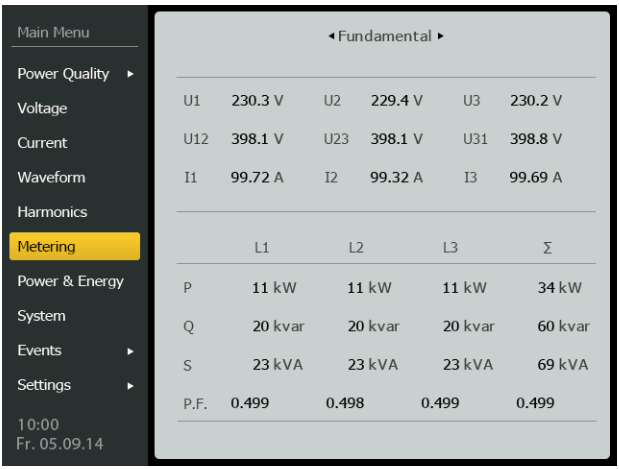


Fig. 12.4: Display "Metering" (fundamentals)

13. Power & Energy

Presentation of the active and reactive power as measured values and as vectors in the quadrants Q1…4. The power values are displayed either as total measurement (Sum) or for each individual conductor L1…3.

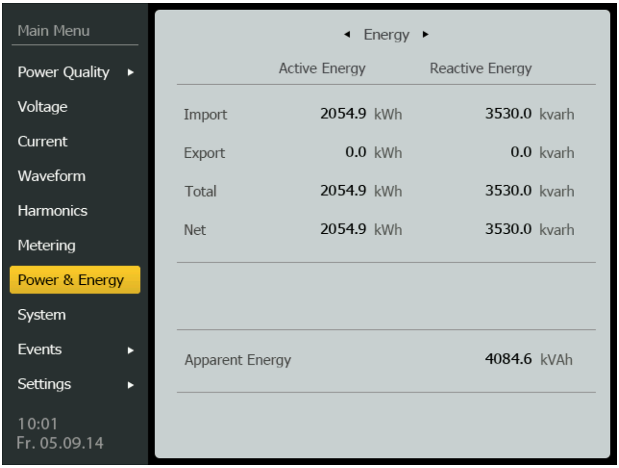


Fig. 13.1: Display: "Power & Energy"

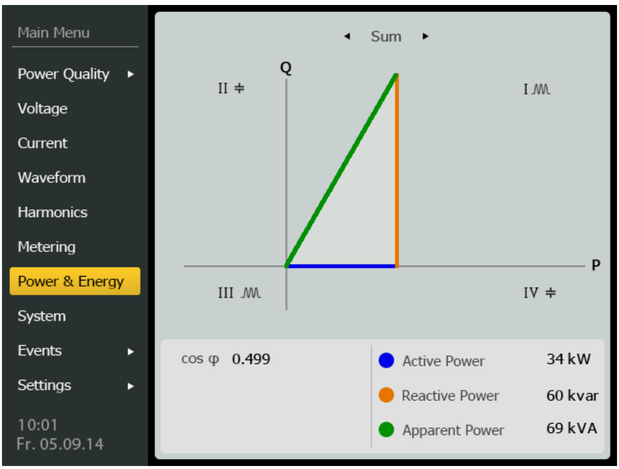
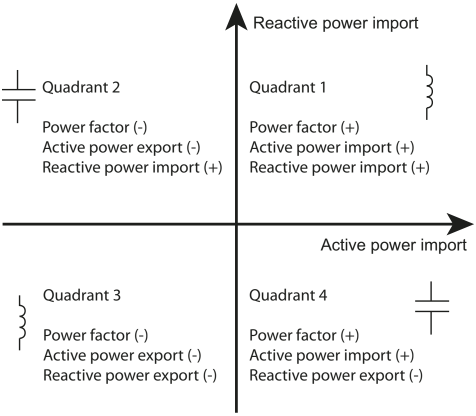
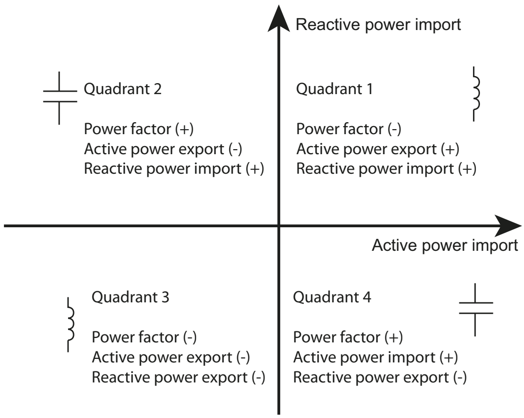


Fig. 13.2: Display: "Power & Energy" (phasor diagram)

Explanation of power factor λ rules:



IEC



IEEE

Fig. 13.3: Power factor λ rules

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

There are two ways of calculating the apparent power:

Vector method V:

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

Scalar method S:

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

Set the power factor ruler λ at the device: **Settings** > **Advanced** >**PF Convention**

14. System

PEM735 features 8 digital inputs, 2 digital outputs and 4 relay outputs. These are displayed directly on the device.

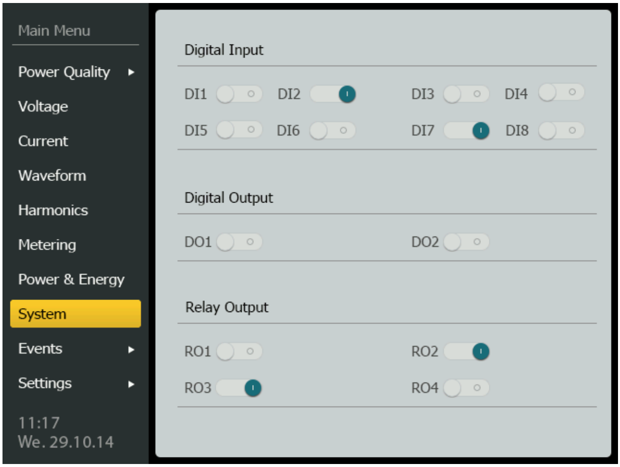


Fig. 14.1: Display "System"

Inputs

The device features eight digital inputs which are internally operated with DC 24 V. Digital inputs are normally used for **monitoring external statuses**. The switch statuses digital inputs can be read from the LC display or the connected system components. External status changes are stored as events in the SOE log with a resolution of 1 ms. One of the digital inputs can be programmed as a **pulse receiver for the synchronisation of the demand measurement**. The setting can be carried out via the registers.

Outputs

The device features 2 digital outputs and 4 relay outputs which are accessible from the back. The required functionality can only be set via the Modbus register (see Annex "Modbus").
At the device itself the connected inputs and outputs can only be indicated.

15. Events

Access to stored events of the SOE (Sequence Of Events) and the PQ (Power Quality) recorder.
In addition to the timestamp, an event description in clear text format and the associated value are displayed.

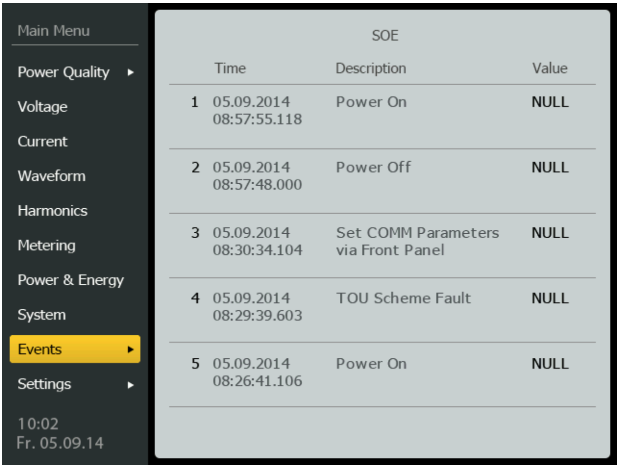


Fig. 15.1: Display "Events" (event log start page)

Press "ENTER" to go back a menu level.
You can use the ∧ and ∨ buttons to switch between the event and the PQ recorder.
You can navigate between the individual subpages using the < and > buttons .
Press the "ESC" button to return to the main menu.

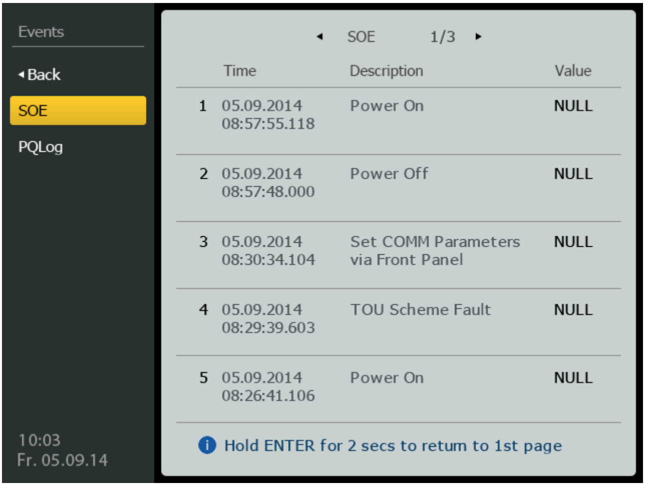


Fig. 15.2: Display "Events" (event log, page 1 of 3)

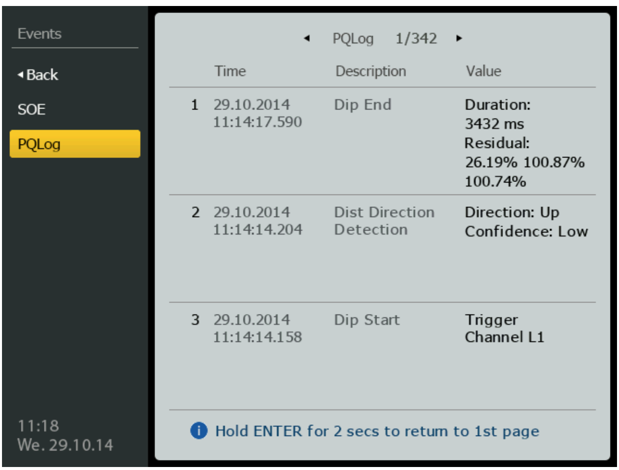


Fig. 15.3: Display "Events" (PQ log)

16. Settings

Here, general information about the universal measuring device is displayed. In addition, parameters for the device can be set here (password protected).

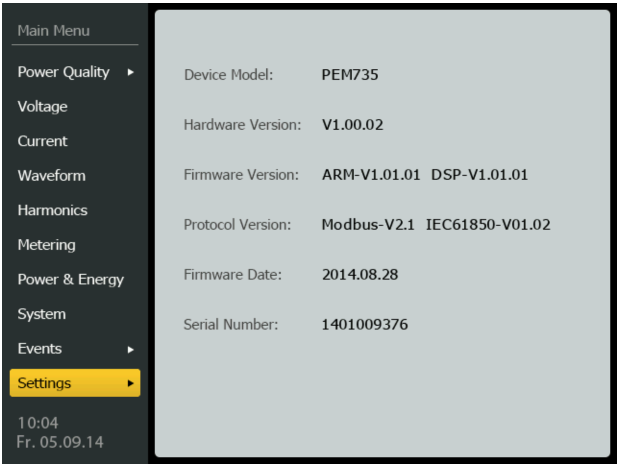


Fig. 16.1: Display "Settings"

Press "ENTER" to go to the "Settings" menu.
Use the ⋀ and ⋁ buttons to navigate between the individual items. For changing parameters, press the "Enter" button for password request.
After entering the correct password, you can go to the setting mode with the "Enter" button.
Press the "ESC" button to return from the submenus.

16.1 Info

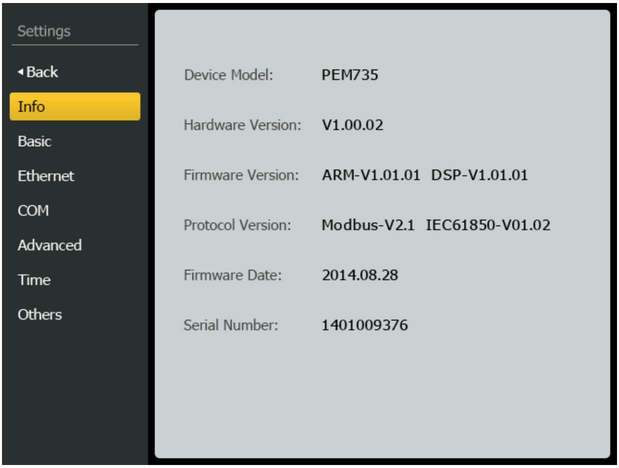


Fig. 16.2: Settings ("Info" view)

You cannot carry out settings in the Info view. This page is only for information purposes.

16.2 Basic

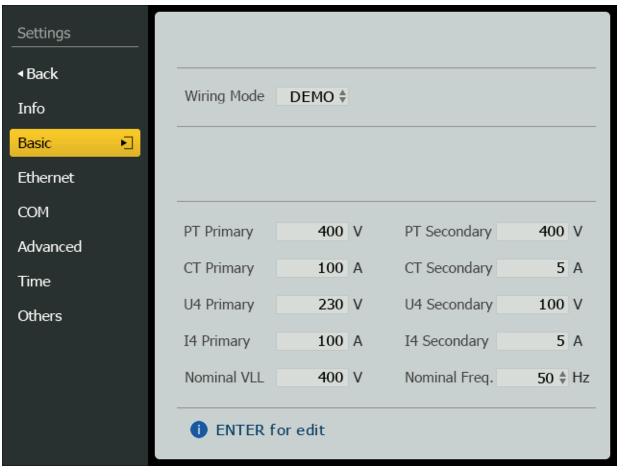


Fig. 16.3: Settings (menu item: "Basic")

Before changing the settings you have to enter the correct password (factory setting: 000000).

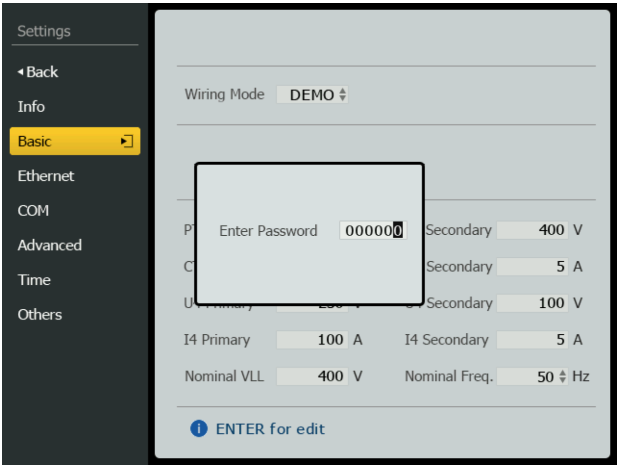


Fig. 16.4: Settings (password entry)

You can change the value of a digit using the ∧ and ∨ buttons.
Use the < and > buttons to navigate between the individual digits of the password
Confirm the password with the "Enter" button.

After successful password entry you can change the settings. The currently selected parameter is highlighted in black.

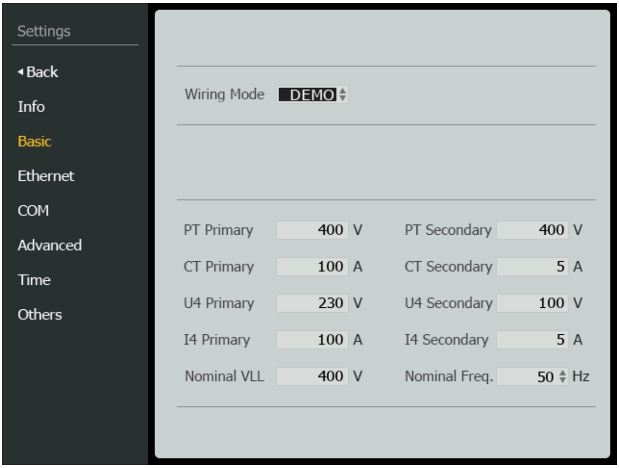


Fig. 16.5: Settings (selected parameter)

You can jump from one field to another using the arrow buttons.
To change the settings, you have to enter the currently selected field (highlighted in black) using the "Enter" button where you can adjust the values and selection possibilities with the arrow buttons.

16.2.1 Ethernet

In this menu you can specify the parameters for the Ethernet interface. You have to set the following parameters:

- IP address
- Subnet mask
- gateway

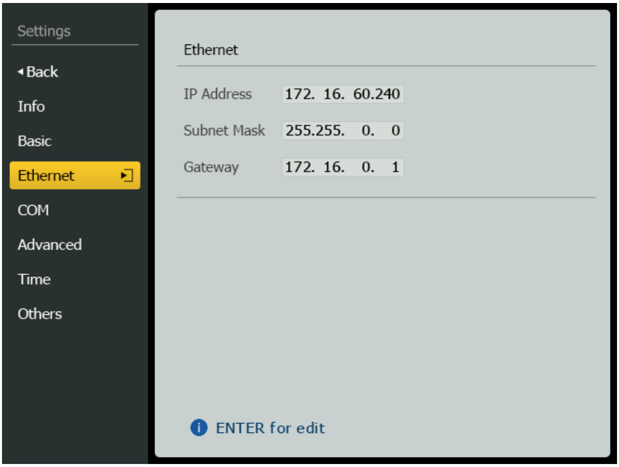


Fig. 16.6: Display "Settings" (Ethernet)

Press "ENTER" to enter the setting mode (after successful password entry).
Select the field to be edited (which is displayed on a black background) using the arrow buttons.
Activate the field with the "Enter" key. The field that can be edited is marked and can be set using the arrow buttons.

You can change the value of a digit using the ∧ and ∨ buttons.
Use the < and > buttons to navigate between the individual digits of an address
Complete the input with the "Enter" button. To exit the menu and save the settings you have to confirm the final query with "Enter". To discard the changes, press "ESC".

Fig. 16.7: Display "Settings"(Ethernet), change settings

16.2.2 COM (communication interface)

PEM735 features two communication interfaces the settings of which can be carried out directly at the device.

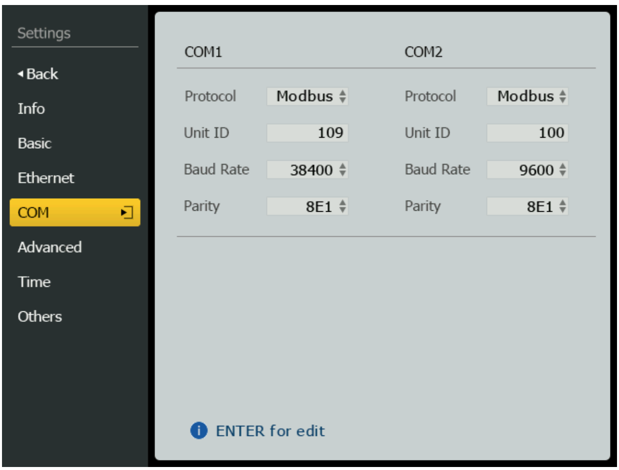


Fig. 16.8: Display "Settings" (COM)

The display shows:

Display text	Description
Protocol	COM1: Timing or Modbus COM2: Gateway or Modbus
Unit ID	
Baud rate	38400, 19200, 9600, 4800, 2400, 1200
Parity	Parity 8N1, 8E1, 8O1, 8N2, 8E2, 8O2

16.2.3 Advanced (advanced settings)

In advanced settings you determine the calculation method for the power factor λ and apparent power *S*, and the calculation settings for the harmonics.

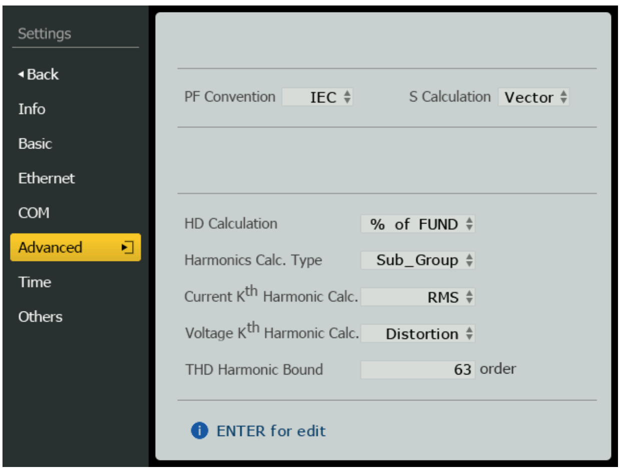
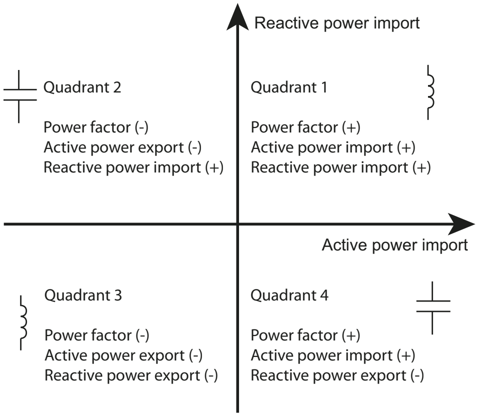


Fig. 16.9: Display "Settings" (Advanced)

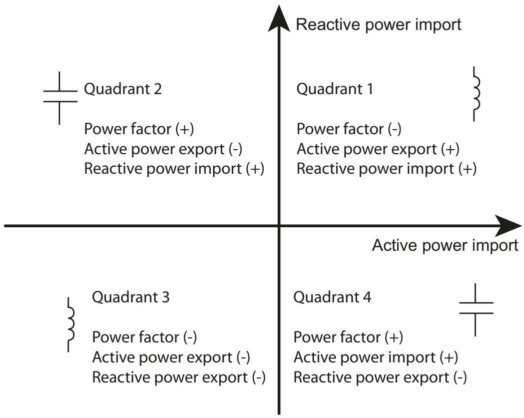
The display shows:

Display text	Description	Note
PF convention	Power factor λ	IEC, IEEE, -IEEE; see Fig. 13.3
S calculation	Calculation method apparent power	Vector or scalar
HD calculation	Value of the harmonic related to the fundamental or the r.m.s. value of all values (fundamental and fundamental)	% of FUND % of RMS
Harmonics calc. type		Group or Sub_Group
Current K^{th} Harmonic Calc.	Display of the harmonic in the diagram as RMS value or percentage (distortion).	RMS, Distortion
Voltage K^{th} Harmonic Calc.		RMS, Distortion
THD Harmonic Bound	Calculation of the THD value up to and including the specified harmonic	order2…63

Explanation of power factor λ rules:



IEC



IEEE

Fig. 16.10: Power factor λ rules

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

There are two ways of calculating the apparent power:

Vector method V:

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

Scalar method S:

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

Set the power factor ruler λ at the device: **Settings** > **Advanced** >**PF Convention**

16.2.4 Time (setting time and date)

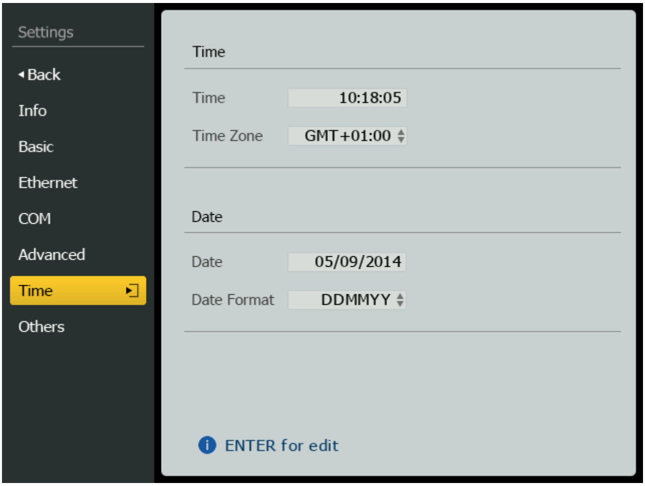


Fig. 16.11: Display "Settings" (time)

The display shows:

Display text	Description	Note
Time	Local time	Relate to GMT
Time zone	Time zone	Relative to GMT
DATE	Current date	
Date format	Date format	YYMMDD, DDMMYY, MMDDYY

Note: The clock is automatically set by a connected CP700.

16.2.5 Others

You can use this menu to set the display properties and the polarity for the measuring current transformers.

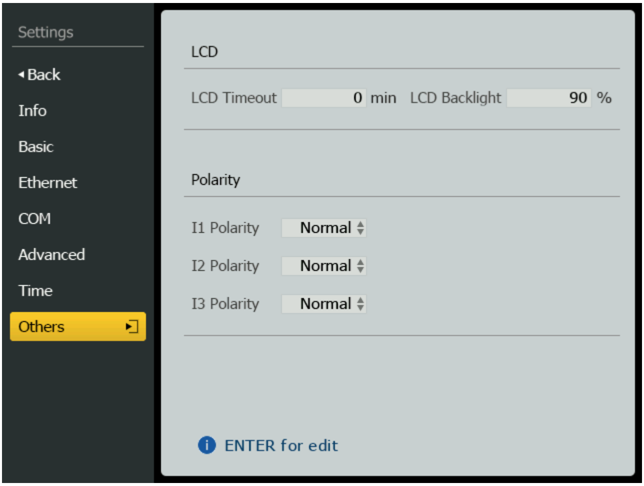


Fig. 16.12: Display "Settings" (Others)

The display shows:

Display text	Description	Note
LCD Timeout	To set the time after which the background lighting automatically switches off	0…60 minutes
LCD Backlight	Brightness of the screen	10…100 %
I1…3 polarity	Set the measuring current transformer polarity	Normal or reversed

Note: In the case of LCD timeout 0 min , the background lighting remains permanently lit (max 24 h).

17. Technical data

Insulation co-ordination

Measuring circuit

Rated insulation voltage .... 600 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 .... ≤ 14 VA

Measuring circuit

Measuring voltage inputs

$U_{L1-N,L2-N,L3-N}$ .... 400 V
$U_{L1-L2,L2-L3,L3-L1}$ .... 690 V
Measuring range .... 10 . . . 120 % U_N
CT transformation ratio
Primary .... 1 . . . 1,000,000 V
Secondary .... 100 . . . 690 V U_{LL} (1 . . . 3)
Secondary .... 1 . . . 400 V (U4)
Internal resistance (L-N) .... > 6 MΩ

Measuring current inputs

External measuring current transformers should at least comply with accuracy 0,2 S
Burden .... n.A., internal current transformers
Measuring range .... 0.1 . . . 120 % I_N
Transducer ratio, secondary .... 1 . . . 5 A
Transducer ratio, primary .... 1 . . . 30,000 A

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

Phase voltage U_{L1-N}, U_{L2-N}, U_{L3-N} .... ± 0.1 % v. M.
Current .... ±0.1 % v. M./+0.05% v.S .
Neutral current I_4 .... 0.5 % v. S.
Frequency .... ± 0.005 Hz
Phasing .... ± 1 °
Measurement of the active energy 0,2 S .... acc. to DIN EN 62053-22 (VDE 0418 Part 3-22)
Measurement of the voltage r.m.s. values .... acc. to DIN EN 61557-12 (VDE 0413-12), chapter 4.7.6
Measurement of the phase current r.m.s. values .... according to DIN EN 61557-12 (VDE 0413-12), chapter 4.7.5
Frequency measurement .... according to DIN EN 61557-12 (VDE 0413-12), chapt. 4.7.4
Measurement of the harmonics acc. to DIN EN 61000-4-7 class A

Interface

Interface/protocol .... 2 x RS-485, Modbus/RTU
Baud rate .... 1.2. . . 19.2 kbits / s
Cable length .... 0 . . . 1200 m
Cable shielded (shield connected to SH terminal on one side) .... recommended J-Y(St)Y min. 2x0.8
Interface .... Ethernet
Protocol .... Modbus/TCP
Baud rate .... 100 Mbit/s

Switching elements

2 electronic outputs (DO) .... max. 30 V
.... I_{max}: 50 mA
4 relay outputs (RO) .... 4 x 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 .... 8 galv. isolated 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-type terminals

Other

Degree of protection, installation IP20
Degree of protection, front IP52
Weight .... ≤ 2000 g

17.1 Standards and certifications

PEM735 was designed in accordance with the following standards:

DIN EN 50160

Merkmale der Spannung in öffentlichen Elektrizitätsversorgungsnetzen (Voltage characteristics of electricity supplied by public distribution networks)

DIN EN 61000-4-30 VDE 0847-4-30

Elektromagnetische Verträglichkeit (EMV)
Teil 4-30: Prüf- und Messverfahren – Verfahren zur Messung der Spannungsqualität (Electromagnetic compatibility (EMC): Part 4-30: Testing and measurement techniques - Power quality measurement methods) (IEC 61000-4-30)

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: Kombinierte geräte zur Messung und Überwachung des Betriebsverhaltens (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 devices (PMD)

DIN EN 62053-22 (VDE 0418 Teil 3-22)

Wechselstrom-Elektrizitätszähler - Besondere Anforderungen - Teil 22: Elektronische Wirkverbrauchszähler der Genauigkeitsklassen 0,2 S und 0,5 S (Electricity meter equipment (AC) - Particular requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S) (IEC 62053);

17.2 Ordering information

17.2.1 PEM

Type	Current input	Article number
PEM735 100…690 V, 50 Hz	5 A	B 9310 0735

17.2.2 Current transformers

Primary current	Accuracy	Secondary current	Type	Design	Art. No.
60	1	5	WL605 KL.1	CTB41	B 9808 6001
		1	WL601 KL.1	CTB41	B 9808 6002
75	1	5	WL755 KL.1	CTB41	B 9808 6003
		1	WL751 KL.1	CTB41	B 9808 6004
125	0,5	5	WL1255 KL.0,5	CTB41	B 9808 6005
		1	WL1251 KL.0,5	CTB41	B 9808 6006
	1	5	WL1255 KL.1	CTB41	B 9808 6007
		1	WL1251 KL.1	CTB41	B 9808 6008
150	0,5	5	WL1505 KL.0,5	CTB41	B 9808 6009
		1	WL1501 KL.0,5	CTB41	B 9808 6010
	1	5	WL1505 KL.1	CTB41	B 9808 6011
		1	WL1501 KL.1	CTB41	B 9808 6012

Primary current	Accuracy	Secondary current	Type	Design	Art. No.
200	0,5	5	WL2005 KL.0,5	CTB41	B 9808 6013
		1	WL2001 KL.0,5	CTB41	B 9808 6014
	1	5	WL2005 KL.1	CTB41	B 9808 6015
		1	WL2001 KL.1	CTB41	B 9808 6016
250	0,5	5	WL2505 KL.0,5	CTB41	B 9808 6017
		1	WL2501 KL.0,5	CTB41	B 9808 6018
	1	5	WL2505 KL.1	CTB41	B 9808 6019
		1	WL2501 KL.1	CTB41	B 9808 6020
300	0,5	5	WL3005 KL.0,5	CTB41	B 9808 6021
		1	WL3001 KL.0,5	CTB41	B 9808 6022
	1	5	WL3005 KL.1	CTB41	B 9808 6023
		1	WL3001 KL.1	CTB41	B 9808 6024
400	0,5	1	WL4001 KL.0,5	CTB41	B 9808 6025
	1	5	WL4005 KL.1	CTB41	B 9808 6026
	0,5	5	WL4005 KL.0,5	CTB41	B 9808 6027
	1	1	WL4001 KL.1	CTB41	B 9808 6028
500	1	5	WL5005 KL.1	CTB41	B 9808 6029
	0,5	5	WL5005 KL.0,5	CTB41	B 9808 6031
	1	1	WL5001 KL.1	CTB41	B 9808 6032
	0,5	1	WL5001 KL.0,5	CTB41	B 9808 6033

Primary current	Accuracy	Secondary current	Type	Design	Art. No.
600	1	5	WL6005 KL.1	CTB51	B 9808 6034
	0,5	5	WL6005 KL.0,5	CTB51	B 9808 6035
	1	1	WL6001 KL.1	CTB51	B 9808 6036
	0,5	1	WL6001 KL.0,5	CTB51	B 9808 6037
800	1	5	WL8005 KL.1	CTB51	B 9808 6038
	0,5	5	WL8005 KL.0,5	CTB51	B 9808 6039
	1	1	WL8001 KL.1	CTB51	B 9808 6040
	0,5	1	WL8001 KL.0,5	CTB51	B 9808 6041
1000	1	5	WL10005 KL.1	CTB51	B 9808 6042
	0,5	5	WL10005 KL.0,5	CTB51	B 9808 6043
	1	1	WL10001 KL.1	CTB51	B 9808 6044
	0,5	1	WL10001 KL.0,5	CTB51	B 9808 6045
50	3FS5	1	WLS501 KL3FS5	KBR18	B 9808 6046
100	3FS5	1	WLS1001 KL.3FS5	KBR18	B 9808 6047
150	3FS5	1	WLS1501 KL.3FS5	KBR18	B 9808 6048
250	3FS5	1	WLS2501 KL.3FS5	KBR32	B 9808 6049
500	3FS5	1	WLS5001 KL.1FS5	KBR32	B 9808 6050

18. Glossary and terms

Abbreviation Term	Long form/Description
COMM	Communication
DI	Digital Input (2.4 mA, DC 24 V)
Dip Threshold	Voltage magnitude specified for the purpose of detecting the start and end of a voltage dip
DMD	Present Demand
DO	Digitaler output (max. 50 mA, max. 80 V)
DR	Data Recorder
FIFO	First In First Out
Flagged data	Flagged measured values: Measurement results (measured or aggregated), which were flagged to indicate that the results may be influenced by interruptions, voltage swells or voltage dips.
Fund.	Fundamental
GB	Gigabyte
GPS	Global Positioning System
HDn	n^{th} order of harmonic distortion
Hn	n^{th} order harmonic, integer multiple (n) of the fundamental frequency (50 Hz or 60 Hz)
HS	High-speed
IHn	n^{th} order Interharmonic in RMS
Interharmonics	n^{th} order Interharmonic represents all components between the $(n-1)^{th}$ and n^{th} harmonic orders in RMS
LCD	Liquid crystal display

Abbreviation Term	Long form/Description
MB	Megabyte
P	Active Power (kW)
P95	Measured value of the 95th percentile (P95) during an observation period (95 % of the values are less than or equal to this measured value)
Percentile	Percentile rank divides the set of data into 100 equal parts.
P_{lt}	Long-term flicker (perceptibility unit long term), 2-hour value, cubic average value from 12 P_{st}
PPS	Pulses Per Second
PQ	Power Quality
P_{st}	Short-term flicker (perceptibility unit short term); 10-minute value
Q	Reactive Power (kvar)
r. m. s.	Root-mean-square value: Square root of the arithmetic mean of the squares of the instantaneous values of a quantity taken over a specified time interval and a specified bandwidth.
Ripple control signal	Mains signaling voltages on electrical low-voltage systems, called "ripple control signal", are a burst of signals, often applied at a non-harmonic frequency, that remotely control industrial equipment, revenue meters and other devices.
RO	Relay output
S	Apparent Power (kVA)
SOE	Sequence of events
Supply voltage unbalance	r.m.s. values of the line voltages (fundamental component) and/or the phase angles between consecutive line voltages, are not all equal. Apply only to three-phase systems.
Swell	Temporary increases in r.m.s. value of AC voltage

Abbreviation Term	Long form/Description
SYNC DI	Demand Sync Input (digital input demand synchronisation)
TEHD	Total Even Harmonic Distortion
THD	Total Harmonic Distortion
TOHD	Total Odd Harmonic Distortion
Transient	Unidirectional impulse of either polarity or a damped oscillatory wave with the first peak occurring in either polarity
U_0	Zero sequence component
u_0	Zero sequence component (ratio expressed as a percentage) $u_0 = (U_0/U_1) \times 100\ \%$
U_0 / I_0	Zero sequence component voltage/current
U_0 / I_0 Unb	Zero sequence voltage/current unbalance
U_1	Positive sequence component
U_1 / I_1	Positive sequence voltage/current
U_2	Negative sequence component
u_2	Negative sequence component ration expressed as a percentage $u_2 = (U_2/U_1) \times 100\ \%$
U2 / I2	Negative sequence component voltage/current
U2 / I2 Unb	Negative sequence component unbalance voltage/current
U_{din}	Declared input voltage; value obtained from the declared supply voltage by a transducer ratio.
unb	Unbalance

Abbreviation Term	Long form/Description
U_{res}	Residual voltage: Minimum value of $U_{rms(1/2)}$ {class A} recorded during a voltage dip or interruption; the residual voltage is expressed as a value in volts, or as a percentage or per unit value of the declared input voltage.
$U_{rms(1)}$	Value of the r.m.s. voltage measured over one cycle, refreshed each cycle.
$U_{rms(1/2)}$	Half-cycle r.m.s. voltage: Value of the r.m.s. voltage refreshed each half-cycle (r.m.s. value measured over one cycle, commencing at a fundamental zero crossing).
U_{sr}	Sliding reference voltage. In principle, not used in low-voltage systems.
Voltage dip	Temporary reduction of the voltage magnitude at a point in the electrical system below a threshold; voltage interruptions are a special case of a voltage dip.
Voltage interruption (polyphase system)	Begins when the U_{rms} voltage on all measured channels falls below the voltage interruption swell threshold; ends when the U_{rms} voltag on any one channel is equal to, or greater than, the interruption threshold plus the hysteresis. Typically, the swell threshold value for voltage interruptions is 5 % or 10 % of U_{din}; typically, the hysteresis is equal to 2 % of U_{din}.
Voltage interruption (single-phase system)	Begins when the U_{rms} voltage falls below the voltage interruption threshold; ends when the U_{rms} voltage is equal to or greater than the voltage interruption threshold plus the hysteresis. Typically, the swell threshold for voltage interruptions is 5 % or 10 % of U_{din}; typically, the hysteresis is equal to 2 % of U_{din}.
Voltage swell (polyphase system)	Begins when the U_{rms} voltage of at least one channel is above the swell threshold; ends when the U_{rms} voltage on all measured channels is equal to or below the swell threshold minus the hysteresis voltage. Typically, the swell threshold is > 110 % of U_{din}; typically, the hysteresis is equal to 2 % of U_{din} .

Abbreviation Term	Long form/Description
Voltage swell (single-phase system)	Begins when the U_{rms} voltage rises above the swell threshold; ends when the U_{rms} voltage is equal to or below the swell threshold minus the hysteresis voltage. Typically, the swell threshold is > 110 % of U_{din}; typically, the hysteresis is equal to 2 % of U_{din} .
WF	Waveform
WFR	Waveform recorder

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