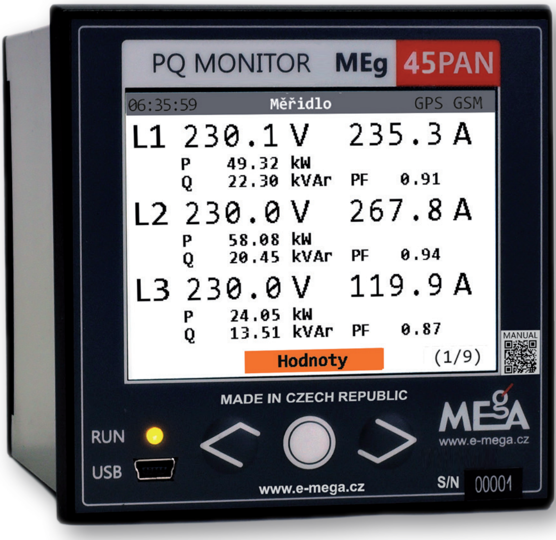
MEg45PAN Universal Monitor

User manual



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MEg45PAN Universal Monitor

1/ INTRODUCTION

The MEg45PAN panel universal monitor is designed for measuring at the LV level with a remote communication option.

It measures three voltages and three currents. It has four two-stage inputs and a relay output. It transmits measured data and evaluated conditions safely via ETH interface and GSM network even during a short power supply failure of all three phases. It features GPS time synchronization.

It directly measures and displays the measured quantities and functions as a recorder, electric meter and voltage quality analyser simultaneously without interruptions and gaps. The MEg45PAN monitor can also be used for oscillographic recording of all measured AC voltages and currents.

For remote transfer of measured data and measurement parametrization, it has an RS485 and ETH interface. It optionally includes a GSM network communication module and a GPS time synchronisation module for 1 ms time synchronisation.

It measures parameters of voltage and current quality by means of Class A methods with the A or S class accuracy. It provides statistical evaluation of all voltage quality parameters stipulated by the standard EN 61000-4-30, ed.3, including the harmonics and inter-harmonics up to the order of 125 and rapid voltage fluctuations. It records their timing in individual phases.

It measures energy in four quadrants and records three-phase and single-phase measurements using six-register time series, allowing subsequent evaluation over any selected time interval. It also measures phase active energy (supply, consumption) during rapid changes in the directions of the energy flows.

In the recording function, the monitor measures and processes all measured quantities, evaluates powers, energies and harmonics up to the order of 64.

When recording voltage phenomena and events on currents, the monitor, aside from recording the course of $U_{RMS1/2}$ and $I_{RMS1/2}$, also makes oscillographic records of all simultaneously measured voltages and currents, for voltages and for currents up to twice the rated value with pre-trigger.

It has protection functions for identification of over-voltage, under-voltage, voltage and current unbalance, reverse current flow signalling and MV fuse blow.

The voltage measuring inputs are designed for direct measurement of three-phase voltages at the LV level even in CAT IV 300 V environments.

The current inputs are designed for indirect measurements only. The MEg45PAN has two standard current input versions. The first standard version features electronically switched current inputs with ranges of 5A and 1 A for instrument current transformers and split-core transformers MTPD.51 or flexible sensors AMOS/1A. The second standard version allows, according to EN 61 869-6, the connection of low-power current sensors LPCT, TORv and TORm toroids with voltages of 225 mV or 150 mV or 22.5 mV.

A special version allows the direct connection of flexible AMOSm sensors.

The MEg45PAN universal monitor has four galvanically isolated two-stage inputs and a controlled output switching contact relay.

The USB interface is intended for local communication. The RS485 interface, ETH interface and the integrated GSM module allow remote data transfer, remote parametrization of the measurement, on-line reading of the measured data and updating of the control program of the processor‘s measurement core. The remote data transmission via the ETH interface and GSM network can be secured by IKEv2/IPsec, L2TP/IPsec or other cryptographic protocols available in the LINUX operating system.

AES-256 encrypted measurement data can be transferred from the instrument using an authorized flash drive. This can also be used to transfer the uniform parametrisation values of the measuring campaign and update the measuring FW.

All three voltage inputs of the MEg45PAN monitor have an overvoltage category of CAT IV 300 V. It can also be powered with an auxiliary DC supply voltage in the range of 10 to 30 V. The power supply of MEg45PAN contains supercapacitors that provide uninterrupted measurement and remote communication even in the case of short power outages with a total duration of up to 30 s.

2/ SW INFORMATION

Local (USB) and remote (IP address) parametrization of the measurements, which includes specifying the recording interval, current transformer conversions and specification of the measured quantities, initiating the measurements and reading the measured data from the MEg45PAN monitor, is handled by the program **PQ_MEg** [1].

The program **DV_MEg** [2] displays the measured data in graphical and tabular form. This program always works with one file.

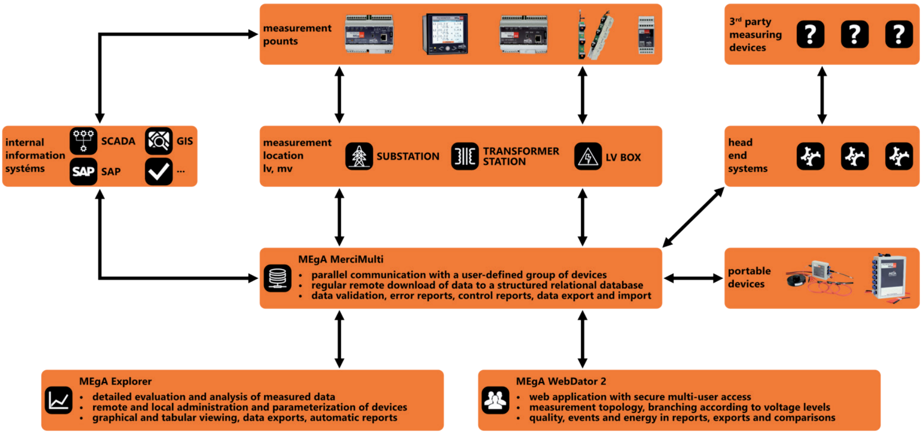
The program **MEgA_Explorer** [3] allows the display and detailed analysis of data from the local SQLite database. It is a Windows application installed on a PC or server. It is mainly focused on the detailed analysis of data from measurement, but also supports selected bulk functions (e.g. measurement reports).

The web application **WebDator2** [4] allows multiple access for data display. It is mainly focused on large groups of instruments, for overview and informative evaluations and summary analyses. The application works over a PostgreSQL or Oracle database.

Continuous remote automatic data reading of one, but especially multiple instruments available on the network, including monitoring of input states is performed by the **MEgA Merci Multi system** [5], which works as a Windows OS service on the server. Periodic data reading is performed at a set interval, usually daily. The system reads newly measured data since the previous reading. The read data is stored in a SQLite, PostgreSQL or ORACLE database. The program also performs automatic exports in CSV format and reports on voltage quality in the form of emails. The program can be used to remotely update the DSP processor core FW after checking the transfer.

With the exception of the WebDatOr2 program, the mentioned programs, including their manuals, are available at http://www.e-mega.cz/DL/.

The MEg45PAN PQ monitor also enables work with third-party SW through the MODBUS RTU (RS-485), MODBUS TCP (Ethernet), ČSN EN 60870-5-104 and DLMS/COSEM protocols. It is possible to set up automatic sending of measured values via the ČSN EN 60870-5-104 protocol according to deviation criteria or at regular intervals. For presentation in other systems, CSV formats can be used, which can be customized. The instrument has web interfaces that allow displaying actual values of selected variables in a web browser.



3/ DESCRIPTION OF THE INSTRUMENT

3.1 Design

The MEg45PAN monitor shown in Figure 1 is designed for fixed mounting in a square panel hole or in a special U-shaped section on the panel. It is housed in a non-flammable black plastic housing measuring 90 × 90 × 90 mm, which has a 96 × 96 mm frame of 6 mm height on the front. For fixing the monitor to a 1–2 mm thick panel, there are two white profiled cams inserted in a pivoted manner in the holes in the upper and lower side of the monitor case. The frame contains a panel with film covering a backlit colour LCD display with 320 × 240 pixels and the displaying area of 72 × 55 mm. Three centred buttons under the display serve to control the display. With an exception of the function of reverse current flow indication, the two outermost buttons are directional and are used to scroll the displayed pages or functions right and down or left and up. The middle button allows you to navigate to the main page and select functions. The **RUN** LED on the front panel displays the operating condition of the instrument by intermittent lighting. When the **RUN** diode is on or off permanently, it signalizes an error state or the state without power supply. The USB Mini B connector accessible from the front is designed for local parametrization of measurements and for loading of measured data by a computer. The local parametrization and data loading can also be done using a flash disc, where measured data are saved in the CSV format. On the front panel is the serial number of the instrument and a QR code with a link to the user information of the instrument.

The rear panel in Figure 2 contains, in addition to the manufacturer's logo, the rated values of the current and voltage inputs and other legal information. It includes current double terminals **I1**, **I2** and **I3** with input contacts **S1(k)** and output contacts **S2(l)**, voltage terminals **U1**, **U2**, **U3** and **Nm**, a hf ground terminal ⏚ and **–** and **+** terminals of the auxiliary DC power supply. The terminals have a pitch of 6.35 mm and have clamps with cross-slotted M3 screws. They enable connecting ropes up to the cross-section of 4 mm^2 and wires up to the cross-section of 6 mm^2. There are also **GPS** and **GSM** antenna connectors on the rear panel and a row of vertically positioned **RS485** interface connectors, four **IN** input signals and an **OUT** relay contact below which is a slot for a SIM card and an RJ45 **ETH** connector. The three-pole RS485 serial interface connector has contacts **A**, **B** and **G1**. The five-pole IN connector has four two-stage input signals **1**, **2**, **3**, **4** and a common contact **G**. On the two-pole OUT connector are pins **21** and **22** of a relay switching contact whose function is controlled by the processor.

The two-stage inputs of the monitor are used to record one- and two-bit values from the operation of the transformer station into the monitor memory with the subsequent possibility of remote transmission. The relay switching contact enables control of the external circuit according to the evaluation of measured quantities outside the tolerance according to the evaluation of protection functions or remote communication.

Figure 1: Design of the MEg45PAN universal monitor

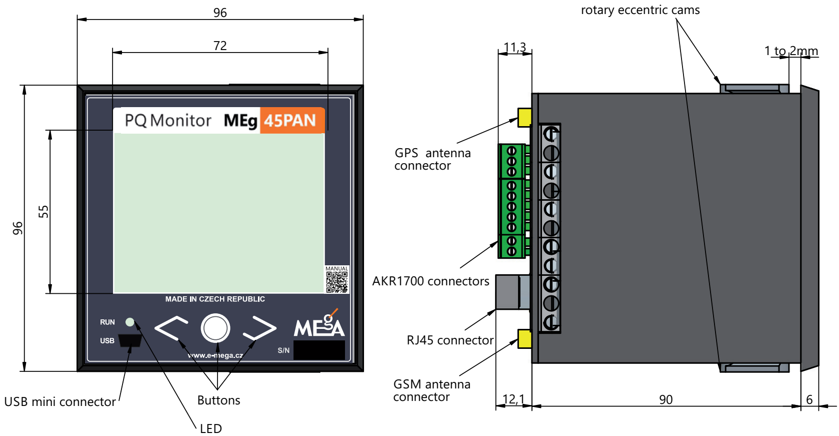
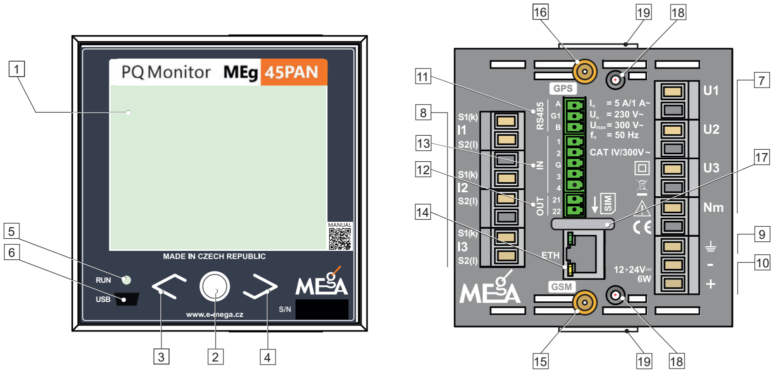


Figure 2: Design elements of the MEg45PAN monitor



There are three variants of monitor current inputs.

The first standard version has electronic switching of the rated current of 5 A or 1 A for MTPD.51 solid or split-core transformers or flexible AMOS/1A sensors with a converter to 1 A.

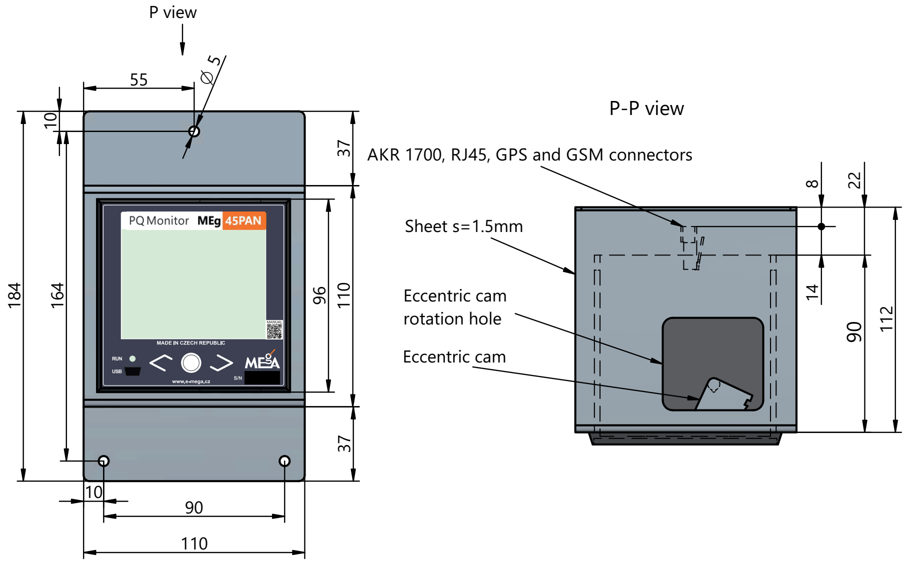
The second standard variant with either 225 mV, 150 mV or 22.5 mV is for LCT split-core power transformers with hole diameters for a 10 to 36 mm wire or for external TORm toroids with a rated current flowing through the toroid of 1 A or 5 A or TORv with a rated current of 10 A or 50 A.

The current inputs of the special third variant of the MEg45PAN monitor can be directly connected to AMOSm flexible sensors with a rated current of 30 A / 100 A / 300 A / 1000 A

/3000 A/5000 A and a length of the sensing part according to order 200 mm, 400 mm or 600 mm. Such a measuring set is calibrated together, and the flexible sensors therefore have a serial number identical to the serial number of the monitor.

Also, the rear panel of the MEg45PAN monitor is provided with information on the rated value of measured phase voltage of 230 V_{ef} with the maximum value of phase voltage of 300 V_{ef} applicable to CAT environment and the rated frequency value. For three-phase measurement, the phase voltage of phase L1 is to be connected to input **U1** according to the voltage quality standard. For single-phase measurement, measured voltage must always be connected to the **U1** input.

Figure 3: Shaped U-profile for fixing of the universal MEg45PAN monitor on the wall or panel of a cabinet



The MEg45PAN universal monitor has three-phase AC supply from measuring inputs, and a single-phase voltage is sufficient to supply power. It is provided with auxiliary power supply terminals, marked + and – on the rear panel, for connecting backed-up supply voltage with the rated value of 12 V_{DC} to 24 V_{DC}.

It can be mounted on a panel in LV cabinet using a shaped U-profile, made of 1.5 mm thick metal plate according to Figure 3, which is attached to a free surface using three ST4.8×13 (DIN7981) self-tapping screws. The monitor is attached to the U-profile by turning the two cams fitted in the openings in the upper and lower side of the monitor case.

Tab. 1: Description of MEg45PAN elements

Item	Group name	Description
1	Display	Backlit colour LCD display with 320 × 240 pixels and the displaying area of 72 × 55 mm
2	Middle button	It allows you to navigate to the main page and select functions
3	Left button	It scrolls the display to the left or top
4	Right button	It scrolls the display to the right or bottom
5	RUN LED	• Once briefly interrupted illumination; the monitor measures according to the programmed parametrisation • Twice briefly interrupted illumination; recording of one or more measurement functions is either not programmed or data is not stored due to exhaustion of dedicated memory • Repeated short flashing; the monitor is malfunctioning or is programmed, it does not measure yet. It is not the default measurement start time yet or the monitor has not been powered at the time of delayed start • Slow alternating illumination; oscillographic record. • Rapid flashing; power failure, the instrument measures and is powered by the internal uninterruptible power supply, • Briefly lit after activation; indicates the progress of internal tests • Continuously on; indication of a fault condition • Continuously off; indication of a fault or deactivated power supply
6	USB 2.0 interface	Mini USB connector for local data transfer
7	Voltage inputs	Terminals U1, U2, U3 for direct voltage connection of phases L1, L2, L3 and neutral conductor PEN to Nm terminal
8	Current inputs	Double terminals I1, I2, I3 for connecting secondary currents or voltages of current transformers or current sensors installed on phases L1, L2, L3. Terminals labelled S1(k) are input, S2(l) are output. Terminals S1(k) of the first standard design are connected to PE, PEN. Terminals S1(k) of the second standard design are connected to the common conductor G of the monitor.

Item	Group name	Description
9	RF grounding	The terminal ⏚ connects to the PEN conductor or to PE ground
10	Auxiliary power supply	Terminals for connecting auxiliary DC supply voltage with a rated value of 12 – 24 V
11	RS485 interface	Terminals for connecting the galvanically isolated RS485 data interface, where terminals A and B are communication terminals and the cable shielding connects to the G1 terminal
12	Output OUT	OUT terminals of the switching contact of the output bistable relay
13	Input IN	Terminals of the four two-stage inputs IN with the common terminal G
14	ETH interface	RJ45 connector for ETHERNET 100Base-Tx interface for remote data transfer. A wiring example is shown in Figure 31. Meaning of LED indicators: • green LINK; LED indicates the speed of the data line on 100 Mbit/s; off 10 Mbit/s • Orange ACTIVITY; LED indicates data transfer by lighting
15	GSM antenna	Connector for connecting a GSM antenna
16	GPS antenna	Connector for connecting a GPS antenna
17	SIM card	SIM card goes into the indicated slot
18	Screws	Screws fastening the rear panel
19	Cams	Cams in the profiled housing hole for attaching the monitor to a LV cabinet panel

3.2 Functions of the monitor

The MEg45PAN universal monitor is a class A or S instrument whose measurement methods meet the requirements of class A according to EN 61000-4-30, ed. 3. The measurement methods and uncertainties of the measured quantities are tested according to EN 62586-2 and the effects of operating conditions according to the procedures specified in EN 62586-1. It measures voltage quality parameters without any interruptions or gaps. The device measures all voltage and current phenomena that have occurred at a measured point during measurement and performs statistical evaluations, including evaluations of extreme values of all measured variables. It measures signal size and records HDO telegrams. It measures energy in all four quadrants. It has protection functions for identifying undervoltage, overvoltage, voltage and current unbalance, a blown HV fuse and directional protection.

For voltage phenomena, events on currents and changes at the two-stage input, it records the courses of RMS½ effective values and oscillographic time courses, both with pre-trigger. The MEg45PAN monitor has four two-stage inputs with internal supply voltage enabling also external power supply and a switching contact of a relay, the second contact of which is controlled by the processor.

The MEg45PAN universal monitor can be set for the function of recording oscilloscope, in which it records measured voltage and current values for a defined period. During oscillographic recording of details and the recording oscilloscope function, three measured voltages and three measured currents are sampled simultaneously with a rate of 256 samples per period. The oscillographic recording uses a pre-trigger of up to 20 periods before the event initialization. Also the number of periods, i.e. the length of the oscillographic record, is SW-adjustable and depends on the extent of allocated memory space. Initiation of the recording can be derived from exceeding the specified limits by any of the six mentioned variables or from the change of the state of the input two-stage signal. The use of automatic remote transmission of measured data can minimise the requirements for memory space in the monitor.

The record of courses of all six measured quantities in the form of RMS½ defined by the voltage quality standard has an adjustable pre-trigger of up to 2 seconds and the possibility of recording up to 400 events with a duration of 300 s.

Currently, the instrument supports the MODBUS RTU protocol at the RS485 interface and the MODBUS TCP and P104 protocols at the Ethernet and GSM interface (according to IEC 60870-5-104). Both protocols can be used to set the device, download data and update the firmware of measuring functions. Measured data are saved in CSV files. The DLMS/COSEM protocol is implemented for data loading. Time synchronization is enabled using the NTP protocol.

To synchronize the function of multiple monitors, the positive zero-crossing of the first phase fundamental harmonic voltage can be used.

The MEg45PAN universal PQ monitor allows secure data transmission, e.g. via IKEv2/IPsec and L2TP/IPsec protocols. The SSH protocol can be used to connect for management of the Linux Debian system, running on the ARM core of the processor and enabling the implementation of advanced communication and other superstructure functions.

3.2.1 Measuring functions

The scope of measured variables depends on the measurement connection and measurement parametrisation. Measured data can be divided into data of continuous phenomena of voltage quality, data of rapid voltage changes, data during one-off voltage phenomena and events related to currents, recorder data, electric meter function data, data from measurements of active energy during rapid changes of flow direction and data of HDO signals. Measurement methods are specified in ČSN EN 61000-4-30, ed.3.

Data of continuous phenomena of three-phase voltage quality at the terminal for an aggregation interval (10 min):

- Number of frequency values in the range of ±1 % f_n and in the range of +4 % to -6 % f_n
- Number of frequency values out of the range of ±1 % f_n and out of the range of +4 % to -6 % f_n
- Frequency f – average, minimum, maximum
- Unbalance of voltage u2 and current i2
- Zero-sequence imbalance of voltage u0 and current i0

Data of continuous phenomena of phase voltage and current quality for each aggregation interval (10 min):

- Voltage – average, minimum, maximum in time and frequency domain
- Current – average, minimum, maximum in time and frequency domain
- Voltage fluctuations U_{over}, U_{under}
- Flicker P_{st} and P_{lt}
- THD_U voltage harmonic distortion factor
- Direct current component U_{DC}
- Fundamental to 125th harmonic of voltage with a proportion of adjacent interharmonics
- Centred subgroups of interharmonic voltages up to the order of 125.
- Fundamental to 125th harmonic of current with a proportion of adjacent interharmonics
- Centred subgroups of interharmonic currents up to the order of 125.
- Voltage of signals in network voltage (HDO) – average, maximum
- Number of 3 s intervals for voltage evaluation of signals in network voltage
- Number of 3 s voltage values of signal in network voltage above set limit.

Data of rapid voltage changes – RVC:

- Start time of rapid voltage change
- Duration of rapid voltage change in ms
- Average voltage in balanced state before RVC
- Average voltage in balanced state after RVC
- Maximum absolute difference between $U_{RMS1/2}$ during RVC and balanced voltage before RVC
- Maximum absolute difference of ten-period voltage U_{RMS10} at RVC and balanced voltage before RVC
- Courses of voltage $U_{RMS1/2}$ and current $I_{RMS1/2}$ at RVC with time data
- Oscillograms of courses of voltage and current during RVC with time data

Description of the *RVC (rapid voltage change)* parameter:

The instrument records rapid voltage changes according to IEC 61000-4-30 ed. 3. The algorithm is based on sliding measurement of 100 values of $U_{RMS1/2}$ in each phase. When parametrizing the device, the user defines a threshold value of voltage $U_{RMS1/2}$ change for starting recording and a size of hysteresis after the rapid change and return to the balanced state. Rapid changes are characterized by the time of beginning, the duration, the difference in voltage between balanced states before a rapid change and after it (ΔUss) and the maximum difference between voltage $U_{RMS1/2}$ during a rapid change and balanced state voltage before the start of a rapid change (ΔU_{max}).

A record of rapid changes can be extended in user SW by a record of the entire course of $U_{RMS1/2}$ values. When the limits of voltage phenomena (0.9 U_n and 1.1 U_n) are exceeded, the rapid voltage change recording is cancelled and the event is evaluated and stored as a voltage phenomenon.

Data during one-time voltage and current phenomena:

- Time of phenomenon occurrence
- Phenomenon duration
- Moments when the limits for interruption, dip and swell of voltage and current are exceeded
- Residual and maximum values of voltage, maximum values of current
- Courses of voltage $U_{RMS1/2}$ and currents $I_{RMS1/2}$
- Oscillogram of the courses of voltage and current during a one-time phenomenon
- Harmonic voltage and current values during a one-time phenomenon

Recorder data for each aggregation interval and phase (from 2 s to 15 min, according to the parametrisation).

Phase:

- Voltage U_{ef}, – average, minimum, maximum
- THD_U voltage harmonic distortion factor
- Direct-current component of voltage U_{DC},
- Harmonic components of voltage U_{Hn} of order n from 1st to 64th,
- Currents I_{ef}, – average, maximum
- THD_I current harmonic distortion factor
- Current harmonics I_{Hn} of order from 1st to 64th,
- Active power – average, minimum, maximum
- Reactive power – average, minimum, maximum
- Apparent power – average, minimum, maximum
- Deformation power – average, minimum, maximum
- Power factor PF and cos φ
- Active power 1stH – average, minimum, maximum
- Reactive power 1stH – average, minimum, maximum
- Apparent power 1stH – average, minimum, maximum
- Active and reactive energy E_{P+}, E_{P-}, $E_{QC/P+}$, $E_{QL/P+}$, $E_{QC/P-}$, $E_{QL/P-}$

Three-phase:

- Active power – average, minimum, maximum
- Reactive power – average, minimum, maximum
- Apparent power – average, minimum, maximum
- Deformation power – average, minimum, maximum
- Unbalance power – average, minimum, maximum
- Power factor PF and cos φ
- Active power 1stH – average, minimum, maximum
- Reactive power 1stH – average, minimum, maximum
- Apparent power 1stH – average, minimum, maximum
- Unbalance power 1stH – average, minimum, maximum

HDO telegram data:

- HDO telegram transmission start time
- HDO telegram phase
- Address and command part of the HDO telegram
- Minimum and maximum voltage of HDO telegram marks
- HDO telegram carrier frequency

Data of electric meter function for output and each phase from the beginning of factory setting and from the start of measurement:

- Active and reactive energy E_{P+}, E_{P-}, $E_{QC/P+}$, $E_{QL/P+}$, $E_{QC/P-}$, $E_{QL/P-}$

Data of the function of active energy measurement during rapid changes of flow direction for the terminal and each phase from the beginning of the measurement according to the measurement parametrization:

- Half-period values of active energy
- Aggregated values of active energy

Measured data can be transferred both by the MODBUS RTU, MODBUS TCO or EN 60870-5-104 protocols, a description of which is provided in [4] and [5].

3.2.2 Description of the measurement of energy during rapid changes in the direction of its flow

Common instruments for measurement of power and energy work with a basic measuring interval in the order of tens of basic frequency periods. It can, in the case of rapid changes in the energy flow direction, e.g., at the places of connection of power supplies in a distribution grid, result in inaccurate recording and inaccurate evaluation of energy flows. The basic evaluating interval in the fast energy measurement function is one half-period (10 ms at a frequency of 50 Hz) and thus even such short overflows are written to the corresponding registers. The registers are separate for each phase. Depending on the settings, it is possible to aggregate all half-period values of active energy into one register during the entire measurement period or to set a time interval during which the half-period values are aggregated into the corresponding registers. Higher SW then enables displaying power and energy into a table or graph, or exporting to a .CSV file.

3.2.3 Protection functions

Protection functions are user-adjustable, examples of settings are shown in Figure 4. The recording of phase voltage and current courses and voltage and current unbalance into the monitor's memory when the protection functions activate is uniform.

The memory always stores the last 12 events of each type of fault.

Two-stage undervoltage protection function

In the function input, the user sets the limit of the 1st stage and the lower limit of the 2nd stage of undervoltage in % U_n, the 1st stage detection time and detection time of the 2nd stage in seconds. In addition, the user sets protection blocking at a phase voltage lower than the set value. Optionally, you can set the closing of the output relay and message sending.

With the undervoltage protection function, the instrument continuously evaluates independently for each phase whether all evaluated voltages are under the undervoltage limit within the detection time. If so, the protection function activates. The instrument records the activation time, the affected phase, the undervoltage value at the moment of protection activation as well as the course of RMS½ phase voltages and currents. According to the initial setting, it sends a message and closes the output relay, which remains closed for the duration of the undervoltage.

Each evaluation of voltage above the detection limit of the 1st stage resets the evaluation of the detection time of the given phase.

A voltage drop of any phase under the blocking level blocks the function of the two-stage undervoltage protection in that phase.

Two-stage overvoltage protection function

In the function input, the user sets the limit of the 1st stage and the limit of the higher 2nd stage of overvoltage in % U_n, the 1st stage detection time and detection time of the 2nd stage in seconds. Optionally, you can set the closing of the output relay and message sending.

With the overvoltage protection function, the instrument continuously evaluates independently for each phase whether all voltages evaluated in succession are above the detection limit within the detection time. If so, the protection function activates. The instrument records the activation time, the affected phase, the overvoltage value at the moment of protection activation as well as the course of RMS½ phase voltages and currents. According to the initial setting, it sends a message and closes the output relay, which remains closed for the duration of the overvoltage.

Each evaluation of voltage under the overvoltage limit of the 1st stage resets the evaluation of the detection time of the given phase.

Function of protection according to voltage unbalance

In the function input, the user sets the limit of the u2 unbalance of three-phase voltage in %, the detection time in seconds and protection blocking at phase voltage lower than the set value. Optionally, you can set the closing of the output relay and message sending.

For protection according to voltage unbalance, the instrument continuously evaluates the u2 unbalance. If all unbalance values evaluated within the detection time above the unbalance limit, the protection function according to voltage unbalance activates. The instrument records the moment of action, the value of voltage unbalance at this time, the course of RMS½ phase voltages and currents and, according to the initial setting, sends a message and closes the output relay. The relay remains closed for the duration of the increased voltage unbalance u2.

Each evaluation of voltage unbalance of a value lower than the set limit resets the detection time. A voltage drop of any phase below the blocking limit blocks the protection function.

Function of protection according to current unbalance

In the function input, the user sets the limit of current unbalance of three-phase current i2 in %, the detection time in seconds and protection blocking at phase current lower than the set value. Optionally, you can set the closing of the output relay and message sending. The two-voltage drop limit and the unbalance limit are preset.

For protection according to current unbalance, the instrument continuously evaluates the i2 unbalance. If all unbalance values evaluated within the detection time above the limit, the protection function according to current unbalance activates. The instrument records the moment of action, the value of current unbalance at this time and records the course of RMS½ phase voltages and currents. According to the initial setting, it sends a message and closes the output relay. The relay remains closed for the duration of the increased current unbalance i2.

Each evaluation of current unbalance lower than the set limit resets the detection time.

A current drop of any phase below the blocking limit blocks the protection function.

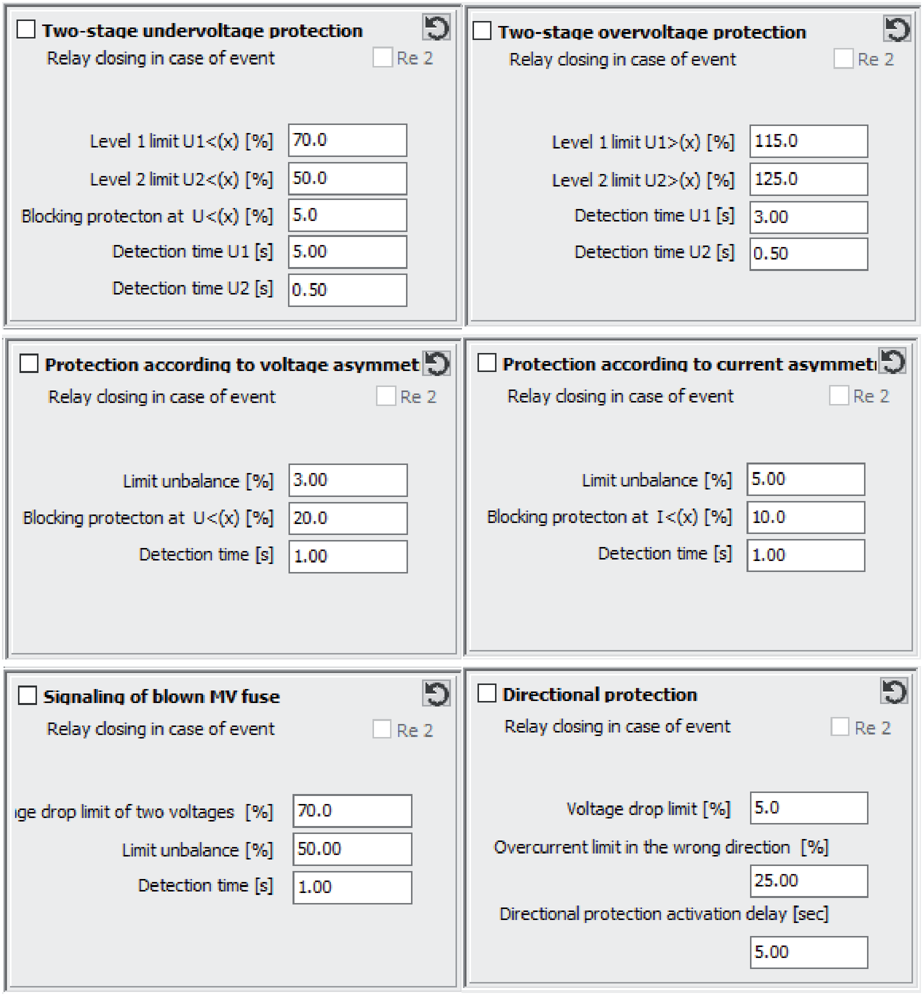
Function of indication of a blown MV fuse

For the function indicating a blown MV fuse of the MV/LV transformer, you can set the detection time in seconds and whether to switch on the output relay and message sending.

With the blown MV fuse indication function, the parameters corresponding to a blown MV fuse are continuously evaluated at the LV level. If all parameters evaluated during the detection time correspond to a blown MV fuse, the protection function activates. The instrument records the moment of protection activation, the course of RMS½ phase voltages, currents and voltage unbalance and, according to the initial setting, sends a message and closes the output relay. The relay remains closed for the duration of the evaluation of a blown MV fuse.

Each evaluation that does not correspond to a blown MV fuse resets the detection time.

Figure 4: Examples of setting protection and signalling functions



Direction protection function

In the function input, users set the limit of voltage drop in % of the rated voltage, the limit of overcurrent in the wrong direction in % of the rated current and the protection activation delay time in seconds. Optionally, you can set the closing of the output relay and message sending.

With the direction protection function, the instrument continuously evaluates the current flow direction. If all current values evaluated during the delay time are in the wrong (opposite) direction, the direction protection function activates. The direction protection function immediately activates if the value of current in the wrong direction exceeds the overcurrent limit and, at the same time, voltage dropped below the set limit. The direction protection function evaluates individual phases separately, which means that the fault is signalized even if the incorrect current direction is in one phase only. When the protection activates, the instrument records the activation time, the affected phase and the course of RMS½ voltages and currents with a pre-trigger of 0.5 s and the total duration of 1.0 s. The activation of the direction protection stays recorded even after restoring supply voltage.

The monitor memory holds data of the last twelve records of faults.

3.3 Description of control elements and displaying on the display

The front panel of the MEg45PAN universal monitor includes, in addition to instrument marking, manufacturer, serial number and QR code with technical information, a large-format colour LCD, under which are three directional touchbuttons, a **RUN** LED and a USB Mini B connector.

After switching on the power supply of the instrument and the delay of the check of the HW indicated by brief illumination of the **RUN** LED, the correct operation of the device is indicated by intermittent illumination of the **RUN** LED. The intermittent lighting of the **RUN** LED has the following meanings:

- Repeated one short flash (0.1 s); recording of measured values to dedicated memory space is in progress
- Repeated two short flashes (2 × 0.1 s); recording of at least one measurement function is suspended or the dedicated memory space is exhausted for at least one measurement function and overcycling is disabled
- Short flash (0.1 s); recording of measurement values is not in progress either due to a malfunction or measurement is suspended
- Fast flashing (0.1 s / 0.1 s); external power supply to the instrument has failed, power is supplied from the internal uninterruptible power supply, recording is in progress
- Slow flashing (0.5 s / 0.5 s); oscillographic recording

Continuously lit **RUN** LED indicates a failure.

When turned on, the display will show the **Přehled** (1/9) (**Overview**) page of the **Měřidlo** (**Meter**) function with the basic measured phase quantities U, I, P, Q, PF.

By pressing the central button with the circular target, the display always switches to the main Menu page, see Figure 5, with the five measurement functions and the **Nastavení** (**Settings**) function, which displays the parametrization values of the instrument and settings as well as the status of the communications. You can use the directional buttons to select a function. The selected function is highlighted in orange.

The top status bar of the main Menu page shows the current time (hour:minute:second) on the left and the abbreviations of the LINUX (LNX), GPS and GSM modules on the right. If the modules are not fitted or not functional, they are shown in black. They are shown in orange if they are functional.

After switching on the instrument and selecting each measurement function for the first time, pressing the middle button again takes you to its first page. When measuring functions are selected repeatedly, pushing the central button opens the page selected before exiting the given function.

The bottom status bar of the selected page shows the page name in the middle and the page number with the total number of pages of the function in round brackets on the right.

The display backlight goes off automatically if no button has been activated in the last five minutes, and it goes on when any button is activated.

In the **Měřidlo** (**Meter**) function, the displayed values are updated at 0.5 s intervals. On the **Přehled** (1/9) (**Overview**) page, see Figure 6, the ten-period values of phase voltage, current, active and reactive power, and power factor PF are visible for each phase L1, L2, and L3. Press the right directional button to go to the **Fázory** (2/9) (**Phasors**) page, see Figure 7. The left half of the page shows the ten-period 1st harmonic voltage and current values of each colour-coded phase. Also, it displays angles between voltages and, in the case of currents, angles between voltage and corresponding current. Displayed in the right side of the page is a vector diagram of phase voltages and phase currents with vectors related to rated value. The instantaneous value of the mains frequency is displayed at the top right.

The **Osciloskop** (3/9) (**Oscilloscope**) page, see Figure 8, repeatedly displays, together with ten-period values of phase voltage and currents, an oscilloscopic record of one period of the mentioned voltage and currents synchronized by transition of U1 voltage to positive values.

The page **Harm.U1** (4/9) to **Harm.U3** (6/9), see Figure 9, repeatedly displays the spectral lines of the 2nd to 40th harmonics of the corresponding phase voltage expressed as a % of the fundamental harmonic. The top right shows the voltage value of the fundamental (1st) harmonic in V, and the total shape harmonic distortion of the THD_U voltage as % of the corresponding phase voltage.

The page **Harm.I1** (7/9) to **Harm.I3** (9/9) repeatedly displays the spectral lines of the 2nd to 40th harmonics of the corresponding current expressed as a % of the measured fundamental harmonic value. On the top right is the magnitude of the fundamental harmonic of the current in A and the total shape harmonic distortion of the current THD_I in %.

In the **Kvalita** (**Quality**) function, the ten-minute average values of the fundamental voltage quality variables are displayed on the **Přehled** (1/8) (**Overview**) page, see Figure 10. These are the phase voltages, the harmonic distortion factors of voltage THD_U and current THD_I for each phase, and the three-phase voltage quality parameters, which are frequency in Hz and voltage and current unbalance in %.

On the **Flikr** (2/8) (**Flicker**) page, see Figure 11, the **Kvalita** (**Quality**) function displays the phase coefficients of the short-term (10 min) flicker P_{st} and the long-term (2 hours) flicker P_{lt} evaluated for the last 10-minute interval marked at the beginning of the lower status bar. The long-term flicker values P_{lt} are sliding and are evaluated every 10 minutes for the past 2 hours.

The **Harm.U1** (3/8), **Harm.U2** (4/8), and **Harm.U3** (5/8) pages of the **Kvalita** (**Quality**) function display the spectral lines of the 2nd to 40th harmonics of a given phase voltage as a % of the fundamental harmonic with the standard limits marked in grey. Blue colour is used to mark measured values if they are lower than defined limits, while red colour is used to mark values that exceed standardized limits. On the top right is the value of the fundamental harmonic of the phase voltage in V and the value of the total harmonic distortion THD of the phase voltage in %. The THD voltage limit value specified by the standard is also shown in grey.

The **Harm.I1** (6/8), **Harm.I2** (7/8) and **Harm.I3** (8/8) pages of the **Kvalita** (**Quality**) function show the spectral lines of the 2nd to 40th harmonics of the phase current in % of the measured value of the fundamental harmonic of the current. On the upper right is the value of the fundamental harmonic of the given phase current in A and the value of the total harmonic distortion of the THD current is displayed in %. The phase current spectrum graphs on pages (6/8) to (8/8) do not have set limits.

In the **Záznamník** (**Recorder**) function, the individual pages display the values that have been evaluated for the last completed recording interval, the time of which can be seen in the bottom line on the left. On the **Přehled** (1/4) (**Overview**) page, these are the average phase values of voltages, currents, active and reactive powers and power factor values. On the **Proudy** (2/4) (**Currents**) page, see Figure 12, these are the average, maximum and minimum current values for each phase. On the **Výkony** (3/4) (**Powers**) page, these are the active and reactive powers for each phase, and on the **Výkon 3f** (4/4) page, these are the three-phase, active power P, reactive power Q, apparent power S, deformation power D, and total unbalance power C.

The **Energie** (**Energy**) function displays four pages. The **Elektroměr** (1/4) (**Electric meter**), see Figure 13, displays three-phase values of active energy supplied in the arrow direction EP+ (OBIS code 1.8.0), active energy consumed EP- (2.8.0), inductive reactive energy during active supply EQL/P+ (5.8.0), inductive reactive energy during active consumption EQL/P- (7.8.0), capacitive reactive energy during active supply EQC/P+ (8.8.0), capacitive reactive energy during active consumption EQC/P- (6.8.0) aggregated from the start of energy measurement. The start time is displayed at the beginning of the bottom status line in the hour-day/month/year format.

The **Energie L1** (2/4), **Energie L2** (3/4) and **Energie L3** (4/4) pages of the **Energie** function always display the values of the six energy registers for a given phase since the start of the energy measurement.

The **Události** (**Events**) function has a total of three pages. The **Jevy** (1/3) (**Phenomena**) page, see Figure 14, contains a table of the values of the eight most recent phenomena in time, with the youngest event listed on the first line of the table and the oldest of the eight displayed on the lowest line. Phenomena include registered voltage dips, increases and interruptions and overcurrents. The phenomenon line contains the date (d/m/y) and time (h:m:s) of the start of the phenomenon, the duration of the phenomenon and the extreme value of the phenomenon. These characteristics of the phenomena are determined according to EN 61000-4-30. For voltage dips it is the residual voltage, for voltage increases it is the maximum voltage, for voltage interruptions it is the lowest voltage and for overcurrents it is the highest overcurrent of all three phases, calculated by the RMS½ procedure. The duration of a given phenomenon, excluding voltage interruptions, is determined as the time difference between the moment of any of the three-phase voltages going out of the allowed tolerances and the moment of the last of the three-phase voltages returning to the allowed tolerances with hysteresis. The duration of a voltage interruption begins when the last of the three-phase voltages falls below the interruption limit and ends when any of the three-phase voltages rises above the hysteresis interruption limit. The duration of overcurrent starts when the measured current rises above a specified limit and ends when it falls below that limit.

The **RVC** (2/3) page of the **Události** (**Events**) function also contains a table of the last eight recorded rapid voltage changes, with the most recent rapid voltage change in the first line of the table. A rapid voltage change is characterized by a URMS½ voltage change greater than the selected magnitude as a % of rated voltage. The display shows changes greater than 3 % of rated voltage. In case of a rapid voltage change, the measured voltage is still within the allowable tolerance of ± 10 % U_n. The table header again shows the date and time of the start of the change, the duration of the change and the maximum magnitude of the voltage change expressed in % of the rated voltage.

The information on the transmission of telegrams of the mass remote control HDO system is given in the table on the **HDO** (3/3) page of the **Události** (**Events**) function. An example display is shown in Figure 15. The information on a single telegram is contained in two lines and includes the date and time the telegram started, the HDO signal frequency, as well as the minimum and maximum ten-period signal voltage value when the HDO telegram is transmitted. The content of a received telegram is recorded as well. Differentiation is made between the parallel command code, i.e., pulse–space, and the serial code, i.e., pulse–pulse, with an addressing configuration according to the company standard of PNE 382530, ed. 3.

On the first page **Měření** (1/5) (**Measurement**), see Figure 16, the **Nastavení** (**Settings**) function contains on the first two lines the measurement location and the point to which the MEg45PAN monitor is connected.

The **Přístroj** (**Instrument**) paragraph shows the rated value of the measured voltage in V and the conversion of current transformers or sensors with the rated value of the primary current and secondary current of the transformer or the output voltage of the sensor, which corresponds to the design and range of current inputs of the MEg45PAN.

The **Události** (**Events**) paragraph informs about the set limits of voltage phenomena, whether they are set according to the standard or modified by the user. There is a limit of registered overcurrents and a minimum magnitude of registered voltage changes in % of rated voltage.

The **Interval záznamníku** (**Recorder interval**) paragraph shows the time interval of the **Záznamník** (**Recorder**) function; this can be set by the user from 2 s to 15 min.

The **Čas** (**Time**) paragraph informs about the date and time of the last synchronization of the MEg45PAN monitor. When GPS synchronization of the internal time is activated, this is displayed in the **Synchr** line. The **Zdroj** (**Source**) line indicates the source of the time synchronization. In addition to GPS, the MEg45PAN has the following time synchronization options: NTP, P104, MODBUS RTU, MODBUS TCP, P202/ETH, P202/USB. When the GPS is synchronized, the source line also displays the active status and, after the slash, the number of satellites whose signal is being received.

The second page **Komunikace** (2/5) (**Communication**) function of the **Nastavení** (**Settings**) function contains in the **LINUX** paragraph one of the following statuses:

- Spí (Sleeping) – Linux not running. This is in cases where Linux activity is not required
- Nabíhá (Booting) – system start that takes about one minute
- Aktivní (Active) – normal system operation with the system version displayed
- Porucha (Failure) – the system has either not booted or has stopped working. SD card damaged or not inserted
- Omezen (Limited) – status after a power supply failure.

The version and type of **SD card** running LINUX is also shown.

The **RS485** paragraph contains the RS485 serial interface address, baud rate in Bd and character format.

In the **ETH** paragraph, the IP address with a mask in CIDR format, e.g. 192.168.11.221/24, is displayed when the device is connected via Ethernet cable.

In the **VPN** (Virtual Private Network) section, a secure IPsec connection with the IP address is shown.

In the **GW** (gateway) section there is an IP address and if (interface) where packets that do not belong to the local network are routed. An example of an interface is a VPN.

The **GSM** paragraph contains information about the connection via GSM modem integrated in the MEg45PAN monitor. The GSM connection is characterized by the IP address e.g. 10.50.1.18/24 and the item Síť (Network) in which the modem is registered. The following types of GSM networks are possible – LTE, HSDPA, EDGE, GPRS. The value after the slash represents the GSM signal level/quality in % or the modem status. The following GSM modem states are distinguished:

- Nepřítomen (Not present) – there is no modem communication board in the device
- Nenalezen (Not found) – modem failure – the communication board is installed in the monitor, but the modem was not detected
- Nekompatibilní (Incompatible) – the modem has been detected, but the installed software does not support it
- Porucha (Failure) – the modem indicates an unknown failure
- Chybí SIM (SIM missing) – SIM card not inserted
- Chyba SIM (SIM error) – SIM card is damaged
- Neznámý stav (Unknown status) – unknown or incommunicable status
- Inicializace (Initialization) – modem is being initialized

- Uzamčen (Locked) – request to enter PIN. Note that this may appear briefly even if the correct PIN is entered in the configuration. The next time the information is refreshed (after 3 minutes), this condition should disappear.
- Pozastaven (Suspended) – modem operation is suspended (e.g. to save energy after a power failure)
- Pozastavování (Suspending) – transition to the ‘Suspended’ state is in progress
- Povolování (Enabling) – transition to normal operating state is in progress
- Povolen (Enabled) – the modem has been put into operating state and subsequently SIM verification and network registration should take place
- Vyhledávání (Searching) – the modem is searching for available mobile operator networks
- Registrován (Registered) – the modem is registered to the mobile operator’s network
- Odpojování (Disconnecting) – disconnection from the APN (Access Point Name) is in progress
- Připojování (Connecting) – connection to APN is in progress, activation of data transmissions
- Připojen (Connected) – the data connection is successfully activated. This is the state the modem should normally be in.
- Rekonfigurace (Reconfiguration) – reconfiguration of system parameters
- Chyba SW (SW error) – a malfunction of the operating software has occurred.

The third page called **IN/OUT** (3/5), see Figure 17, of the **Nastavení** (**Settings**) function displays the state of two-stage input signals and the state of the relay output contact. The input signals can be two-bit with valid states 01 and 10 or one-bit with the states Rozepnut (Open) and Sepnut (Closed). The output contact is either Spojen (Connected) or Rozpojen (Disconnected).

The fourth page named **Směrová ochr.** (4/5) (**Direction protection**) of the **Nastavení** (**Settings**) function contains the directional protection settings. These are:

- Minimum reverse current in % I_n
- Delay voltage limit in % U_n
- Delay before protection activation in seconds
- Output relay switch on time.

The direction protection function is not included in the standard offer. A basic description of the direction protection function is given in chapter 3.2.3.

The fifth page **Jazyk** (5/5) (**Language**) of the **Nastavení** (**Settings**) function can be used to change the display language Čeština / English.

Figure 5: Menu

Figure 6: Overview / Meter

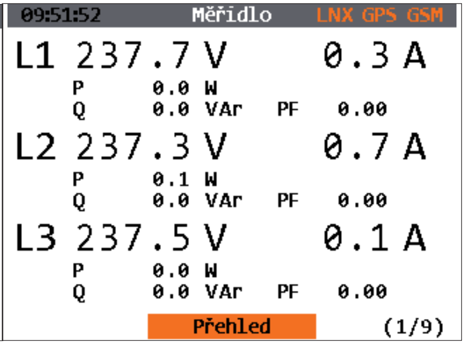


Figure 7: Phasors

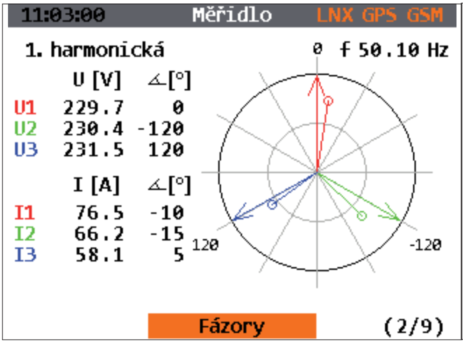


Figure 8: Oscilloscope

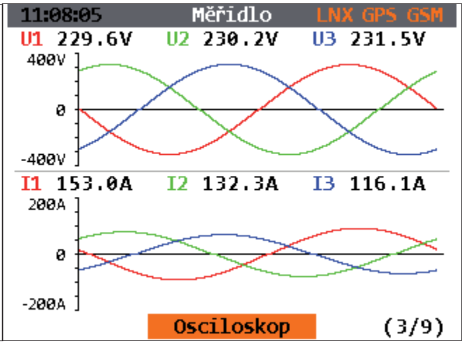


Figure 9: Harmonic voltages

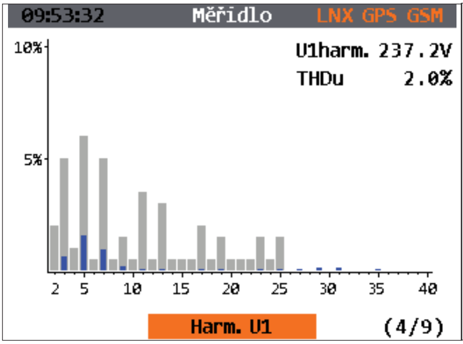


Figure 10: Overview / Quality

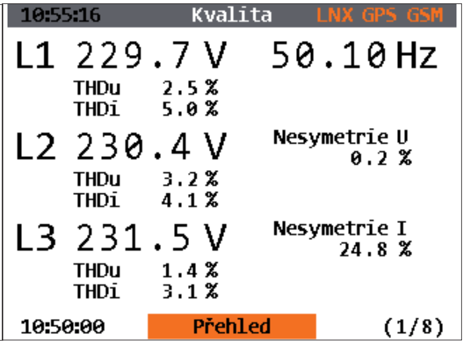


Figure 11: Flicker

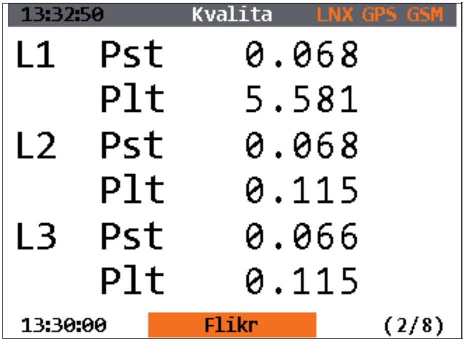


Figure 12: Currents / Recorder

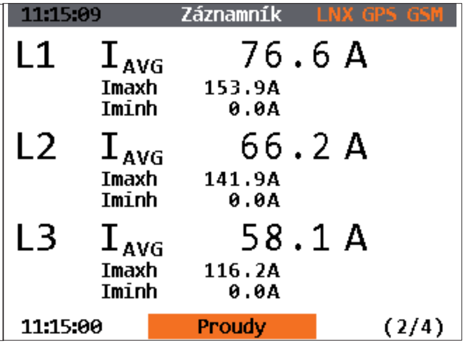


Figure 13: Electric meter/Energy

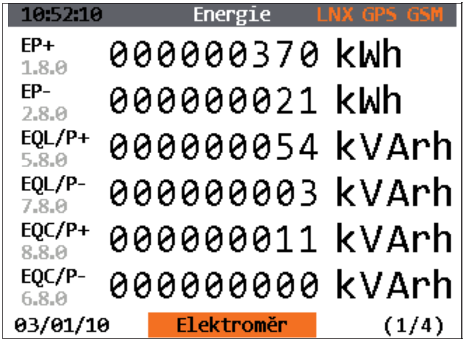


Figure 14: Phenomena/Events

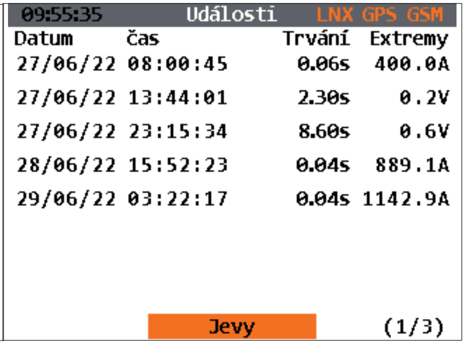


Figure 15 HDO

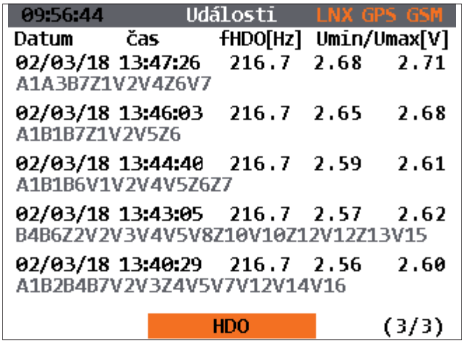


Figure 16 Measurement/Settings

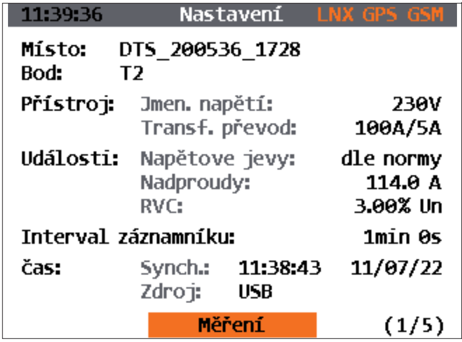
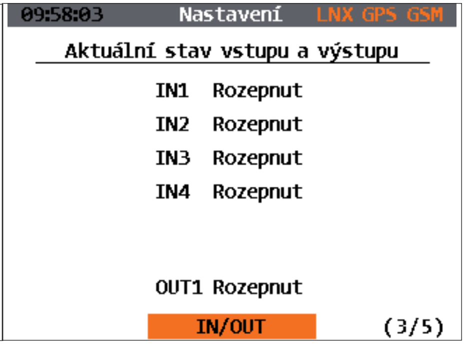


Figure 17: IN/OUT / Settings



4/ MEASURING AND COMMUNICATION CONNECTION, CONNECTION OF INPUTS AND OUTPUTS

The MEg45PAN universal PQ monitor is designed for measuring in power facilities of LV grids and distribution LV grids in the most demanding operating conditions. It has two-way data transfer. It is designed in the measuring category and overvoltage category CAT IV 300 V and in the safety class II. The four input and one output two-stage signal is ready for connection to external devices. Already operated measuring and information systems can be additionally supplemented with functions provided by the MEg45PAN monitor using the local and remote communication interfaces RS485 and ETH.

Phase voltages are measured to the neutral conductor. Voltage inputs of the instrument are marked **U1**, **U2** and **U3**; connecting to the neutral conductor is via the **Nm** terminal.

Line voltages are evaluated from the difference of instantaneous phase voltage samples.

The high-frequency grounding of the instrument on terminal ⏚, is connected to the PE conductor in TN-S networks and to the PEN conductor in TN-C networks.

The MEg45PAN monitor is powered by the voltages of the measuring voltage inputs. It also has an auxiliary DC power supply with a rated value of 12 – 24 V connected between terminals **+** and **–**.

The current inputs of MEg45PAN are designed just for indirect current measurement via current transformers or sensors, meeting the requirements for safety at the site of installation. The current inputs of MEg45PAN universal monitors are manufactured with a standardised rated value of current or voltage. They are also produced for the direct connection of AMOSm flexible current sensors. The rated value of the current input of the monitor or the type of the connected sensor is stated on the back panel of the monitor. The type and rated value are the same for all three current inputs. Each current input I1, I2 and I3 of the monitor has input terminal **S1(k)** and output terminal **S2(l)** for the positive current direction. These are to be connected to the outputs of current sensors designated **k** and **l** or **S1** and **S2**. The **S1** input terminals of current transformers are to be grounded.

The connection of the common terminals in MEg45PAN in safety class II is shown in Figure 18. The measuring and power supply terminals **U1**, **U2**, **U3**, **Nm** are connected to an internal galvanically isolated power supply, the isolated part of which is connected by one pole to the common conductor **G**. This is connected to the negative pole of the auxiliary DC power supply and to the shielding contacts of the **GSM** and **GPS** antenna connectors. The measuring and supply terminals of the AC voltages and the neutral conductor are connected to it via protective impedances. The galvanically isolated power supply of the **RS485** interface has a common terminal labelled **G1**. The high-frequency shielding of the **USB**, **ETH** interface connectors and **SIM card** housing is connected to the HF ground terminal, which is connected to the PE or PEN ground conductor. This ground connection is not a safety connection and therefore uses a low-current conductor.

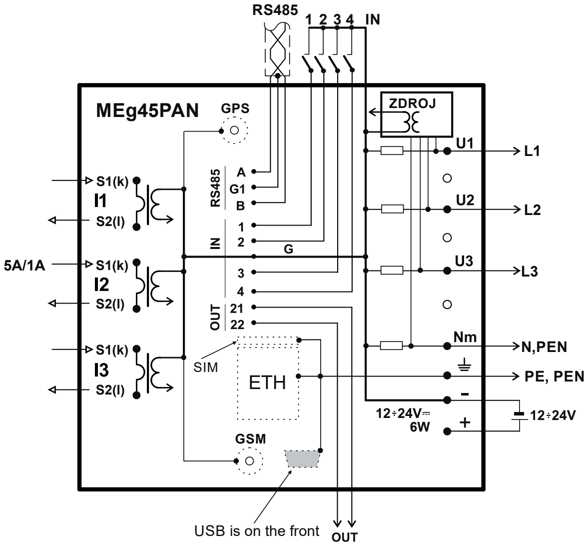
Note that when using an auxiliary power supply with a grounded positive pole in the MEg45PAN version with sensor current measurement, sensors with grounded S1 and S2 contacts must not be used.

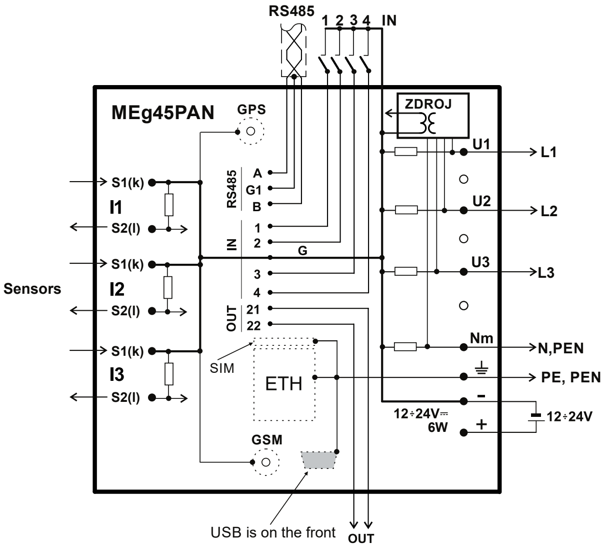
Figure 19 shows a circuit with conventional current transformers with a rated secondary current of 5 A or 1 A. If these current transformers are not equipped with the possibility of protection during disconnecting of the secondary circuit or the possibility of short-circuiting the secondary circuit during assembling, it is advisable to insert in their secondary circuits short-circuiting terminals enabling the installation of a measuring instrument without the need to switch off the network circuits. The MEg45PAN in Figure 19 is powered from the measured voltages only via a three-pole fuse disconnector.

For the additional installation of current measurement in operated cabinets with CAT IV 300 V overvoltage category, if wired according to Figure 20, you can use a split-core current transformer **MTPD.51** with a rated secondary current of 1 A and electronic protection in case of disconnection of its secondary circuit. In this figure, the power supply of the MEg45PAN is provided by the DC voltage of the floating uninterruptible power supply in addition to the measured voltages.

For additional measuring of currents in structurally complicated types of collecting points (doubled collecting point, low distances between busbars, etc.) and in CAT IV 300 V areas, it is advisable to use the flexible **AMOS** type current sensors. The flexible AMOS sensors are made with the loop length of 20 cm, 40 cm or 60 cm and with the rated measured current from 30 A to 5000 A. An advantage of the AMOS sensors is the speed of installation, which can be conducted even under voltage without the need for switching off.

Figure 18: Interconnection of common terminals in MEg45PAN





When using standard **AMOS/1A** sensors, the 2 m loop supply cable defines the maximum distance between the installation location of the sensor loop and its converter unit. The distance between the monitor and the converter unit, according to Figure 21, is determined by the maximum load impedance of 2.5 Ω. To power the AMOS/1A sensors, use an external DC power supply in the range of 10 V to 30 V.

The design of **AMOSm** flexible sensors with low-voltage direct connection to specially modified current inputs of the MEg45PAN monitor is shown in Figure 22. The interface between the sensors and the monitor is non-standard, but allows for increased accuracy of the entire measurement chain.

Phase currents of a LV network can be measured by the MEg45PAN monitor with the use of **LCT** split-core transformers with the rated primary current of 5 A, 20 A, 60 A, 75 A, 100 A, 120 A, 200 A, 300 A, 400 A, 500 A and 600 A, which have holes for a conductor with measured current with a diameter of 10 mm, 16 mm, 24 mm and 36 mm. The wiring is shown in Figure 23. LCT transformers have a standard output voltage of 225 mV, 150 mV and 22.5 mV. In this case, the MEg45PAN monitor has current inputs with the corresponding voltage values. LCT transformers can only be installed on insulated conductors at air and surface distances from live parts meeting the safety requirements of the installation site.

TORm and **TORv** toroids should be used if it is possible to disconnect circuits with measured currents. The toroids enable accurate measurements of even small currents. A TORm toroid with a hole for a conductor with the diameter of up to 6 mm can be used for primary current with the rated value of I_n = 1 A or 5 A and a TORv toroid with a hole for a conductor with the diameter of 15 mm for I_n = 10 A and 50 A. Toroids of both of these types meet the requirements of CAT IV 300 V. The connected MEg45PAN monitor has current inputs with the corresponding rated voltage. Thanks to their small dimensions, both types of toroids can be used for measurements in LV installations, refer to Figure 24.

The TORm toroid can also be used for measurement of secondary currents of instrument current transformers. In this way it is possible to galvanically isolate the current circuits of the electric meter and the voltage quality monitor. A wiring example is shown in Figure 25.

The wiring of the four two-stage inputs **IN1** to **IN4** of the IN connector of the MEg45PAN monitor is shown in Figure 26. The internal supply voltage is 24 V_{DC}. Input signals IN1 to IN4 have a common contact that is galvanically connected to the common conductor **G** of the monitor circuits.

Figure 27 shows an example of the connection of a load to the monitor in CAT IV / 300 V environment using the **REL IV/DC** external isolation relay. Terminals OUT21 and

OUT22 of the switching contact of the output relay switch the excitation circuit of the REL IV/DC electronic relay with inputs A1, A3 powered by an external 24 V power supply. The galvanically safely isolated (CAT IV 300 V) output power contact of the REL IV/DC relay switches the AC circuit of the motor.

The connection of local communication between the measuring and control system and a group of MEg45PAN monitors using the **RS485** interface is shown in Figure 28. One RS485 interface with the MODBUS RTU allows communication with up to 30 devices. The end of the communication link with the shielded twisted pair must be terminated with a 120 Ω resistor.

Figure 29 shows the use of a MEg45PAN universal monitor with an ARM communication core and a secure two-way transmission using the Linux IPsec function for **GSM** data transmission between an electric meter concentrator and the IT of a distribution company. A safe GSM extension cable with a length of 2.5 m can be used to safely connect GSM communication in the CAT IV substation environment.

Figure 30 shows the connection of a **GPS** antenna for time synchronization and GSM antenna for remote communication to the MEg45PAN monitor. The monitor only needs signals from three GPS satellites to synchronize the time. If necessary, a 10 m safe GPS extension cable with increased insulation in a length of 2.5 m can be used.

For GSM communication, the antenna can be connected via a safe GSM extension cable of 2.5 m length in hazardous environments and a GSM extension cable of 10 m length in safe environments.

Figure 30 shows the connection of the MEg45PAN universal monitor to an **Ethernet** network via an RJ45 connector. Even in this case, if installed in a hazardous environment, a safe ETH extension cable with a length of 2.5 m can be supplied.

Figure 31 shows an example of use of the ETH serial interface with the RJ45 connector for remote transmission of data of more than one MEg45PAN universal monitor with the use of a Switch unit. The monitor is fitted with a short RJ45 connector, enabling connecting to the Ethernet network even when the device is installed using the U-profile.

The connection of MEg45PAN during **single-phase LV measurement** is shown in Figure 32. The measured and supply phase voltage must be connected through a single-pole fuse disconnector to the U1 input of the monitor. The DC uninterruptible power supply of the monitor is not used in the figure.

Fig. 19: Connection of MEg45PAN in a transformer station, CAT IV 300 V, current transformers with $I_n = 5\,A$

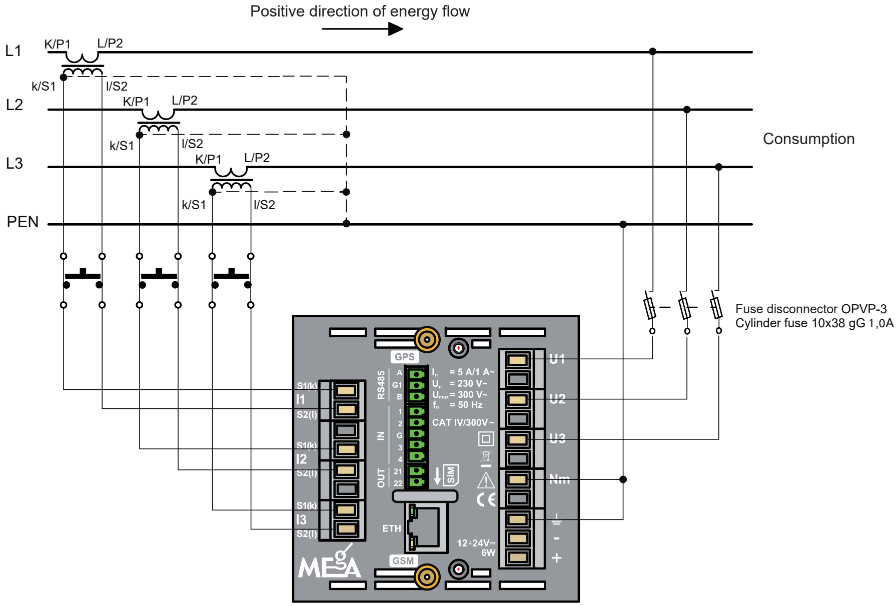


Fig. 20: Connection of MEg45PAN in LV TN-S type network, with fuse disconnectors in voltage circuits and current transformers MTPD.51 with $I_n = 1\,A$

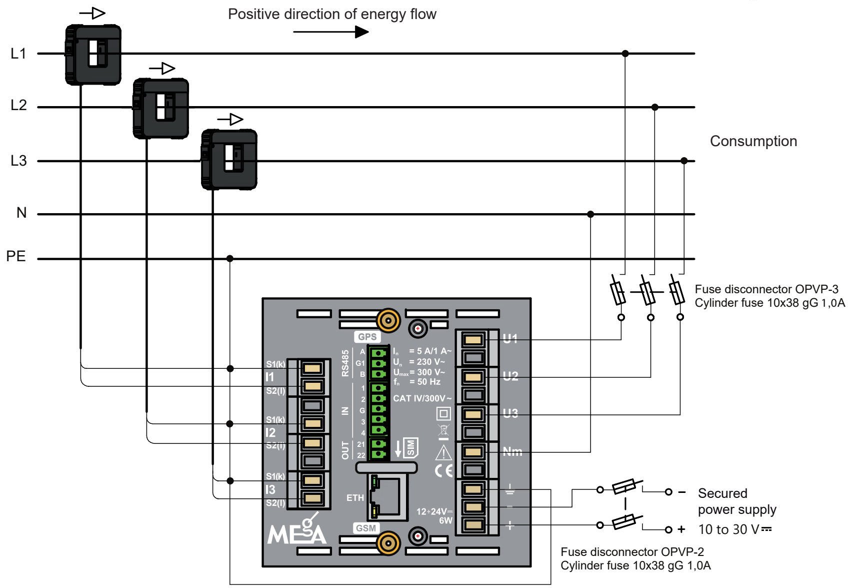


Fig. 21: Connection of MEg45PAN in a LV TN-C type network, with fuse disconnectors in voltage circuits and current measurement by AMOS/1A sensors, category CAT IV 300 V

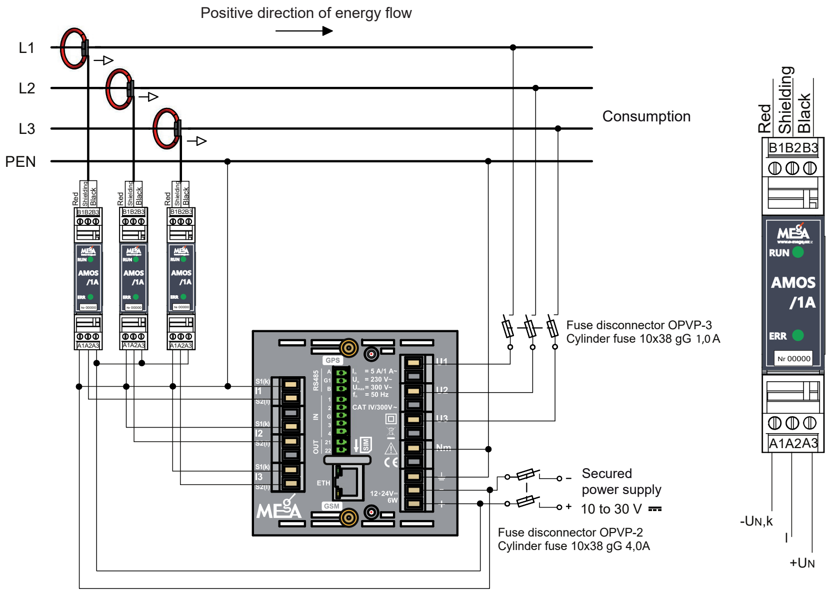


Fig. 22: Connection of MEg45PAN in a LV TN-S type network, current measurement by AMOSm sensors, category CAT IV 300 V

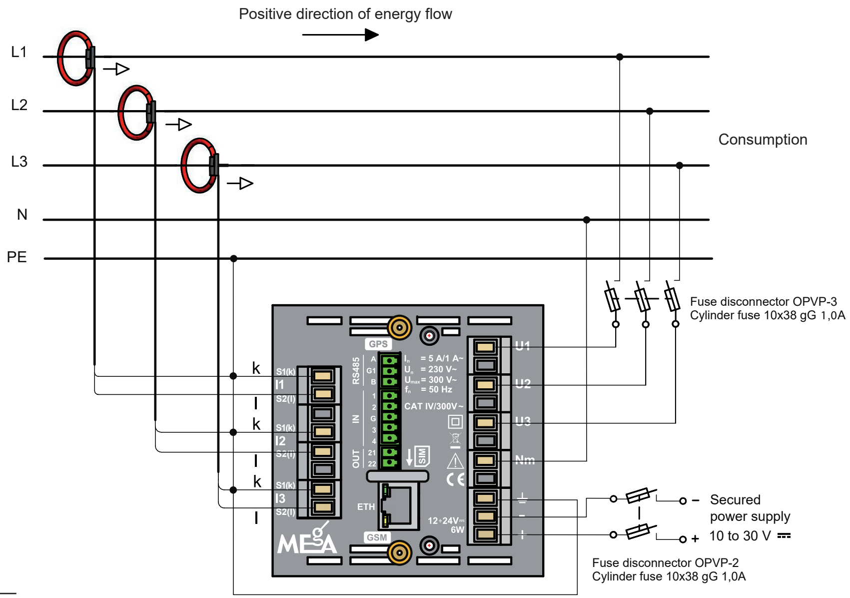


Fig. 23: Connection of MEg45PAN in a LV TN-S type network, current measurement by LCT

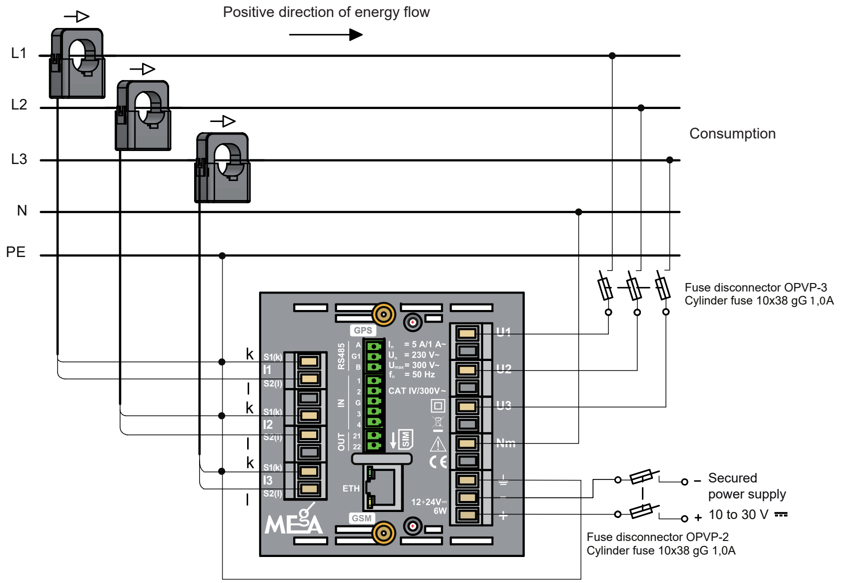


Fig. 24: Connection of MEg45PAN in a LV TN-C type network, current measurement by TORv or TORm toroids, category CAT IV 300 V

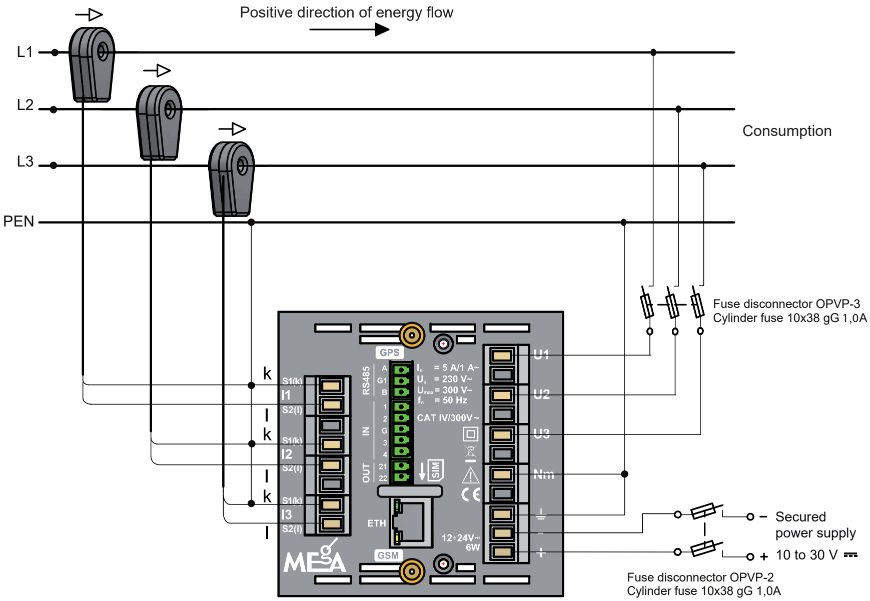


Fig. 25: Connection of MEg45PAN monitor with current measurement by TORm toroids connected in secondary current circuits of current transformers

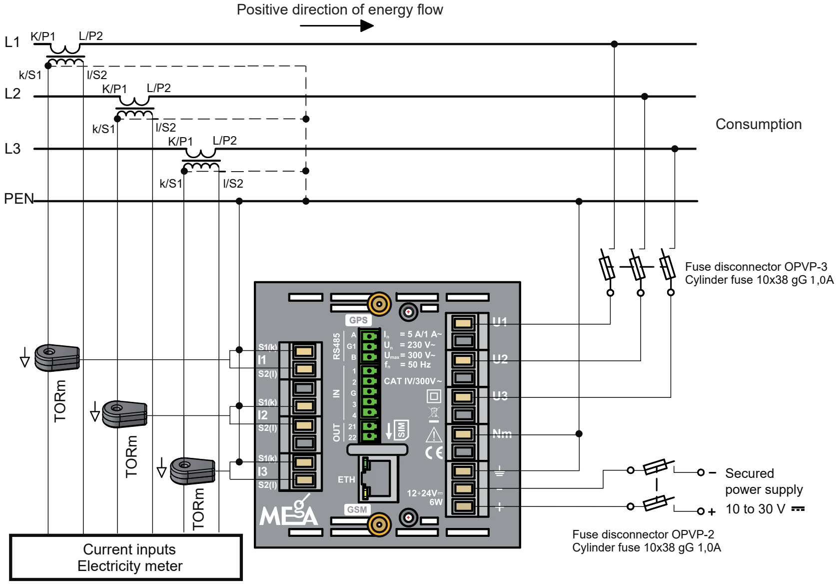


Fig. 26: Connection of two-stage inputs of MEg45PAN

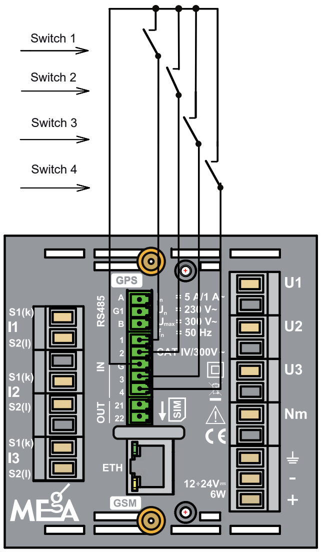


Fig. 27: Wiring for controlling the mains load via the safety relay RELIV/DC

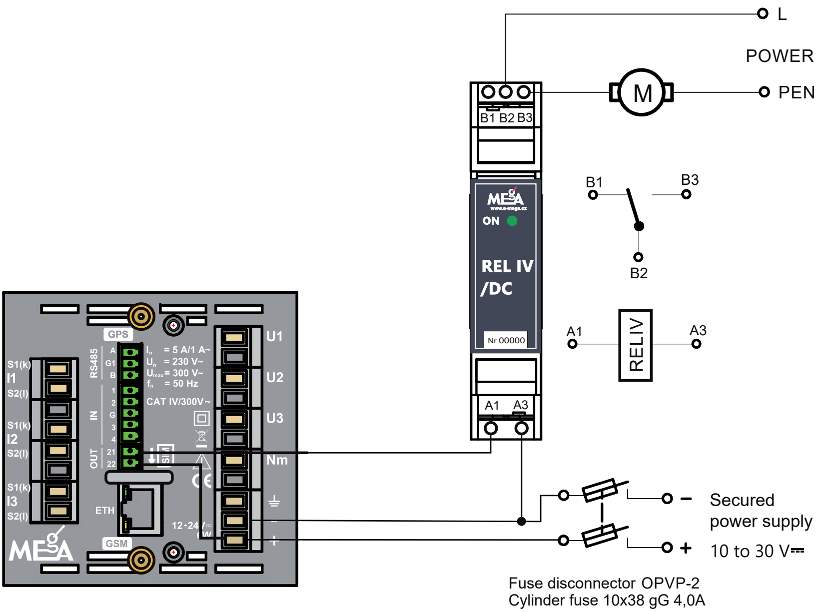


Fig. 28: Communication of MEg45PAN monitors via the RS485 interface

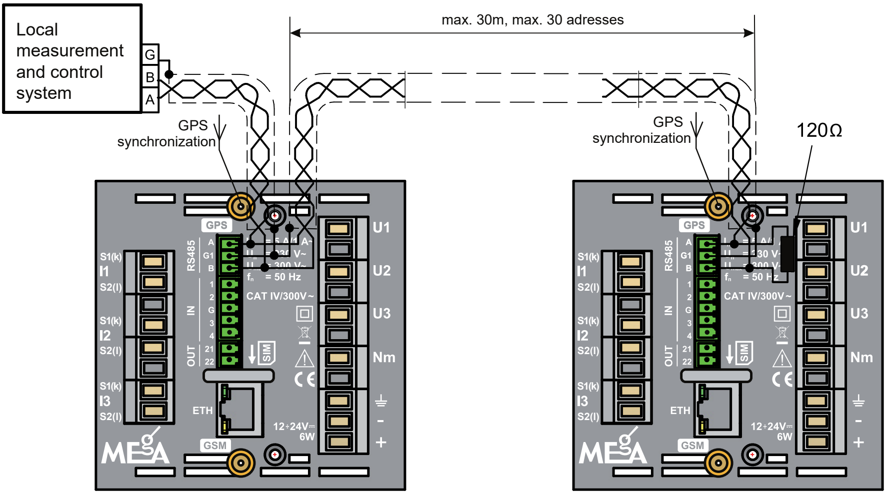


Fig. 29: Secure GSM communication of the MEg45PAN monitor via data concentrator

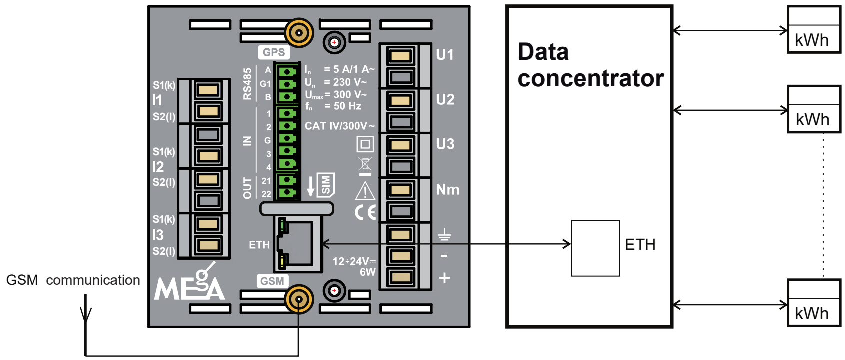


Fig. 30: Connection of MEg45PAN to an Ethernet network

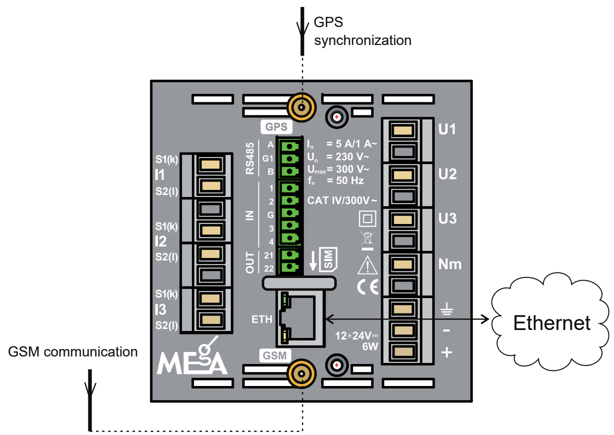


Fig. 31: Communication of MEg45PAN monitors via the ETH interface and Switch unit

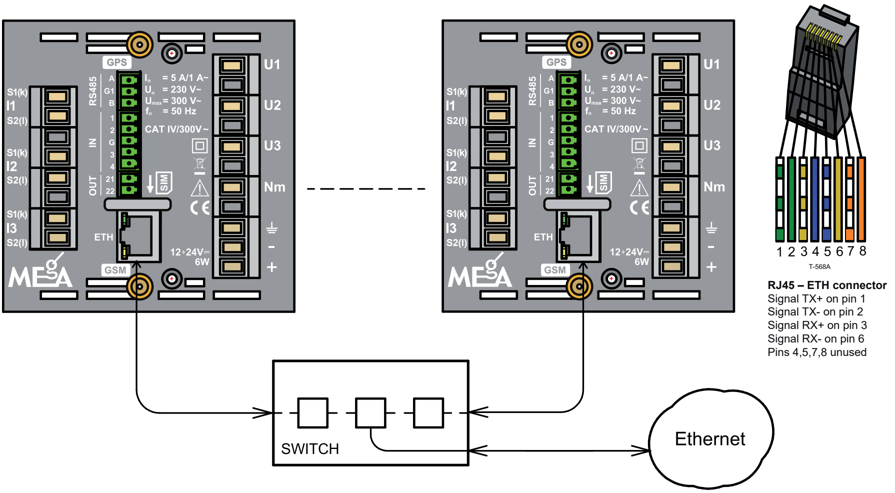
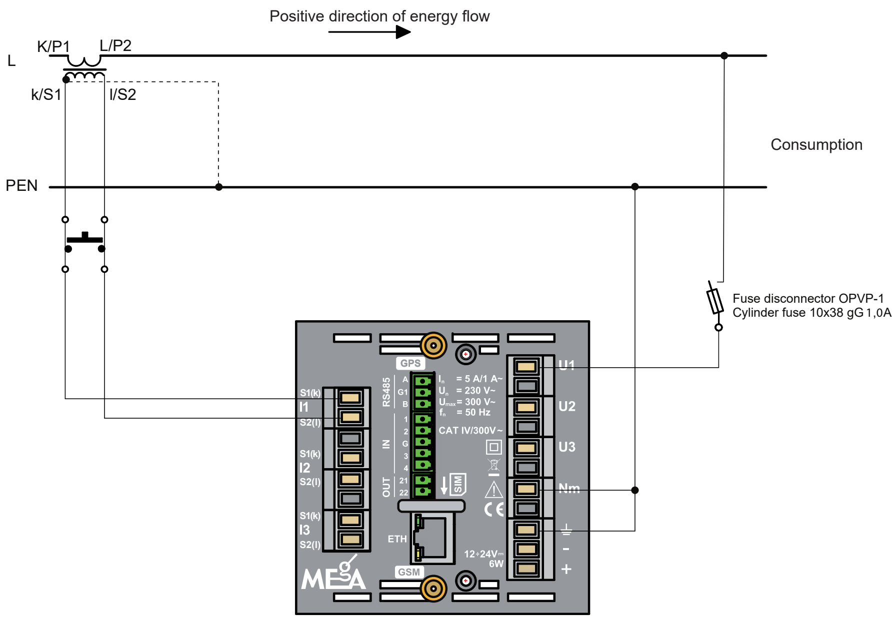


Fig. 32: Single-phase measurement using MEg45PAN



5/ SAFETY INFORMATION

Pay maximum attention to this information.

⚡ The warning draws attention to the facts presenting safety risks to the operator.

⚠ Cautions indicate conditions and facts that may cause damage to the MEg45PAN monitor.

⚡ **Warning**

- **Be careful, the operator performing the installation of the MEg45PAN universal monitor into circuits and areas with live parts must be equipped with personal protective equipment and additional safety means and use them during the installation.**
- **When the MEg45PAN universal monitor is used in a different way than it is specified by the manufacturer, the protection provided by the MEg45PAN monitor can be impaired.**
- The operator installing the instrument must be qualified for work on or near dangerous voltages. The operator must also be trained in providing first aid.
- The monitor may only be operated by skilled personnel.
- Maintenance and repairs of monitors may only be carried out by the manufacturer or service organizations authorized by the manufacturer.
- It is not permitted to use other accessories than those included in the MEg45PAN monitor set delivery.

⚠ **Caution**

Explanation of symbols used in the user manual and in the specifications of the MEg45PAN universal monitor:

⚠	Note in documentation / Warning, risk of danger
⚡	Danger, risk of electric shock
CAT IV	Overvoltage category / measuring category, characterizing the state of transient overvoltage. CAT IV 300 V applies to installation in DTS at the LV level with a voltage of up to 300 V.
⧈	Safety class II, double or increased insulation
IP code	Degree of ingress protection

IK code Degree of mechanical protection provided by enclosure

The product is intended for recycling and collection points

CE Declaration of Conformity – European Community

High-frequency grounding

6/ INSTALLATION OF THE MONITOR, PREPARATION FOR MEASUREMENT

Power supply and measuring voltage circuits shall be connected in a voltage-free state.

Voltage inputs must not be connected to phase voltage exceeding 300 V_{AC} and line voltage exceeding 510 V_{AC} in CAT IV 300 V measurement category circuits.

Current inputs are not designed for direct measurement of currents. Currents are connected to outputs of current sensors, which must meet the safety requirements applicable at the place of installation. Current circuits are connected in the off state or when the secondary windings of instrument current transformers are short-circuited if they are not equipped with overvoltage disconnection protection.

The MEg45PAN monitor shall only be installed by qualified personnel equipped with personal protective equipment against electric shock and trained in the provision of first aid.

Warning! In the MEg45PAN monitor with current inputs for low-power sensors with output voltage, the **S1** terminals of the current sensors, the common terminal of inputs and the negative terminal for connecting the auxiliary power supply are connected via the common pole **G**, see Figure 18. When installing external components with a grounded pole, this grounded pole must be connected to the above terminals..

In order to suppress hf interference, the terminal marked with the ground symbol ⏚ must always be grounded.

Measured voltage must always be brought to the **U1** reference voltage input..

All three current inputs of the MEg45PAN monitor shall be, in accordance with the specification on the rear panel of the monitor, connected to current transformers/sensors with the identical rated value of secondary current or voltage or the identical type of non-standard current sensor.

1. The MEg45PAN universal monitor is installed in a square-shaped opening with the size of 92 × 92 mm in the panel of a LV cabinet. It is necessary to leave at least 50 mm of space around the case of the instrument to enable connecting of measuring conductors, antennas and accessing the locking cams. The instrument is fixed in the opening by turning the two white locking cams inserted in the black upper and lower side of the plastic case of the instrument.

   The monitor can be installed on a panel or wall using a shaped U-profile with a square opening, refer to Figure 3. The U-profile is attached by means of three screws ST4.8×13 (DIN7981) screwed in the holes in the panel. A drill with the diameter of 3.8 mm shall be used for panel thickness of 1 mm, and a drill with the diameter of 4.2 mm shall be used for panel thickness of 2 mm. When installing the instrument in a U-section in CAT IV 300 V environment, make sure that the minimum aerial and ground distance of live uninsulated parts of conductors in the terminals **U1**, **U2**, **U3** and **Nm** from the panel is more than 11 mm.
2. Connect voltage terminals **U1**, **U2**, **U3** through a disconnecting element to phase conductors L1, L2, L3. Use a three-pole disconnector, e.g. OPVP with 1.0 A cylinder fuses with a size of 10 × 38 mm.
3. Connect the **Nm** terminal to the neutral conductor.
4. The hf grounding terminal ⏚ always connects to the ground. In a LV TN-C type network to the **PEN** conductor, and in a LV TN-S network to the **PE** conductor.
5. If backed-up power supply of the MEg45PAN monitor is needed, a DC power supply shall be used with the rated voltage from 12 V to 24 V. The plus pole of the power supply shall be connected over the first fuse of the two-pole fuse disconnector to the **+** terminal of the monitor, and the minus pole of the power supply shall be connected over the second fuse of the two-pole fuse disconnector to the **–** terminal of the monitor.

   To power only the MEg45PAN monitor, use fuses with a rated value of 1.0 A. To power the MEg45PAN unit and three AMOS/1A converters, use fuses with a rated value of 4.0 A.
6. Check the conformity of the marking of the current inputs on the rear panel of the device with the type of connected current sensors.

   The first standard version MEg45PAN with $I_n = 5\,A | 1\,A$ is connected to secondary circuits with the given rating. The choice between 5 A or 1 A rated current is to be made after measurement parametrization.

   The second standard design with one of the rated input voltages of 225 mV or 150 mV or 22.5 mV allows connection of low power **LCT** transformers or **TOR** toroids with the same rated output voltage.

The third, special version of MEg45PAN connects directly to the loops of **AMOSm** flexible sensors.

a) Standard instrument solid-core current transformers with a convenient rated value of primary current and with a rated secondary current of 5 A or 1 A are connected to the measured LV phases L1, L2 and L3. Measured current enters the **P1(K)** terminal of the primary winding of the transformer connected in the L1 phase and exits from the **P2(L)** terminal towards the load. The **S1(k)** terminal of their secondary winding is connected to the **S1** terminal of the monitor I1 current and grounded; the **S2(l)** terminal of the secondary winding is connected to the **S2** terminal of the monitor I1 current. The same procedure shall be used for connecting the instrument current transformers in the L2 and L3 phase. Possible disassembling of the MEg45PAN monitor or other measuring instruments connected in the secondary circuit of a current transformer not allowing short-circuiting of its output terminals or without protection for secondary circuit disconnection is enabled by the installation of short-circuiting double-terminals as close as possible to these terminals, which enable short-circuiting of the secondary circuit of the transformer even during operation, see Figure 19.

b) A current transformer of the **MTPD.51** type with split-core and integrated low-loss protection against disconnecting of the secondary circuit and with a given rated primary current shall be set in the open position on the L1 phase conductor with measured current so that the arrow on the transformer is in the direction of the flow of measured current towards the appliance. Then, engage the turning part of the core in the fixed part of the core and secure it using a colour-contrasting pin inserted in the common hole of both parts of the core. The output cable of the transformer with marked conductors **S1(k)** and **S2(l)** shall be connected to the corresponding **S1** and **S2** terminals of the I1 current of the MEg45PAN monitor with currents $I_n = 5\,A / 1\,A$, refer to Fig. 20.

   To mechanically attach the transformer at the place of installation on a conductor with measured current, use one or two profiled clamps with holes for cable ties. Mount the clamps on the fixed part of the transformer. Use cable ties threaded through the holes in the clamps to attach the current transformer to the conductor with measured current.

c) A flexible **AMOS/1A** sensor consists of a sensing loop connected to a converter unit by means of a 2 m long shielded cable with a red and black terminal and a shielding terminal. These terminals are connected to terminals **B1** (red), **B2** (shielding) and **B3** (black) of the converter unit during production. The A line terminals on the bottom of the converter are designed for output current and power supply to the unit. The common **A1** terminal of the sensor connected to phase L1 shall be connected to the minus pole of supply voltage with a rated value of 12 – 24 V and to the **S1** terminal of the I1 current input of the monitor, which shall be grounded at the same time. The **A2** terminal shall be connected to the **S2** terminal of the I1 monitor input and the **A3** terminal shall be connected to the plus pole of supply voltage. Connect the circuits of AMOS/1A sensors of phases L2 and L3 in the same way. When installing sensing loops, the arrow direction on the loop must be in the direction of the current flowing to the load.

During three-phase measurement, the three converter units with connected sensing loops can be installed on a DIN TS35 rail with a minimum width of 54 mm (3 × 18 mm), extended by holes for fastening the rail. The DIN rail preferably installs on a panel or walls of a LV cabinet in the horizontal position and the converter unit in such a way that the B line terminals are on top. The place of installation of a converter unit is at the distance of 2 m from the place of installation of the measuring loops. An example of connection of the **A1**(-U_N, k), **A2**(l), **A3**(+U_N) contacts of all three converter units to the input current terminals **S1** and **S2** of the I1, I2 and I3 current inputs of the MEg45PAN monitor, grounding of the -U_N, k terminals and connecting of power supply to the converter units is shown in Fig. 21.

Finally, measuring loops of flexible AMOS/1A sensors shall be installed on the L1, L2 and L3 phase conductors with measured currents as follows:

Open the AMOSm measuring loop by turning the lock on its closure and wrap the free end of the loop around the conductor with measured current in such a way that the direction of current flowing towards the load is the same as the direction of the arrow on the pictogram on the loop closure. Insert the free end of the loop in the loop closure deep enough to be locked against accidental extraction by the lock.

When installed on the ribbon steel of a LV busbar, fix the position of the loop on the busbar using a clamp with a clearance of 5 mm or 10 mm. Mount the clamp on the busbar at the site of installation, insert the closed closure of the flexible sensor loop in its cavity so that the closure is guarded against accidental opening and, moreover, the body of the clamp reduces direct electric and thermal contact between the busbar and the loop.

During installation on a round or segment conductor of a LV cable, use a thin securing band that pulls the lock towards the inserted free part of the closure. Attach the closed measuring loop secured against opening and wrapped around the conductor with the measured current using one or two cable ties to the conductor with the measured current. Preferably, attach the measuring loop to the conductor with the measured current at a point farthest from the closure. The closure should not be near another conductor. The conductor at the place of installation of the flexible sensor loop can be without insulation as well.

The cables and loops meet the safety and insulation requirements of CAT IV 300 V and the environment temperature of up to 120 °C.

d) Before installing **LCT** low-power split-core transformers, make sure they are at a safe air and surface distance from live parts at the place of their installation. If necessary, make sure they are safely isolated by using additional insulation.

Before the installation, also make sure that the rated primary current value of all three sensors is the same.

TORm and **TORv** toroids meet the requirements of the CAT IV 300 V measuring category and can therefore be installed in a voltage-free state directly on live conductors.

LCT transformers, like TOR toroids, have a 2 m long shielded output cable with S1 or k and S2 or l terminals, with the cable shield connected to the k terminal.

Connect the **S1** or **k** terminals of the three LCT sensors or TOR toroids to the **S1** terminals of the monitor current inputs. The **S1** terminals shall also be grounded.

Connect the **S2** or **l** terminals of the three LCT sensors or toroids to the **S2** terminals of the monitor current inputs.

When installing the LCT and TOR sensors, make sure the direction of the arrow on the sensor matches the direction of the current flow towards the load.

The LCT low-power current transformers are to be installed on de-energized phase conductors with the cores open, and the sensor connected to the **I1** current input of the monitor shall be positioned on the L1 phase and engaged, the sensor connected to the **I2** current input of the monitor shall be positioned on the L2 phase, and the sensor connected to the **I3** current input of the monitor shall be positioned on the L3 phase. The position of the sensor on the conductor with the measured current must be secured with two cable ties in the LCT holders surrounding the conductor with the measured current.

Slide the TORv or TORm toroids connected to the I1, I2 and I3 current inputs of the monitor over the L1, L2 and L3 disconnected phase conductors in the de-energized state and reconnect the circuits of the phase conductors. The position of the toroid on the phase conductor with the measured current can be secured with a cable tie.

e) Before installing three **AMOSm** sensor loops on phase conductors with measured current according to Figure 22, check the marking **I1**, **I2** and **I3** on the individual sensors and the conformity of the serial numbers of all three AMOSm sensors with the serial number of the MEg45PAN monitor with which they were calibrated by the manufacturer. Then, check the AMOSm marking near the current on the rating plate of the installed MEg45PAN monitor.

Use the procedure stated in article c) of the previous section to install the measuring loops of AMOSm current sensors on phase conductors with measured currents. The loops of AMOSm sensors have two terminals at the end of the output cable marked **S1** or **k** and **S2** or **l**. The shield of the output cable of the AMOSm sensor is connected in the cable to the k terminal.

Connect the **k** terminal of the AMOSm sensor marked I1 to the **S1** terminal of the I1 current of the MEg45PAN monitor, which shall also be grounded. Connect the **l** terminal of this sensor to the **S2** terminal of the I1 current of the monitor. Similarly, connect the terminals of the AMOSm sensor loop marked I2 to the I2 current terminals of the monitor and connect the terminals of the AMOSm sensor loop marked I3 to the I3 current terminals of the monitor.

7. The MEg45PAN universal monitor can also be used for single-phase measurement, see Figure 32. In this case, the measured voltage must be connected to the **U1** input and the measured current to the **I1** terminals.
8. The galvanically free switching contacts of up to four external devices powered by the internal 24 V voltage of the MEg45PAN monitor in Figure 26 are to be connected to terminals **1** to **4** of the **IN** inputs. If the switching contacts are grounded by one pole, these poles must be connected to the common contact **G** of the five-pole **IN** input connector.
9. The galvanically free output switching contact of the MEg45PAN monitor relay at terminals **21** and **22** of the **OUT** output allows switching of DC and AC circuits with a rated voltage up to 48 V and a current up to 2 A. The function of the monitor output contact is verified by checking the function of the second isolated contact of the output relay.

   Figure 27 shows an example of switching of an AC LV circuit with external REL IV/DC relay in DIN rail design with CAT IV 300 V overvoltage category between input and output circuits.
10. Figure 28 to Figure 31 show the basic connection of MEg45PAN with local and remote communication.

    Figure 28 shows local communication of monitors via the RS485 interface with a local measuring and control system using a shielded twisted pair. For communication of multiple devices with the **RS485** interface, interconnect the **A** terminals of all devices and the **B** terminals of all devices and connect the **G1** terminals of all devices to the shielding of a twisted pair that should not be longer than 30 m in total in a CAT IV 300 V environment. Connect a terminating resistor of 120 Ω between the **A** and **B** terminals of the last communicating device. In MEg45PAN, they can also be connected via a SW command.

Figure 29 shows data collection from electric meters in a LV network through a **data concentrator** (e.g. type PLC) and their further secure transmission via a transparent channel with the IPsec function through a GSM network to the information system of a distribution company.

The connection of the **GSM** remote communication antenna and the **GPS** time synchronisation antenna to the MEg45PAN monitor is shown in Figure 30.

Figure 31 shows an example of MEg45PAN connection to an Ethernet network through a cable inserted in a RJ45 WS 8-8 connector labelled **ETH**.

If the monitor is to be connected to local and remote communication in a dangerous voltage environment, use a cable meeting the safety requirements for that environment or attach a standard cable so as to meet the safety surface and air distances.

Multiple MEg45PAN universal monitors can be connected to an Ethernet network through a Switch unit, see Figure 31. In a LV cabinet, use a safe ETH extension cable with a length of 2.5 m and additional LV insulation.

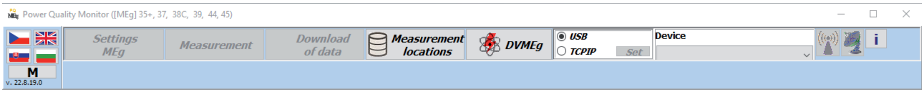
7/ SWITCHING ON THE MONITOR, PREPARATION FOR MEASUREMENT

1. After switching on any of the measured voltages or supply voltage, the **RUN** LED flashes with a delay of approx. 2 s, necessary to start the power supply and check the correct function of the individual monitor blocks. The flashing pattern is determined by previous programming of the monitor.

   If the **RUN** LED is continuously on or off, the monitor or power supply is in a fault state.

   LINUX starts approximately 2 minutes after connecting supply voltage.
2. The software **PQ_MEg** launches in the inspection computer. If it launches correctly, the main window with a bar according to Figure 33 is displayed, where USB communication is to be selected. For a detailed description of the PQ_MEg software, visit www.e-mega.cz/DL.

Figure 33: Start of the PQ_MEg software



3. Use a USBmini communication cable to connect the inspection computer to the MEg45PAN monitor. The main window will display information on the SW and FW version. The bar in the main window displays the type and serial number of the connected monitor, see Figure 34.

Fig. 34: Confirmation of USB communication between MEg45DIN and an inspection computer

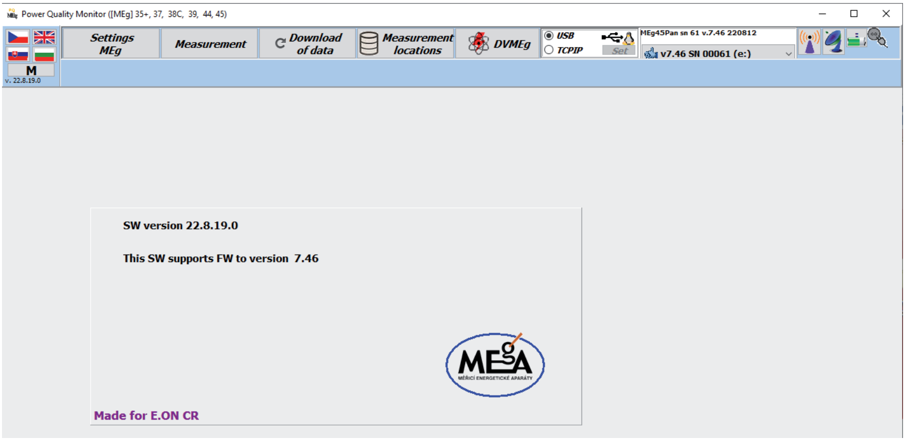
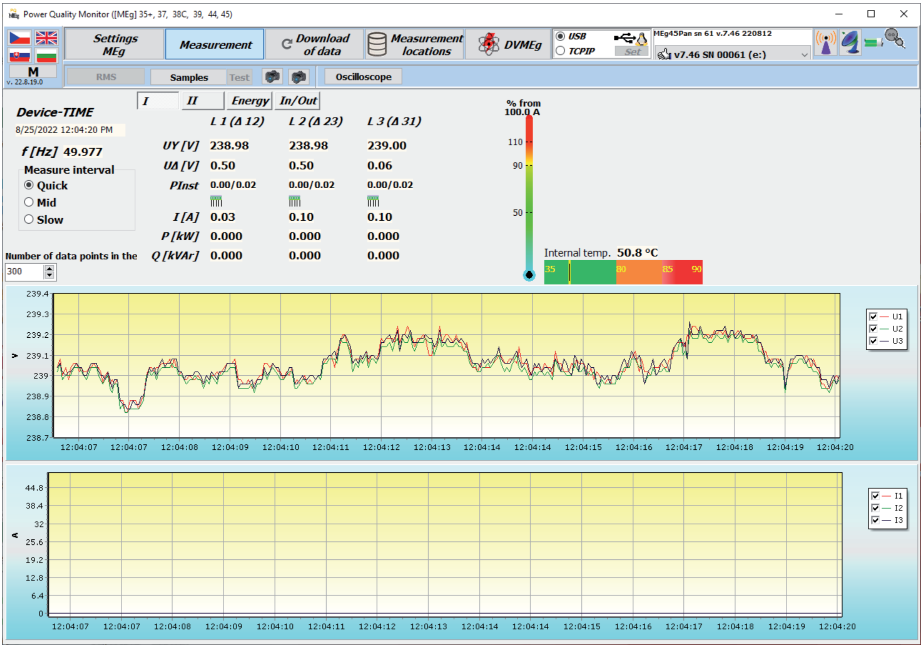
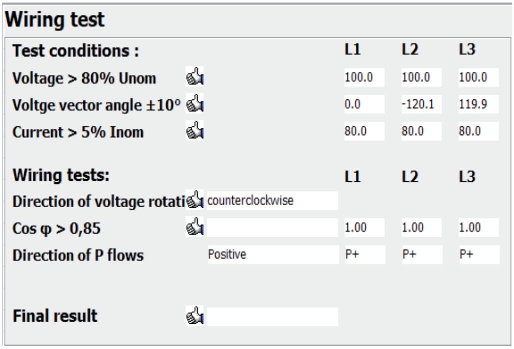


Fig. 35: Connection of measured voltages and currents



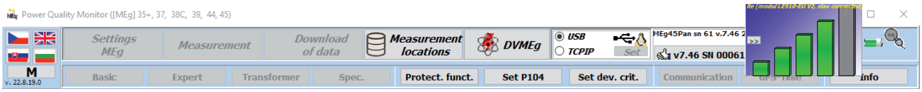
4. In the main bar, select **Měřidlo** (**Meter**) according to Figure 35. This shows the values of the connected phase voltages and phase currents in the **Samples** view. To check the correct direction of current connection, correct direction of phase voltage rotation and correct assignment of phase currents to phase voltages, press the **Test** button. An example of a correct test is shown in Figure 36.

Fig. 36: Check of the correct connection of measured voltages and currents



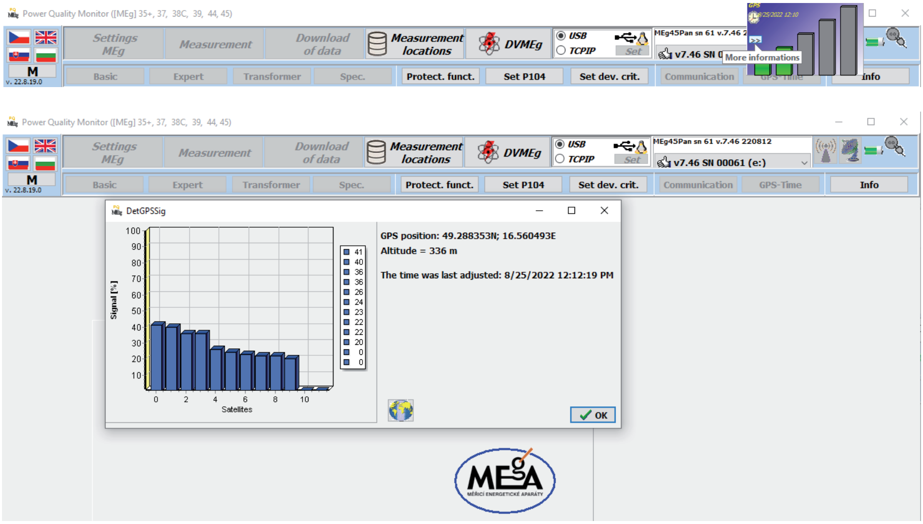
5.  A check of the correct connection of a GSM network antenna with sufficient GSM network signal intensity is indicated by a highlighted GSM network pictogram at the end of the main bar of the program. Click on the pictogram to display information on the GSM network signal intensity at the antenna installation location, see Fig. 37.

Fig. 37: Display of the GSM network signal intensity at the antenna installation location



6.  Approximately 2 minutes after connecting a GSM antenna installed with direct sky visibility, the GPS pictogram will be highlighted. After it is activated, a new window will display the number of received satellites, the monitor installation location and the moment of the last synchronisation of the monitor time, see Figure 38.

Fig. 38: Information on the GPS signal reception conditions at the antenna installation location and data in MEg45DIN



8/ MAINTENANCE

Caution

- The repairs of the MEg45PAN universal monitor during the warranty period may only be carried out by the manufacturer's skilled and trained personnel or by the manufacturer's service organizations.
- The monitor may not be exposed to chemicals.
- The monitor must only be transported in original transport packaging supplied by the manufacturer.

The monitor does not require any special maintenance if properly used in compliance with this user manual. Only if dirty should the device be carefully cleaned with a damp cloth without using cleaning agents.

Batteries

The monitor uses the following batteries:

- type CR2032 lithium battery for the clock circuit,
- supercapacitors with a declared lifetime of 10 years.

Fuses

To protect the measuring voltage inputs of the monitor, which also power the monitor, use cylinder fuses 10×38gG 1.0 A.

To protect the auxiliary DC power supply of the monitor, use cylinder fuses 10×38gG 1.0 A.

To protect the auxiliary DC power supply of the monitor and the trio of AMOS/1A flexible sensors, use 10×38gG 4.0 A cylinder fuses.

9/ DISPOSAL

When the service life of the MEg45PAN universal monitor is over, it must be recycled at waste disposal sites according to rules for electronic waste disposal.

10/ WARRANTY

The MEg45PAN universal PQ monitor is covered by a 24-month warranty from the date of purchase, however not longer than 30 months from the date of release from the manufacturer's warehouse. Defects originating during this period as a demonstrable result of defective design, manufacturing or using improper material will be repaired free of charge by the manufacturer.

It is not permitted to open the MEg45PAN universal monitor during the warranty period.

The warranty becomes void if the user carries out unauthorized modifications or changes on the MEg45PAN monitor, if the user connects the monitor incorrectly or if the monitor has not been operated in accordance with technical conditions.

Defects on the MEg45PAN monitor originating during the warranty period shall be claimed by the user with the manufacturer. The claimed monitor shall include the warranty certificate.

Under no circumstances the manufacturer is liable for subsequent damage caused by using the MEg45PAN monitor. This warranty does not in any case imply manufacturer's liability exceeding the price of the MEg45PAN monitor.

11/ ORDERS

The basic version of MEg45PAN has:

voltage inputs U_n = 230 V, serial interface RS485 and ETH interface, four input and one output signal, three-phase power supply from measured voltages, auxiliary power supply with rated DC voltage 12 V to 24 V. The MEg45PAN panel design has a display with three control buttons.

The basic MEg45PAN design includes current inputs with a programmable standard range of 5 A / 1 A or one of 225 mV, 150 mV, 22.5 mV standard voltages or non-standard inputs for AMOSm flexible sensors.

- Function W0, Recorder
- Function W1, Voltage quality
- Function W2, Voltage phenomena and events related to currents
- Function W5, Four-quadrant active and reactive electric meter
- 1 communication cable USBmini 1.5 m
- 1 socket for a nano SIM card 115S-ACA1

Optional accessories for the MEg45PAN variant:

- Function W3, Oscillographic measurement
- Function W4, Evaluation of HDO telegrams
- Function W6, Measurement of fast active energy
- Function W7, Direction protection
- Function W8, Two-stage undervoltage and overvoltage protection
- Function W9, Protection according to voltage and current unbalance
- Function W10, Indication of a blown MV fuse
- Three current transformers MTPD.51, I_n = 400 A, 600 A, 1000 A [1)]
- Three clamps for MTPD.51 transformer with cable ties
- Three LCT current transformers with accessories according to Tab. 2
- Three TORm toroids
- Three TORv toroids
- Three AMOSm/1A flexible sensors, Tab. 3
- Three loops of AMOSm flexible sensors, Tab. 3
- Three AMOSm and AMOS/1A sensor holders, busbar clearance 10 mm
- Three AMOSm and AMOS/1A sensor holders, busbar clearance 5 mm
- GPS time synchronisation module
- GSM remote communication module

- LTE/GPS PUCK, mounting antenna AO-AKOM-36SS/MEgA [2)]
- GPS PUCK, mounting antenna GPS PUCK AP-AGPS-36/MEgA [2)]
- LTE rod, rod antenna LTE AO-ALTE-G124S/MEgA [2)]
- GPS magnet, GPS magnetic antenna AP-A20C-M5RA/MEgA [2)]
- GPS extension cable /10 m [3)] with thicker insulation with a length of 2.5 m
- GSM extension cable /2.5 m [3)]
- ETH safe extension cable /2.5 m [3)]
- Cable USB OTG AF to mini-BM, 15 cm for flash drive connection

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[1)] Can be ordered with I_n = 100 A, 200 A
[2)] Technical data are provided in Chapter “GSM and GPS antennas of the MEg45PAN PQ monitor”
[3)] Other lengths are available

Specification of an order of MEg45PAN

MEg45PAN / X / W3 to W10 / cl. A or cl. S

X:
- 5 A, 1 A
- 225 mV
- 150 mV
- 22,5 mV
- AMOSm

W3 to W10:
- W3 Oscillographic measurement
- W4 HDO telegram evaluation
- W6 Measurement of active energy at rapid changes of flow direction
- W7 Direction protection function
- W8 Two-stage undervoltage and overvoltage protection
- W9 Protection according to voltage and current unbalance
- W10 Indication of a blown MV fuse

Cl. A means Class A and Cl. S means Class S according to EN 61000-4-30, ed. 3

Order examples:
- MEg45PAN/5A,1A/W3,W7,W8/cl.A
- MEg45PAN/225mV/W8,W9/cl.S
- MEg45PAN/AMOSm/W3/cl.S

Tab. 2: Current ranges of LCT split-core transformers (× = yes, ⁄ = no)

Diameter [mm]	Primary current											
	5A	10A	20A	60A	75A	100A	120A	200A	300A	400A	500A	600A
10	×	⁄	×	×	×	⁄	⁄	⁄	⁄	⁄	⁄	⁄
16	⁄	⁄	⁄	⁄	⁄	×	×	×	⁄	⁄	⁄	⁄
24	⁄	⁄	⁄	⁄	⁄	×	⁄	×	⁄	×	⁄	⁄
36	⁄	⁄	⁄	⁄	⁄	⁄	⁄	⁄	×	×	×	×

Tab. 3: Current ranges of AMOS/1A flexible sensors and AMOSm loops (× = yes, ⁄ = no)

Loop length	Primary current					
	30A	100A	300A	1000A	3000A	5000A
short	×	×	×	×	⁄	⁄
standard	×	×	×	×	×	⁄
long	⁄	⁄	⁄	×	×	×

12/ TECHNICAL PARAMETERS

General information

The MEg45PAN universal monitor meets, according to EN 61010-2-30, the measuring category and the overvoltage category of CAT IV 300 V.

The MEg45PAN universal monitor is classified, according to EN 62586-1, as PQI-A-FI1-H or PQI-S-FI1-H.

The development and production of the monitor is in conformity with ISO 9001, ISO 14001:2005, OHSAS 18001:2008, ISO/IEC 27001:2014.

Operating conditions

Operating temperature:	-10 °C to +45 °C, guaranteed measurement uncertainty
Threshold operating temperature:	-25 °C to +55 °C
Stabilisation period:	10 minutes after start-up
Relative humidity:	5 % to 95 %, non-condensing
Altitude:	up to 2000 m

Design data

Dimensions:	90 × 90 × 90 mm, frame 96 × 96 mm
Weight:	0.5 kg
Measuring category:	CAT IV 300 V according to EN 61010-2-030:2011
Safety class:	II, reinforced insulation
Protection:	IP30 front panel, IP20 body and rear panel
Use:	interior
Pollution degree:	2
Enclosure panel thickness:	1 mm to 2 mm

Power supply

	From measuring inputs	**Auxiliary**
Range:	160 V_{AC} to 300 V_{AC} for CAT IV 160 V_{AC} to 460 V_{AC} for CAT III	10 V_{DC} to 30 V_{DC}
Input power:	6.5 W	5 W
Frequency:	50 Hz ± 15 %	
Internal uninterruptible power supply:	20 s with charged supercapacitors, charge time 5 minutes	

Protection

$U_n = 160\,V_{AC}$ to $460\,V_{AC}$:	3 cylinder fuses 10 × 38gG 1,0 A fuse disconnector OPVP-3
$U_n = 12\,V_{DC}$ to $24\,V_{DC}$:	2 cylinder fuses 10 × 38gG 1,0 A fuse disconnector OPVP-2

Measuring characteristics

A/D converter:	16 bit
Sampling frequency:	256 samples per period
Anti-aliasing filter:	digital filter, type FIR
Phase-locked loop:	controlled by the passage of the fundamental harmonic voltage U1 through zero
Aggregation intervals:	quality function – according to EN 61000-4-30, ed. 3 recorder function – from 1 s to ¼ hod
Synchronisation of aggregation:	according to EN 61000-4-30, ed. 3, class A
Time base:	±1 s in 24 h at the operating temperature without external synchronisation ±1 ms at the operating temperature with GPS
Data memory capacity:	512MB, circular organization for each function

Voltage inputs U1, U2 and U3

Rated phase voltages U_n, P-N:	$230\,V_{AC}$
Rated line voltages U_n, P-P:	$400\,V_{AC}$
Maximum voltage, P-N:	$300\,V_{AC}$ for CAT IV
Voltage measuring range, P-N, cl. S:	$0.2\,V_{AC}$ to $350\,V_{AC}$
Voltage measurement uncertainty, P-N, cl. S:	±0.2 % M.V. ± 0.025 % U_n, f = 50 Hz
Voltage measuring range, P-N, cl. A:	$0.2\,V_{AC}$ to $460\,V_{AC}$
Voltage measurement uncertainty P-N, cl. A:	±0.05 % M.V. ± 0.025 % U_n, f = 50 Hz
Change of value with temperature:	0.05 % U_n /10 K
Input resistance of voltage inputs:	1.68 MΩ

Voltage inputs with a common center conductor are separated by a high resistance.

Current inputs I1, I2 and I3

Rated value of current I_n:	$5\,A_{AC}$ / $1\,A_{AC}$ electronically switched, CAT II / 300 V
Rated voltage value at I_n [1)]:	$225\,mV_{AC}$, $150\,mV_{AC}$, $22.5\,mV_{AC}$
Current measuring range:	1 % I_n up to 200 % I_n
Current measuring uncertainty [2)]:	±0.2 % M.V. ± 0.025 % I_n (45 Hz to 60 Hz)
Overcurrent measuring range:	200 % I_n up to 1000 % I_n
Overcurrent measuring uncertainty [2)]:	±0.5 % M.V. (45 Hz to 60 Hz)
Change of value with temperature:	0.05 % I_n /10 K
Permanent overload:	$10\,A_{AC}$
Maximum current, 1 s:	$50\,A_{AC}$, 1 / 1 min
Input resistance of current inputs:	≤ 50 mΩ

Current inputs are galvanically free.

The current measurement parameters of the MEg45PAN set with current sensors MTPD.51, AMOS/1A, LTE, TOR and AMOSm are supplemented by the parameters listed in the following chapter Current sensors of the MEg45PAN universal PQ monitor.

Active power, reactive power, PF, energy

Active power [2)]:	±0.5 % M.H. ± 0.2 % P_n	at U ≥ 80 % U_n, I ≥ 5 % I_n, PF ≥0.5
Reactive power [2)]:	±0.5 % M.H. ± 0.2 % Q_n	at U ≥ 80 % U_n, I ≥ 5 % I_n, PF ≤ 0.866
PF:	±0.01	at U ≥ 80 % U_n, I ≥ 5 % I_n
Active energy:	Class B	EN 50470-1
Reactive energy:	Class 1	TPM 2440-08, ČMI 2008

Note [1)] One of the values [2)] at I_n = 1 A, 5 A and I_n = 225 mV, 150 mV
M. V. – measured value

IN input contacts

Number:	4, with common pole
Internal supply voltage:	$24\,V_{DC}$
Max. resistance of contact external circuit:	100 Ω

OUT output contacts

Number:	1, galvanically free switching contact
Rated switched voltage:	12 V or 24 V, DC or AC
Maximum switched current:	2 A
Maximum switched voltage:	48 V

USB interface

Type:	USB2.0
Communication speed:	5.4 Mbit/s
Connector:	USBmini B
Flash drive:	maximum supply current 100 mA

RS485 interface

Default settings:	115.2 kbit/s, 8 bit, no parity, one stop bit
MODBUS RTU protocol:	Application Protocol Specification V1.1b3

ETH communication

Speed:	10/100 Mbps Ethernet,
Standard:	Ethernet verze 2.0/IEEE 802.3
Protocols for data reading:	MODBUS TCP, IEC 60870-5-104, DLMS/COSEM
VPN protocols:	L2TP/IPsec, IKEv2/IPsec
Management:	SSH (including central management of user access by means of the RADIUS or TACACS+ protocol), SNMP, SYSLOG
Other properties:	Firewall, static routing, dynamic routing protocols
Connector:	RJ45 type WS 8-8

GSM communication

SIM card type:	mini SIM	
Technology:	LTE Cat. 4, HSPA+, EDGE, GPRS (class B, CS1 to CS4)	
Frequency bands [MHz]:	4G	B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800)
	3G	B1 (2100), B8 (900)
	2G	B3 (1800), B8 (900)

Watchdog for modem restart in case of communication loss

Protocols, management and other properties are the same as for ETH communication

ETH time synchronization

Protocols:	NTP, IEC 60870-5-104, MODBUS TCP

GPS time synchronization

Uncertainty:	± 1 ms	Frequency band:	GPS(L1)
Standards:	NMEA, RTCM104		

Classification of MEg45PAN universal monitor according to EN 62586-1

Universal monitor MEg45PAN Cl. A is classified **PQI-A-FI1-H**,
Universal monitor MEg45PAN Cl. S is classified **PQI-S-FI1-H**,
f = 50 Hz, CAT IV 300 V according to EN 61010-2-030.

Table of the MEg45PAN functions according to IEC 61000-4-30, ed.3

Functions and measured data	Method of measurement	Measurement uncertainty, measuring range	
		MEg45PAN cl. S	MEg45PAN cl. A
Net frequency, 10 s data	Class A	Class S	Class A
Voltage value, 150 periods, 10 min, 2 hours	Class A	Class S	Class A
Flicker, 10 min P_{st}, 2 hours P_{lt}	Class A	Class S	Class A
Voltage drops and increases, residual and max. U, T duration	Class A	Class S	Class A
Supply voltage interruption, residual and maximum U, T duration	Class A	Class S	Class A
Voltage unbalance, 150 periods, 10 min, 2 hours	Class A	Class S	Class A
Harmonic voltages, 150 periods, 10 min, 2 hours	Class A	Class S	Class A
Interharmonic voltages, 150 periods, 10 min, 2 hours	Class A	Class S	Class A
Voltage of signals in the supply voltage, voltage value	Class A	Class S	Class A
Positive and negative voltage deviations, 150 periods, 10 min, 2 hours	Class A	Class S	Class A
Rapid voltage changes - RVC, $U_{RMS1/2}$	Class A	Class S	Class A

Note: According to EN 61557-12, the MEg45PAN universal monitor is a measuring device of the PMD SD class (performance measuring and monitoring device) with current measurement by means of sensors and direct voltage measurement. It integrates the functions of recording, electric energy measurement, voltage quality measurement, recording of HDO telegrams.

Measurement uncertainty and measuring ranges of voltage quality parameters during test conditions 1, 2 and 3 according to EN 61000-4-30, ed. 3

Parameter	MEg45PAN Class S		MEg45PAN Class A	
	Uncertainty	Measuring range	Uncertainty	Measuring range
Frequency	± 2 mHz	42.5 Hz – 57.5 Hz	± 2 mHz	42.5 Hz – 57.5 Hz
Voltage deviation	± 0.2 % U_n	10 % U_n – 120 % U_n	± 0.1 % U_n	10 % U_n – 150 % U_n
Flicker P_{st}, P_{lt}	± 7.5 % P_{st}, P_{lt} IEC 61000-4-15, ed. 2	P_{st}, P_{lt} (0.4 – 4.0) 1–4000changes/min	± 5.0 % P_{st}, P_{lt} IEC 61000-4-15, ed. 2	P_{st}, P_{lt} (0.2 – 10.0) 1–4000changes/min
Flicker $P_{inst, max}$	8 % $P_{inst, max}$	$P_{inst, max}$ (0 – 4) sinus, right angle	8 % $P_{inst, max}$	$P_{inst, max}$ (0 – 10) sine, rectangular
Voltage phenomena	Amplitude: ± 0.5 % U_n Duration: ± 1 period	5 % U_n – 150 % U_n 0.02 s – 1.0 s [1)]	Amplitude: ± 0.2 % U_n Duration: ± 1 period	5 % U_n – 200 % U_n 0.02 s – 1.0 s [1)]
Interruption	Duration: ± 1 period	0.02 s – 1.0 s [1)]	Duration: ± 1 period	0.02 s – 1.0 s [1)]
Unbalance	± 0.2 %	1.0 % u_2 – 5 % u_2 1.0 % u_0 – 5 % u_0	± 0.15 %	0.5 % u_2 – 5 % u_2 0.5 % u_0 – 5 % u_0
Harmonic voltages	± 5 % U_{harm}, $U_{harm} \geq 3\,\%\,U_n$ ± 0.15 % U_n, $U_{harm} < 3\,\%\,U_n$	10 % – 100 % cl. 3 IEC 61000-2-4	± 5 % U_{harm}, $U_{harm} \geq 1\,\%\,U_n$ ± 0.05 % U_n, $U_{harm} < 1\,\%\,U_n$	10 % – 200 % cl. 3 IEC 61000-2-4
Inter-harmonic voltages	± 5 % U_{harm}, $U_{harm} \geq 3\,\%\,U_n$ ± 0.15 % U_n, $U_{harm} < 3\,\%\,U_n$	10 % – 100 % cl. 3 IEC 61000-2-4	± 5 % U_{harm}, $U_{harm} \geq 1\,\%\,U_n$ ± 0.05 % U_n, $U_{harm} < 1\,\%\,U_n$	10 % – 200 % cl. 3 IEC 61000-2-4
Signals in voltage	± 10 % U_{sig} for $3\,\%\,U_n \leq U_{sig} \leq 15\,\%\,U_n$, ± 0.3 % U_n for $1\,\%\,U_n \leq U_{sig} \leq 3\,\%\,U_n$	0 % U_n – 15 % U_n	± 5 % U_{sig} for $3\,\%\,U_n \leq U_{sig} \leq 15\,\%\,U_n$, ± 0.15 % U_n for $1\,\%\,U_n \leq U_{sig} \leq 3\,\%\,U_n$	0 % U_n – 15 % U_n
Rapid voltage changes – RVC, $U_{RMS1/2}$	Amplitude: ± 0.5 % U_n Duration: ± 1 period	Treshold 1.0 – 10 % U_n Hysteresis 50 % tresh.	Amplitude: ± 0.2 % U_n Duration: ± 1 period	Treshold 1.0 – 10 % U_n Hysteresis 50 % tresh.
Current	± 2 % $I_{measured}$	10% – 100 % I_{max}	± 1 % $I_{measured}$	10% – 100 % I_{max}
Time base	± 1 s per 24 h, ± 10 ms with GPS function	–	± 1 s per 24 h, ± 10 ms with GPS function	–

[1)] With uninterruptible power supply, duration depends on the external power supply

Overview of evaluated quantities in record function

F evaluated values during measurement of phase voltage

S evaluated values during measurement of line voltage

Quantity	Symbol	For each phase	For the three--phase terminal	Average/sum per interval [1)]
Effective voltage	U_{ef}	F, S		F, S
Voltage harmonics – 1st to 64th harmonic	$U_{1.h}$ to $U_{64.h}$	F, S		F, S
Overall harmonic distortion of voltage	THD_U	F, S		F, S
Effective current	I_{ef}	F, S		F, S
Current harmonics – 1st to 64th harmonic	$I_{1.h}$ až $I_{64.h}$	F, S		F, S
Overall harmonic distortion of current	THD_I	F, S		F, S
Power factor	$\cos\varphi$	F	F, S	F, S
Power factor	PF	F	F, S	F, S
Active power	P	F	F, S	F, S
Reactive power	Q	F	F, S	F, S
Apparent power	S	F	F, S	F, S
Deformation power	D	F	F	F
Unbalance power [2)]	N		F, S	F, S
Active power (1st harmonic)	$P_{1.h}$	F	F, S	F, S
Reactive power (1st harmonic)	$Q_{1.h}$	F	F, S	F, S
Apparent power (1st harmonic)	$S_{1.h}$	F	F, S	F, S
Unbalance power (1st harmonic)	$N_{1.h}$		F, S	F, S

Quantity	Symbol	For each phase	For the three--phase terminal	Average/sum per interval [1)]
Active energy – consumption	EP+	F	F, S	F, S
Active energy – supply	EP-	F	F, S	F, S
Reactive inductive energy during active consumption	EQL/EP+	F	F, S	F, S
Reactive capacitive energy during active consumption	EQC/EP+	F	F, S	F, S
Reactive inductive energy during active supply	EQL/EP-	F	F, S	F, S
Reactive capacitive energy during active supply	EQC/EP-	F	F, S	F, S
Active energy – consumption (1st harmonic)	$EP+_{1.h}$	F	F, S	F, S
Active energy – supply (1st harmonic)	$EP-_{1.h}$	F	F, S	F, S
Reactive inductive energy during active consumption (1st harm)	$EQL/EP+_{1.h}$	F	F, S	F, S
Reactive capacitive energy during active consumption (1st harm)	$EQC/EP+_{1.h}$	F	F, S	F, S
Reactive inductive energy during active supply (1st harm)	$EQL/EP-_{1.h}$	F	F, S	F, S
Reactive capacitive energy during active supply (1st harm)	$EQC/EP-_{1.h}$	F	F, S	F, S

1) Record interval adjustable from 1 s to 15 minutes. Energy represented by total value per interval, other quantities are average values per interval.

2) In the line voltage measuring mode, the unbalance power contains even deformation influences.

3) In the recorder function, the 200 ms maxima and 200 ms minima are evaluated for phase voltages and 200 ms maxima for phase currents at each recording interval.

13/ LITERATURE

[1] User description of PQ – MEg, www.e-mega.cz/DL

[2] User description of MEgA Explorer, www.e-mega.cz/DL

[3] User description of MEgA Merci Multi, www.e-mega.cz/DL

[4] User description of MODBUS TCP protocol for MEgA instruments, www.e-mega.cz/DL

[5] User description of ČSN EN 60870-5-104 protocol for instruments on request

[6] User description of WebDatOr2, on request

14/ MANUFACTURER

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AGSM AND AGPS ANTENNAS OF THE MEg45PAN UNIVERSAL MONITOR

Antennas	**AO-AKOM-36SS/MEgA**	**AO-ALTE-G214S/MEgA**
Use	GSM/UMTS/LTE/GPS	GSM/UMTS/LTE
Frequency bands MHz	800 / 900 / 1700 / 1800 1900 / 2100 / 2600 2700 /1757.42	700 / 800 / 900 / 1700 1800 / 1900 / 2100 / 2600
Gain	0 / 30 dBi	6 dBi
VSWR	< 2.0 : 1	< 3.0 : 1
Impedance	50 Ω	50 Ω
Direction	omnidirectional	omnidirectional
HPBW	H 360° V 30°	H 360° V 30°
Polarisation	linear / R.H.C.P.	vertical
Maximum output power	10 W	10 W
Supply voltage	2.7 - 5.5 V_{DC}	-
Dimensions	ø 54.4 × 24.6 mm	315 × ø 29.5 mm
Weight	165 g	55.99 g
Operating temperature	-30 °C to +90 °C	-40 °C to +85 °C
Design	PUCK	whip
Mounting method	installation	magnetic
Cable type	2 × RG174/U	R174/U
Cable length	2 × 3 m	3 m
Connector type	SMA(m) / SMA(m)	SMA(m)
Overvoltage category	CAT IV 2.5 m	CAT IV
Safety class	II 2.5 m	II 2.5 m

Antennas	**AP-AGPS-36/MEgA**	**AP-A20C-M5RA/MEgA**
Use	GPS	GPS
Frequency bands MHz	1575.42	1575.24
Gain	30 dBi	32 dBi
VSWR	< 2.0 : 1	< 2.0 : 1
Impedance	50 Ω	50 Ω
Direction	omnidirectional	omnidirectional
HPBW	H 360° V 30°	H 360° V 30°
Polarization	R.H.C.P.	R.H.C.P.
Maximum output power	10 W	10 W
Supply voltage	2.7 - 5.0 V	2.7 - 5.0 V
Dimensions	ø 54.7 × 23 mm	38.5 × 34.5 × 12.3 mm
Weight	190 g	88.38 g
Operating temperature	-30 °C to +90 °C	-40 °C to +90 °C
Design	PUCK	external
Mounting method	installation	magnetic
Cable type	R174/U	R174/U
Cable length	10 m	5 m
Connector type	SMA(m)	SMA(m)
Overvoltage category	CAT IV 2.5 m	CAT IV 2.5 m
Safety class	II 2.5 m	II

CURRENT SENSORS OF THE MEg45PAN UNIVERSAL PQ MONITOR

Technical data of the MTPD.51 split-core current transformer [1)]

Rated primary current I_n [2)]:	400 A, 600 A, 1000 A
Rated secondary current:	1 A
Rated frequency:	50 Hz
Frequency range:	42.5 Hz to 69 Hz [3)]
Rated load:	2.5 VA
Rated load resistance:	2.5 Ω
Precision class:	0.5 % according to EN 61869-2
FS safety factor:	5
Rated short-term thermal current I_{tn}:	$10 \times I_n$
Rated dynamic current I_{dyn}:	$2.5 \times I_{tn}$
Operating temperature range:	-25 °C to +60 °C
Temperature range with non-destructive effects:	-40 °C to +70 °C
Insulation temperature class:	+120 °C
Maximum temperature of conductor with measured current:	+120 °C
Average relative humidity:	≤ 90 % RH, non-condensing
Ingress protection:	IP20
Impact protection:	IK08
Pollution degree:	2
Altitude:	up to 2000 m
Rated phase voltage of measured conductor:	230 V_{AC}
Maximum rated voltage of measured conductor:	300 V_{AC}
Measuring category:	CAT IV / 300 V
Impulse withstand voltage:	6 kV
Testing voltage:	5.4 kV / 5 s

Safety class:	II
Weight:	0.5 kg
Outer dimensions:	100 × 95 × 29 mm
Dimensions of transformer window:	52 × 33 mm

Supply cable (optional):

Maximum length of supply cable:	10.0 m
Supply cable diameter:	7.0 mm
Supply cable conductor cross-section:	1.5 mm^2
Colour-coding of conductors:	S1(K) – brown, S2(L) – blue

Note: 1) Under the reference conditions: T ambient = 20 °C, humidity 40 to 60 % RH
2) A single value only
3) It shall not be used for currents with a rated frequency value outside the stated frequency range

The MTPD.51 transformer can only be installed in inaccessible areas due to its mechanical strength and high temperature.

Technical data of AMOS/1A flexible sensors

The flexible AMOS/1A sensor consists of an AMOSm sensor with the specified length of measuring loop with shielded cable and of a converter unit with the output voltage of 1 A.

Rated input alternating current I_n [1)] [2)]:	100 A, 160 A, 250 A
Rated output alternating current $I_{n\,OUT}$:	1 A
Measuring range:	max. 1.25 I_n
Load impedance range:	$R_L = 0$ to 2.5 Ω
Band width:	2.5 kHz at $R_L = 1\ \Omega$
Maximum rated load S_{max}:	2.5 VA
Load resistance R_L:	≤ 2.5 Ω, to the common terminal
Internal impedance of current output:	> 1 kΩ
Amplitude error:	≤ 0.5 % I_n for the range from 5 % to 120 % I_n
Phase error:	≤ 1 ° for the range from 5 % to 120 % I_n
Measuring section length – standard, long, short:	400 mm / 600 mm / 200 mm
Sensing part diameter:	8 mm
Diameter of inserted section of the closure:	10 mm
Permitted radius of bend of the sensing part:	≥ 20 mm
Supply cable length [3)]:	2 m
Supply cable diameter:	4.8 mm
Maximum alternating voltage of the measured conductor:	CAT IV/300 V, CAT III/600 V
Sensor safety class:	II, measuring part AMOS/1A III, converter unit AMOS/1A
Ingress protection:	IP20
Converter unit dimensions:	90 × 60 × 18 mm
Converter unit installation:	DIN rail, TS35
Operating temperature:	-20 °C to +60 °C
DC supply voltage U_{supply}:	10 V_{DC} to 28 V_{DC}

Consumption at I_n and $R_L = 2.5\,\Omega$: $\leq 5\,W$

Idle consumption: 70 mA at $U_N = 12\,V$
50 mA at $U_N = 24\,V$

Total efficiency at I_n and $R_L = 1.0\,\Omega$: 42 %

Total efficiency at I_n and $R_L = 2.5\,\Omega$: 60 %

The negative pole of the power supply is connected to the common terminal of the converter.

Note: 1) A single value only
2) Possible rated value 30 A to 3 000 A
3) A maximum of 5 m can be ordered

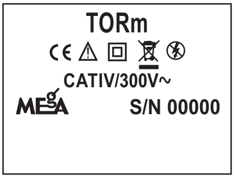
AMOS/1A flexible sensor with loop length short, standard and long.

Technical data of TORv and TORm toroids

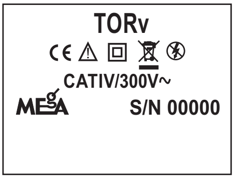
	TORv	TORm
Rated input current I_n:	10 A, 50 A	1 A, 5 A
Output voltage [1]:	$225\,mV_{AC}$, $150\,mV_{AC}$, $22.5\,mV_{AC}$	
Measuring range:	5 % to 120 % I_n	
Measurement error at f = 50 Hz [2]:	0.5 % from the range	
Harmonic measurement uncertainty up to the order of 50: [2] [3] [4]	$\pm 5\,\%\,I_{harm}$ at $I_{harm} \geq 3\,\%\,I_n$ $\pm 0.15\,\%\,I_n$ at $I_{harm} < 3\,\%\,I_n$	$\pm 10\,\%\,I_{harm}$ at $I_{harm} \geq 3\,\%\,I_n$ $\pm 0.3\,\%\,I_n$ at $I_{harm} < 3\,\%\,I_n$
Measuring category:	CAT IV / 300 V	
Safety class:	II	
Ingress protection:	IP40	
Operating temperature:	-10 °C to +55 °C	
Temperature coefficient:	0.2 % / 10 K	
Relative humidity:	≤ 85 %	
Cable length:	2 m	
Dimensions:	40 × 15 × 55 (80) mm	30 × 16 × 45 (70) mm
Max. diameter of measured conductor:	15 mm	6 mm
Weight:	0.1 kg	0.1 kg

Note:
[1] Only one of the values
[2] In the range of 5 % I_n to 120 % I_n
[3] Up to the order of 25 the maximum peak factor 2
[4] Class 1 according to EN 61000-4-7, ed. 2

TORm toroid



TORv toroid



Technical data of LCT split-core current transformers

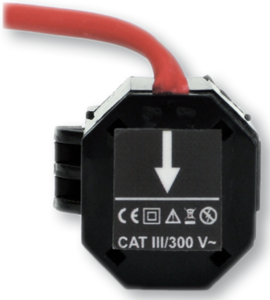
Rated primary current I_n [1)]:	LCT-10	5 A, 20 A, 60 A, 75 A
	LCT-16	100 A, 120 A, 200 A
	LCT-24	100 A, 200 A, 400 A
	LCT-36	300 A, 400 A, 500 A, 600 A
Rated secondary voltage [1)]:	225 mV, 150 mV, 22.5 mV	
Precision class:	0.5 according to EN 61689-2	
Rated frequency:	50 Hz	
Frequency range:	33 Hz to 1 kHz	
Rated load:	2 MΩ / 50 pF	
Operating temperature range:	-25 °C to +50 °C	
Storage temperature:	-30 °C to +70 °C	
Relative humidity:	≤ 85 % RH, non-condensing	
Operating position:	any	
Altitude:	up to 2,000 m	
Rated phase voltage:	230 V	
Maximum phase voltage:	300 V	
Measuring category:	CAT III / 300 V	
Supply cable length:	2 m ± 5 cm	
Designation of output conductors:	k, l	
Cable ties:	WT - 200MC, length 203 mm, width 2,5 mm	

	LCT-10	LCT -16	LCT -24	LCT -36
Weight [dkg]:	6	9	16	27
Outer dimensions, h × w × d [mm]:	41,5 × 27 × 30	46 × 32 × 42	67 × 47 × 42	82 × 62 × 46
Window dimensions [mm]:	10 × 10	16 × 16	24 × 24	36 × 36

Insulation tape SCOTCh 3M22 for installation on and near LV conductors.

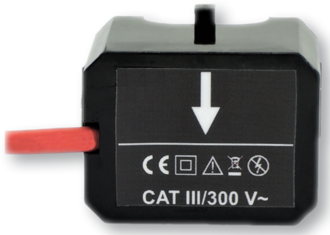
1) Only one of the values

LCT-10 split-core transformer, hole diameter 10 mm



LCT-16 split-core transformer, hole diameter 16 mm

LCT-24 split-core transformer, hole diameter 24 mm



LCT-36 split-core transformer, hole diameter 36 mm

Technical data of the loops of flexible sensors AMOSm / short, AMOSm / standard a AMOSm / long in a measuring set with the MEg45PAN universal PQ monitor

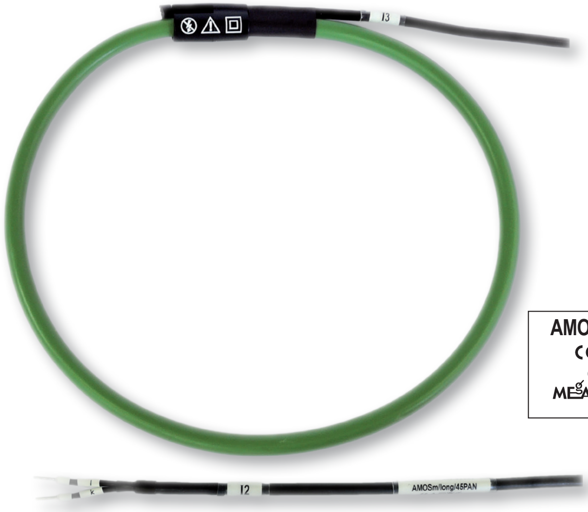
SW setting of the rated value.

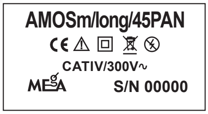
Rated alternating current I_n	
AMOSm/short:	30 A, 100 A, 300 A
AMOSm/standard:	30 A, 100 A, 300 A, 1000 A, 3000 A
AMOSm/long:	1000 A, 3000 A, 5000 A
Current measuring range:	5 % I_n to 120 % I_n
Frequency range:	40 Hz to 7.2 kHz
Current measuring uncertainty: [1]	
I_n = 30 A, 5000 A:	1.0 % M.V. ± 0.1 % I_n (45 Hz to 60 Hz)
I_n = 100 A, 300 A, 1000 A, 3000 A:	0.5 % M.V. ± 0.1 % I_n (45 Hz to 60 Hz)
Change of value with position:	± 1.0 % M.V.
Change of data due to external fields:	± 1.0 % M.V. ± 0.2 % I_n
(external field of a conductor with 0.3 I_n/50 Hz positioned 35 mm from the closure)	
Harmonic measurement uncertainties up to the order of 50. [1), 2), 3)]	
I_n = 100 A, 300 A, 1000 A:	± 5 % I_{harm} at 3 % $I_n \leq I_{harm} \leq$ 10 % I_n and ± 0.15 % I_n at I_{harm} < 3 % I_n
I_n = 30 A a 3000 A:	± 10 % I_{harm} at 3 % $I_n \leq I_{harm} \leq$ 10 % I_n and ± 0.3 % I_n at I_{harm} < 3 % I_n
Phase error, (45 Hz to 60 Hz): [1]	2,0 °
Working temperature:	-20 °C to + 55 °C
Temperature coefficient:	0.2 % I_n / 10 K
Relative humidity:	≤ 95 % RH
Ingress protection:	IP65
Measuring category:	CAT IV / 300 V
Safety class:	II
Loop length:	40 cm (standard), 60 cm (long), 20 cm (short)

Note: [1] In the range of 5 % I_n to 120 % I_n
[2] Up to the order of 25, the maximum peak factor 2
[3] Class 1 according to EN 61000-4-7, ed. 2
M.V. = measured value

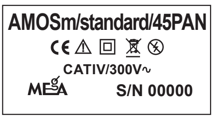
Loop diameter: 8 mm
Enclosure free end diameter: 10 mm
Permissible loop bending radius: > 20 mm
Cable length: 2 m

Flexible sensor AMOSm/long (loop length 60 cm)

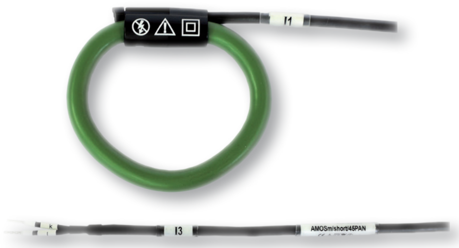


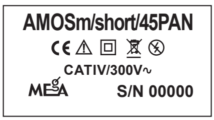


Flexible sensor AMOSm/standard
(loop length 40 cm)



Flexible sensor AMOSm/short
(loop length 20 cm)





Technical data of CAT IV / 300 V relay

Input circuit; terminals A1, A3

REL IV DC

Maximum and minimum control voltage:	$30\,V_{DC}$ / $10\,V_{DC}$				
Minimum withstand voltage:	$6\,V_{DC}$				
Control DC voltage [1]:	10 V	12 V	15 V	24 V	30 V
Control DC current :	55 mA	65 mA	60 mA	45 mA	40 mA

REL IV AC

Maximum and minimum control voltage:	$24\,V_{AC}$ / $10\,V_{AC}$		
Minimum withstand voltage:	$10\,V_{AC}$		
Control AC voltage:	10 V	12 V	15 V
Control alternating current:	55 mA	65 mA	60 mA

Output circuit; terminals B1, B2, B3

Contact configuration:	1 P, 1 CO (SPDT)
Switched current rated / maximum:	$6\,A_{ef}$ / $10\,A_{ef}$
Switched voltage rated / maximum:	$250\,V_{ef}$ / $300\,V_{ef}$
Rated load AC1 (resistance load):	1500 VA
Rated load AC15 (230 V, electromagnetic load):	300 VA
Rated load by single-phase motor (230 V_{ef}):	0.185 kW
Interrupting capacity DC1 (resistance load) 30 / 110 / 220 V_{ss}:	6 A / 0.2 A / 0.12 A
Minimum interrupted load:	500 mW (12 V / 10 mA)
Contact material:	Ag/Ni

[1] The polarity of connected voltage does not matter.

General data

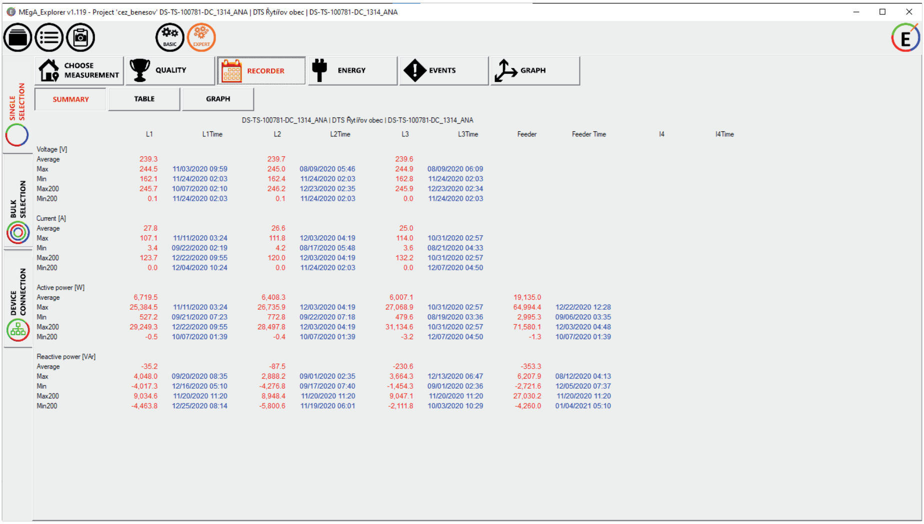
Dimensions:	90 × 60 × 18 mm
Relay installation:	TS35 DIN rail
Number of cycles:	$10 \cdot 10^6$
Time closing/opening REL IV DC:	8 ms / 5 ms
Time closing/opening REL IV AC:	10 ms / 15 ms
Consumption:	≤ 1.2 W
Overvoltage category (EN 61010-1, ed. 2):	CAT IV 300 V
Ingress protection:	IP20
Protection class	II, reinforced insulation
Operating temperature:	-20 °C to +70 °C
Altitude:	up to 2000 m
Weight:	70 g

APPENDIX

Examples of the evaluation of data measured by the MEg45PAN program MEgA Explorer

Measuring function Záznamník (Recorder)

Average and extreme values with time data, voltage, currents, active and reactive power



	L1	L1Time	L2	L2Time	L3	L3Time	Feeder	Feeder Time	I4	I4Time
Voltage [V]										
Average	239.3		239.7		239.6					
Max	244.5	11/03/2020 09:59	245.0	08/09/2020 05:46	244.9	08/09/2020 06:09				
Min	162.1	11/24/2020 02:03	162.4	11/24/2020 02:03	162.8	11/24/2020 02:03				
Max200	245.7	10/07/2020 02:10	246.2	12/23/2020 02:35	245.9	12/23/2020 02:34				
Min200	0.1	11/24/2020 02:03	0.1	11/24/2020 02:03	0.0	11/24/2020 02:03				
Current [A]										
Average	27.8		26.6		25.0					
Max	107.1	11/11/2020 03:24	111.8	12/03/2020 04:19	114.0	10/31/2020 02:57				
Min	3.4	09/22/2020 02:19	4.2	08/17/2020 05:48	3.6	08/21/2020 04:33				
Max200	123.7	12/22/2020 09:55	120.0	12/03/2020 04:19	132.2	10/31/2020 02:57				
Min200	0.0	12/04/2020 10:24	0.0	11/24/2020 02:03	0.0	12/07/2020 04:50				
Active power [W]										
Average	6,719.5		6,408.3		6,007.1		19,135.0			
Max	25,384.5	11/11/2020 03:24	26,735.9	12/03/2020 04:19	27,068.9	10/31/2020 02:57	64,994.4	12/22/2020 12:28		
Min	527.2	09/21/2020 07:23	772.8	09/22/2020 07:18	479.6	08/19/2020 03:36	2,995.3	09/06/2020 03:35		
Max200	29,249.3	12/22/2020 09:55	28,497.8	12/03/2020 04:19	31,134.6	10/31/2020 02:57	71,580.1	12/03/2020 04:48		
Min200	-0.5	10/07/2020 01:39	-0.4	10/07/2020 01:39	-3.2	12/07/2020 04:50	-1.3	10/07/2020 01:39		
Reactive power [VAr]										
Average	-35.2		-87.5		-230.6		-353.3			
Max	4,048.0	09/20/2020 08:35	2,888.2	09/01/2020 02:35	3,664.3	12/13/2020 06:47	6,207.9	08/12/2020 04:13		
Min	-4,017.3	12/16/2020 05:10	-4,276.8	09/17/2020 07:40	-1,454.3	09/01/2020 02:36	-2,721.6	12/05/2020 07:37		
Max200	9,034.6	11/20/2020 11:20	8,948.4	11/20/2020 11:20	9,047.1	11/20/2020 11:20	27,030.2	11/20/2020 11:20		
Min200	-4,463.8	12/25/2020 08:14	-5,800.6	11/19/2020 06:01	-2,111.8	10/03/2020 10:29	-4,260.0	01/04/2021 05:10		

Time course of average, minimum and maximum voltage, average and maximum currents

Measuring function Napěťové jevy (Voltage phenomena)

Standard parameters of voltage phenomena

Id	Event beginning	Duration	U1 max/min [%]	U2 max/min [%]	U3 max/min [%]
1	09/09/2020 06:25:42,941 PM	00:00,080	91.97/85.18	93.64/86.67	104.00/101.35
2	09/11/2020 06:37:58,146 AM	00:00,070	101.87/98.58	91.29/81.43	92.24/83.48
3	09/18/2020 12:33:50,450 PM	00:00,030	89.61/88.90	92.07/89.75	102.02/100.39
4	09/30/2020 02:40:15,596 AM	00:00,060	90.01/86.43	101.56/98.86	92.56/88.54
5	10/07/2020 01:38:57,582 PM	52:07,418	100.00/0.72	100.00/0.75	78.41/0.77
6	10/12/2020 10:17:19,957 AM	00:00,074	102.70/100.57	93.26/86.87	91.35/86.97
7	10/14/2020 12:03:06,376 PM	06:21,624	100.00/0.01	100.00/0.00	86.36/0.00
8	10/14/2020 12:09:33,219 PM	00:00,140	91.97/82.99	97.95/94.57	97.82/94.39
9	10/14/2020 12:12:00,523 PM	00:00,110	95.76/90.99	91.68/85.84	97.56/92.44
10	10/21/2020 07:22:28,620 AM	00:41,380	100.00/0.00	100.00/0.00	88.70/0.01
11	10/31/2020 10:28:08,802 AM	00:00,340	101.48/56.29	97.30/34.74	90.21/58.91
12	10/31/2020 10:28:13,691 AM	00:00,573	98.15/35.27	97.05/34.14	104.72/34.88
13	10/31/2020 10:28:35,710 AM	00:00,569	97.77/88.42	69.17/33.30	102.09/93.09
14	11/01/2020 08:27:55,245 AM	00:01,209	102.83/95.77	95.27/83.69	88.94/47.88
15	11/01/2020 08:28:17,312 AM	00:01,290	88.37/79.47	107.35/103.82	97.99/93.44
16	11/01/2020 08:31:49,328 AM	00:02,070	89.10/67.40	106.19/101.03	96.57/90.30

Contingency table of voltage drops

Ujm[%] / t[ms]	10<t <=200	200<t <=500	500<t <=1000	1000<t <=5000	5000<t <=60000
90 > U >= 80	3	0	0	0	0
80 > U >= 70	1	0	0	0	0
70 > U >= 40	3	0	0	0	0
40 > U >= 5	0	1	0	0	0
5 > U >= 0	0	0	0	0	0

Contingency table of voltage increases

Ujm[%] / t[ms]	10<t <=500	500<t <=5000	5000<t <=60000
120 > U >= 110	0	0	0
U >= 120	0	0	0

Contingency table of voltage interruptions

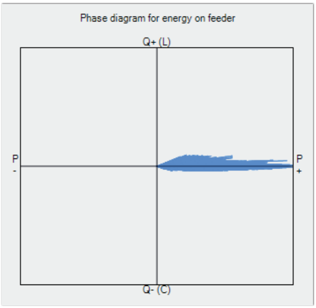
Ujm[%] / t[s]	t <= 1	1 <t <= 180	t > 180
5 > U	0	0	0

Measuring function Elektroměr (Electric meter)

Total energy of three phases and individual phases with a phasor diagram

08/06/2020 01:10:00,000 PM - 01/08/2021 12:14:00,000 AM

	Feeder	L1	L2	L3
EP+ [kWh]	70,304.585	24,688.012	23,547.219	22,069.355
EP- [kWh]	0.000	0.000	0.000	0.000
EQC_EP+ [kVArh]	2,542.071	650.420	818.816	1,072.831
EQL_EP+ [kVArh]	1,242.766	520.565	496.679	225.522
EQC_EP- [kVArh]	0.000	0.000	0.000	0.000
EQL_EP- [kVArh]	0.000	0.000	0.000	0.000



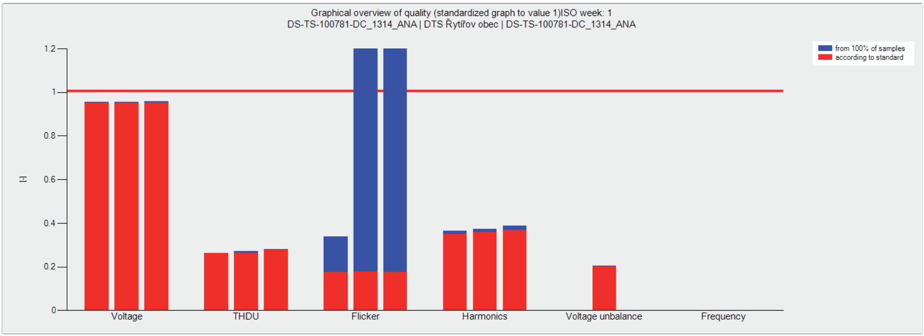
Quarter-hour and daily table of three-phase active energy

Datum	EP+ L1 [kWh]	EP+ L2 [kWh]	EP+ L3 [kWh]
08/06/2020 02:10:00 PM-08/06/2020 02:15:00 PM	0.5	0.3	0.4
08/06/2020 02:15:00 PM-08/06/2020 02:30:00 PM	1.5	0.7	1.6
08/06/2020 02:30:00 PM-08/06/2020 02:45:00 PM	2.4	0.5	1.3
08/06/2020 02:45:00 PM-08/06/2020 03:00:00 PM	2.1	1.0	1.6
08/06/2020 03:00:00 PM-08/06/2020 03:15:00 PM	2.7	1.4	1.1
08/06/2020 03:15:00 PM-08/06/2020 03:30:00 PM	2.5	0.9	1.1
08/06/2020 03:30:00 PM-08/06/2020 03:45:00 PM	2.9	0.7	1.3
08/06/2020 03:45:00 PM-08/06/2020 04:00:00 PM	2.6	0.6	1.5
08/06/2020 04:00:00 PM-08/06/2020 04:15:00 PM	2.2	0.5	1.0
08/06/2020 04:15:00 PM-08/06/2020 04:30:00 PM	2.3	0.7	1.0
08/06/2020 04:30:00 PM-08/06/2020 04:45:00 PM	3.4	0.6	1.3
08/06/2020 04:45:00 PM-08/06/2020 05:00:00 PM	2.4	0.9	1.9
08/06/2020 05:00:00 PM-08/06/2020 05:15:00 PM	1.1	1.2	1.2
08/06/2020 05:15:00 PM-08/06/2020 05:30:00 PM	1.1	1.3	0.9
08/06/2020 05:30:00 PM-08/06/2020 05:45:00 PM	1.5	0.9	0.8
08/06/2020 05:45:00 PM-08/06/2020 06:00:00 PM	2.0	1.5	0.6
08/06/2020 06:00:00 PM-08/06/2020 06:15:00 PM	1.5	1.2	1.1
08/06/2020 06:15:00 PM-08/06/2020 06:30:00 PM	1.2	1.3	1.0
08/06/2020 06:30:00 PM-08/06/2020 06:45:00 PM	1.5	1.1	1.1

Datum	EP+ L1 [kWh]	EP+ L2 [kWh]	EP+ L3 [kWh]
08/06/2020 02:10:00 PM-08/07/2020 12:00:00 AM	65.5	39.3	49.4
08/07/2020 12:00:00 AM-08/08/2020 12:00:00 AM	100.1	89.4	99.2
08/08/2020 12:00:00 AM-08/09/2020 12:00:00 AM	109.3	91.2	121.6
08/09/2020 12:00:00 AM-08/10/2020 12:00:00 AM	118.3	94.1	116.0
08/10/2020 12:00:00 AM-08/11/2020 12:00:00 AM	89.3	72.7	88.1
08/11/2020 12:00:00 AM-08/12/2020 12:00:00 AM	90.3	78.1	73.6
08/12/2020 12:00:00 AM-08/13/2020 12:00:00 AM	110.1	83.4	96.0
08/13/2020 12:00:00 AM-08/14/2020 12:00:00 AM	96.7	75.8	75.4
08/14/2020 12:00:00 AM-08/15/2020 12:00:00 AM	103.6	79.2	100.7
08/15/2020 12:00:00 AM-08/16/2020 12:00:00 AM	129.9	111.5	89.6
08/16/2020 12:00:00 AM-08/17/2020 12:00:00 AM	114.2	94.1	102.5
08/17/2020 12:00:00 AM-08/18/2020 12:00:00 AM	88.7	80.7	85.4
08/18/2020 12:00:00 AM-08/19/2020 12:00:00 AM	91.5	73.7	83.4
08/19/2020 12:00:00 AM-08/20/2020 12:00:00 AM	91.8	87.9	76.4
08/20/2020 12:00:00 AM-08/21/2020 12:00:00 AM	94.2	76.9	68.8
08/21/2020 12:00:00 AM-08/22/2020 12:00:00 AM	108.7	98.8	98.2
08/22/2020 12:00:00 AM-08/23/2020 12:00:00 AM	127.7	103.6	125.1
08/23/2020 12:00:00 AM-08/24/2020 12:00:00 AM	114.3	97.8	121.4
08/24/2020 12:00:00 AM-08/25/2020 12:00:00 AM	105.9	97.4	111.0

Measuring function Kvalita napětí (Voltage quality), selected examples

Graphic overview of continuous voltage quality parameters throughout the entire period of measurement



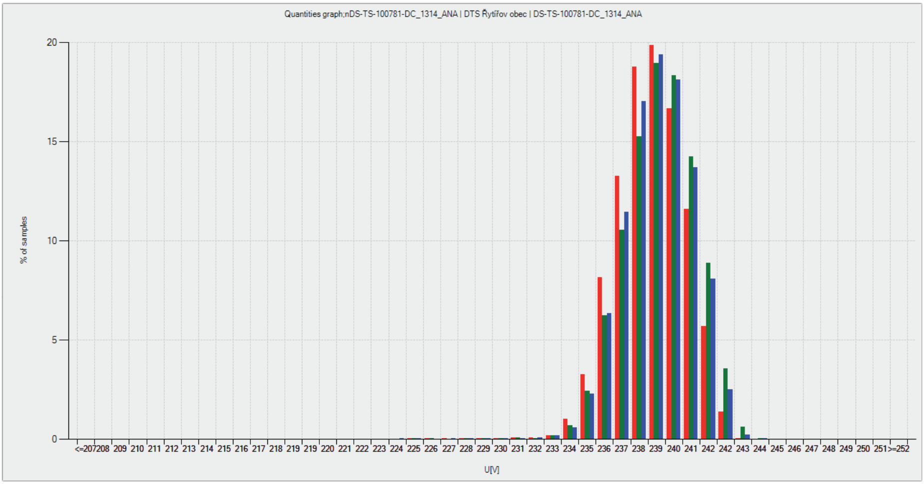
Weekly evaluation of voltage quality

1. quarter													
2. quarter													
3. quarter						32	33	34	35	36	37	38	39
4. quarter	40	41	42	43	44	45	46	47	48	49	50	51	52
53. week	53												

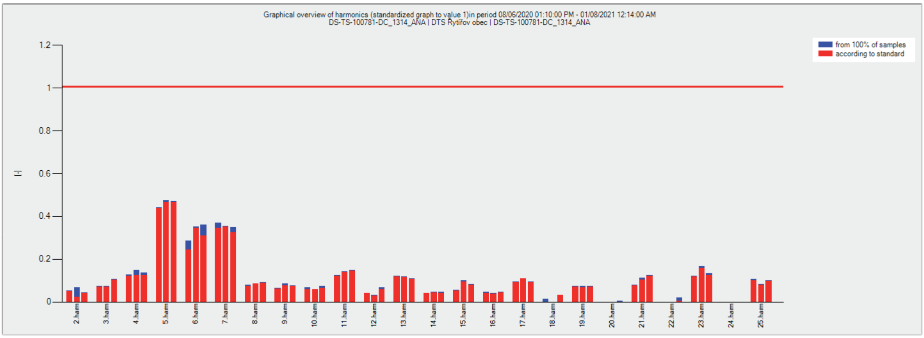
Values are in the form A - B / C (A - minimal value from 95% samples, B - maximal value from 95% samples, C - compliant samples in % from all samples)

Sense of background color:
green - complete count of samples, quality compliant
orange - incomplete count of samples, quality compliant
red - quality not compliant

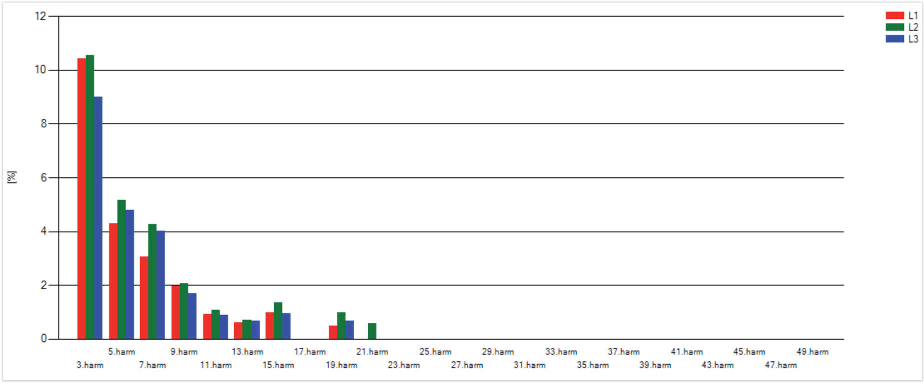
Histogram of phase voltage



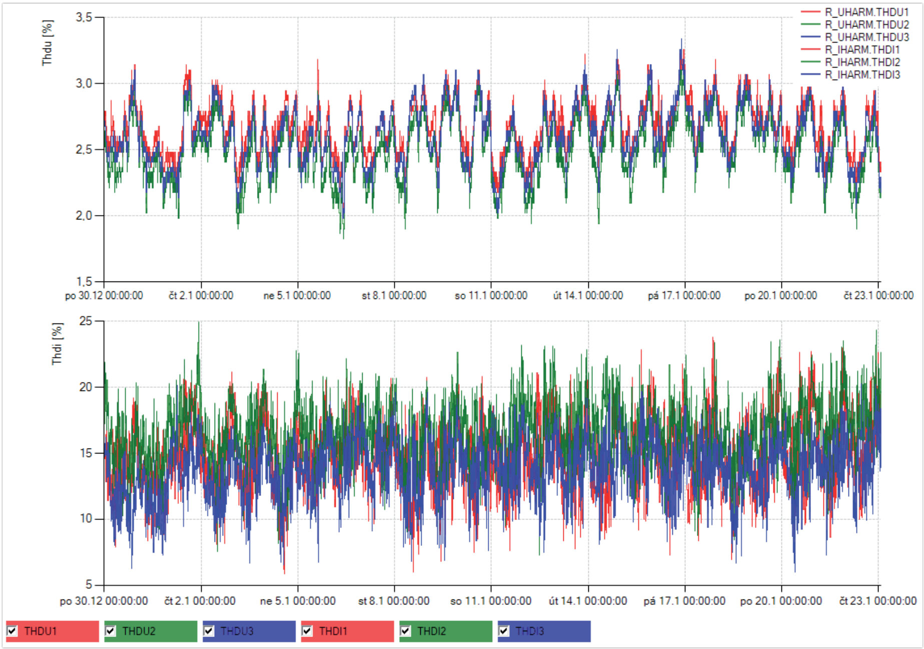
Standardized spectrum of harmonic phase voltages



Spectrum of phase currents



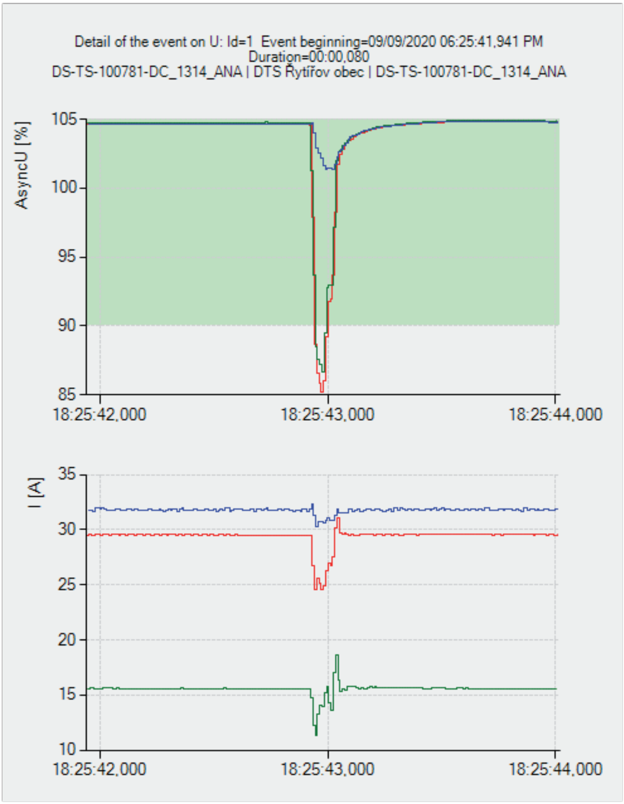
Time course of THDU and THDI harmonic distortion factors



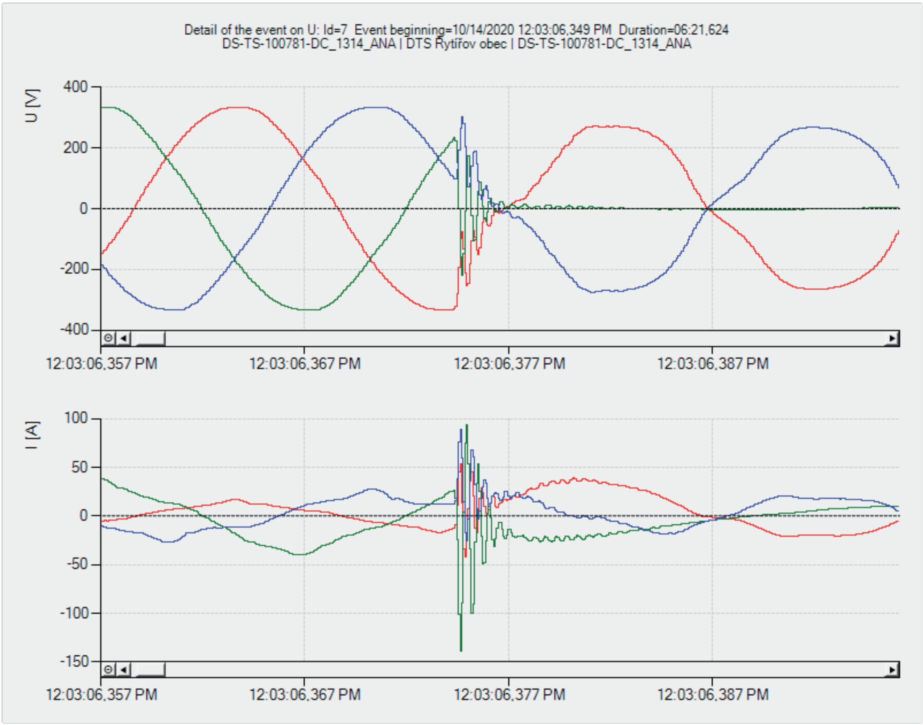
Characteristics of the first voltage drop

1	10.01.2020 06:33:26,942	00:00,320	93,41/32,05	101,97/31,73	102,35/30,83

Course of voltage $U_{RMS1/2}$ and $I_{RMS1/2}$ during the first voltage drop



Oscillographic record with pre-trigger of the first voltage drop



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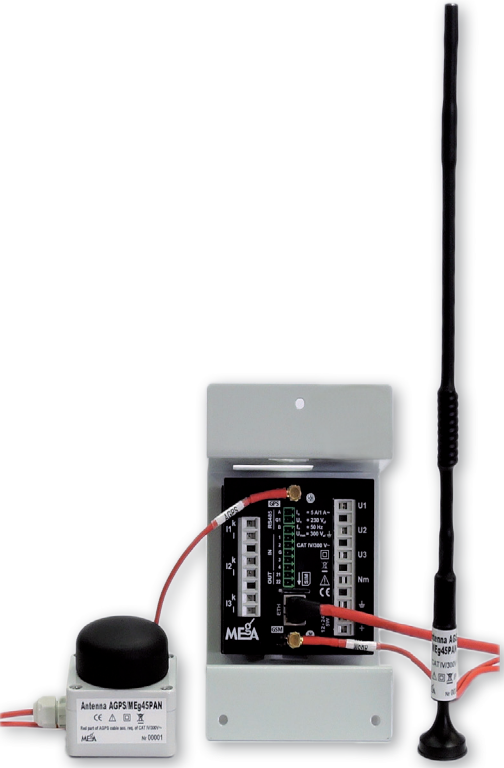
MEg45PAN Universal Monitor
User manual



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Edition: 02/2024