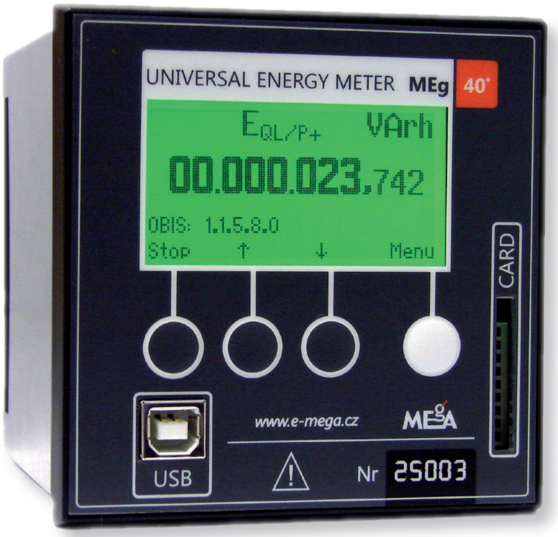
Universal Energy Meter
MEg40+



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Universal energy meter MEg40+

1/ PURPOSE AND DESCRIPTION

The universal energy meter MEg40+ works as an energy meter and a monitor at the same time. In the function of the energy meter, it has a set of six energy registers for each phase. In the function of the monitor, it records long-term voltage, current and power curves and according to the voltage quality standard ČSN EN 50160 ed. 3, it registers voltage deviations in class S. The values of energies and recorded quantities are shown on the display. The instrument MEg40+ is designed for LV, MV and HV measurements.

For LV measurements, it is possible to use both the basic version and the version MEg40+/S1, which uses split core instrument transformers SMART PTD to indirectly measure currents. The version MEg40+/S3 uses flexible current sensors AMOSm to measure currents; this version can be installed in uninterrupted power supply technology PPN (live-line working). [1)]

The universal energy meter MEg40+ is an instrument of the measurement category IV, it is designed for installation in unprotected circuits of LV stations and substitutes classic pointer registering instruments and also four-quadrant energy meters.

MEg40+ stores all measured data in the Flash data memory for further processing in PC or PDA and archiving in database tools. The internal 4 MB data memory can be replaced by a removable 16 MB memory card of special design that enables fast and on personnel and technical means undemanding data transfer into information systems. The standard communication interface of the instrument MEg40+ is USB 2.0. It is made also in versions with the RS232 / RS485 interface that are used to integrate the instrument MEg40+ into measuring systems. The USBhost / RS485 converter can be also additionally connected to the instrument MEg40+ made with USB 2.0 interface.

The measuring modes and conversion constants of components of the measurement chain can be programmed from the keyboard of the instrument or more comfortably using PC. The user program of the instrument MEg40+ evaluates data of one instrument in PC. Data measured by more instruments MEg40+ and archived in a database can be processed using the system software WebDatOr. The user SW is described in the User manual MEg40+.

[1)] The versions of MEg40+/S1 and MEg40+/S3 are described in separate manuals.

2/ TECHNICAL PARAMETERS

Reference conditions: U_{supply} = 230 V / 50,0 Hz
ambient temperature = 20 °C, relative humidity = 40 % to 70 %.

Measured voltages and currents have a frequency identical with U_{supply} and make a three-phase system.

Measured quantity	Rated value	Range of measurement	Accuracy [% of range]	Note
TRMS voltage	U_{nom} = 230 V	0 V to 290 V	0.2 % ± 1 digit	1), 2)
	U_{nom} = 57.73 V	0 V to 125 V	0.2 % ± 1 digit	
TRMS current	I_{nom} = 1 A	0 A to 1.2 A	0.2 % ± 1 digit	1), 2), 3)
	I_{nom} = 5 A	0 A to 6 A	0.2 % ± 1 digit	
Power factor PF	$U > 0.8\,U_{nom}$ $I > 0.1\,I_{nom}$	PF > 0.1	0.5 % ± 1 digit	4)
Active power	230 V / 5 A, 1 A	PF > 0.4	0.5 % ± 1 digit	4)
Reactive power	230 V / 5 A, 1 A	PF < 0.6	0.5 % ± 1 digit	4)
Active energy	230 V / 5 A	$U \geq 0.8\,U_{nom}$ $I > 0$ $\cos\varphi$ L > 0.5 $\cos\varphi$ C > 0.8	Class B according to TPM 2440-08 ČMI	
Voltage events	U_{nom}	$0.05\,U_{jm}$ to $1.20\,U_{nom}$ $T \leq 1$ sec	1.0 % U_{nom} 20 msec	5), 6)

Notes:

1) Only the range is to be specified in the order.
2) The rated value of the primary quantity is to be entered using PC or from the keyboard.
3) Only indirect current measurement through measuring current transformers. In LV and MV networks, special measuring current split core transformers PTD with the rated currents 100 A, 200 A, 300 A, 400 A, 500 A, 600 A and 900 A can be used.
4) It measures in 4 quadrants.
5) It evaluates events according to the voltage $U_{rms1/2}$ specified in ČSN EN 61000-4-30, ed. 2 with characteristics in ČSN EN 50160, ed. 3, i.e. with the residual voltage and event duration.
6) With an external uninterruptible power supply unit, e. g. MEg102, it can measure longer voltage events.

Frequency range of phase lock loop:		47.4 Hz to 52.9 Hz
Input impedance	in 230 V range:	1.8 MΩ
	in 57.7 V range:	0.9 MΩ
Maximum input phase voltage		
	in 230 V range:	295 V_{ef}
	in 57.7 V range:	150 V_{ef}
Maximum voltage on current inputs at I_{nom}		
	in 5 A range:	0.16 V_{ef}
	in 1 A range:	0.8 V_{ef}
Overload capacity of current inputs:		1 min – 2 × I_{nom}
		1 sec – 30 × I_{nom}
Allowable voltage between current inputs:		50 V_{ef}
Supply voltage $U_{AC\ supply}$:		230 V +10 %, –30 %
Spotřeba při $U_{AC\ supply}$ = 230 V:		5,0 VA

Quantities measured in MEg40+:

Phase voltage	Active energy at consumption
Delta voltages	Active energy at delivery
Phase currents	Reactive energy L at consumption
Active and reactive powers	Reactive energy L at delivery
U and I events	Reactive energy C at consumption
Maximum currents	Reactive energy C at delivery

Quantities calculated in PC :	**Quantities displayed on MEg40+:**
True power factors - PF	Phase/delta voltages
Daily current diagrams	Phase currents
Statistics of events	Active powers

General data

Flash data memory: 4 MB[1)]

Data memory organisation: linear or circular

Serial communication: USB2.0 / RS232 / RS485[2)]

Speed of serial communication (USB2.0, RS485 and RS232):
115,2 kBd (default), 256 kBd when the measurement is stopped (USB 2.0 only)

Internal time: 1,0 sec / 24 hr., $T_{network}$ ± 1 sec at $f_{network}$ synchronization

Notes:

[1)] 16 MB when 16 MB memory card is used

[2)] One type of communication as ordered.

Construction

Dimensions	body:	90 × 90 × 90 mm
	frame:	95 × 95 mm
Weight:		0.6 kg
Terminal block:		max ø of wires 3.0 mm
Panel attachment:		2 pcs of removable eccentrics

Operating data

Working temperature:	-25 °C to +55 °C
Storage temperature:	-25 °C to +85 °C
Relative humidity:	20 % to 90 % at 40 °C
Ingress protection rating (IEC 60529):	front panel IP40, other parts IP20
Pollution degree:	2
Measurement category:	IV, U_{nom} = 230 V
Battery type for internal time:	Li battery CR ½ AA CD

Electromagnetic compatibility

Electrostatic discharge immunity:	conforming to IEC 61000-4-2 (4 kV / 15 kV)
Immunity to radiated radio-frequency fields:	conforming to IEC 61000-4-3 (10 V/m, 80 MHz - 2000 MHz)
Immunity to fast transients:	conforming to IEC 61000-4-4 (2 kV)
Surge immunity:	conforming to IEC 61000-4-5 (4 kV)
Immunity to induced voltages:	conforming to IEC 61000-4-6 (3 V)
Immunity to dips, short interruptions:	conforming to EN 61000-4-11 (1 period / 100 %)
Interference voltages conducted:	conforming to EN 55011
Radiated emissions in the range 30-1000 MHz:	conforming to EN 55011
Harmonic current emissions:	conforming to EN 61000-3-2
Voltage changes, voltage and flicker fluctuations:	conforming to EN 61000-3-3
Magnetic fields with f = 50 Hz, 0,5 mT:	conforming to IEC 1036
External electric field 50 Hz / 10 kV/m:	conforming

3/ FUNCTION DESCRIPTION

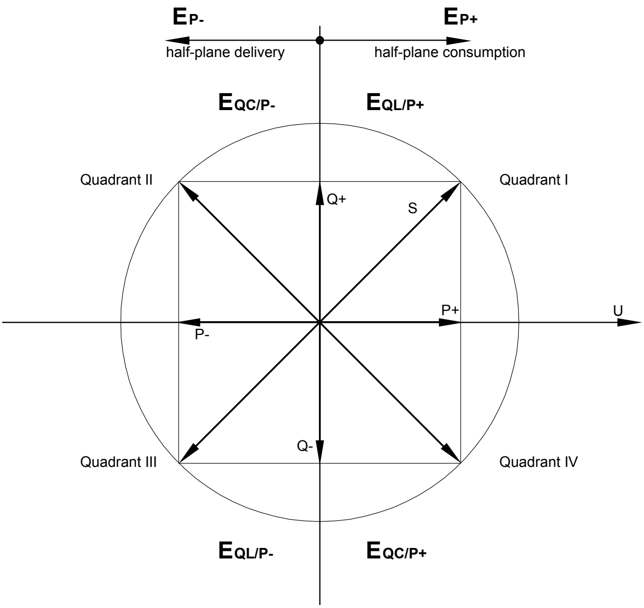
Compared with the original universal monitor MEg40, the universal energy meter MEg40+ offers extended functions to measure electrical energy. When measuring energies, it stores measured values into non-destructive registers and allows also additional creation of tariff bands and load profiles, without limitation of their number and time. Thanks to the possibility of subsequent analysis, MEg40+ can be used in locations with a set of functionally independent consumptions unspecified in advance, e.g. in manufacturing and commercial complexes.

The instrument MEg40+ has a set of six energy registers for each phase according to standard IEC 62053-23, see Fig. 1. They are the following registers:

OBIS: 1.1.1.8.0 E_{P+} - active energy, consumption
OBIS: 1.1.2.8.0 E_{P-} - active energy, delivery
OBIS: 1.1.5.8.0 $E_{QL/P+}$ - reactive energy inductive at consumption
OBIS: 1.1.7.8.0 $E_{QL/P-}$ - reactive energy inductive at delivery
OBIS: 1.1.8.8.0 $E_{QC/P+}$ - reactive energy capacitive at consumption
OBIS: 1.1.6.8.0 $E_{QC/P-}$ - reactive energy capacitive at delivery

The set of six registers for an outlet is located in the basic non-destructive memory of the instrument and the set of six distributed registers of the individual phases is located in the data flash memory that can be realized as a memory card.

Fig. 1: Definition of quadrants of active and reactive energy according to IEC 62053-23



The display of the instrument MEg40+ shows total registers for the three-phase outlet. The set of six registers for the individual phases are read by the user program. The phase energy measurement is unimportant when it is measured in compensated MV networks (MVL). Also in the recorder mode, only basic voltage, current, active power and voltage event data and other user information appear on the display.

The basic measurement time is 10 periods. True RMS voltage, current, power and energy values are measured continuously thanks to the phase lock look. As well, intervals to record into the data memory are multiples of 10 periods. In this case, the sampling rate of the measured voltages and currents is controlled by the phase locked loop derived from the L1 phase voltage. The phase locked loop is active in the frequency range from 47.4 Hz to 52.9 Hz. If the frequency of the L1 phase voltage is outside the frequency interval, the sampling rate is set at 50.00 Hz.

Apparent powers, reactive powers and true power factors - PFs are calculated in MEg40+ from true RMS voltages and currents and from active powers recorded during the recording interval into the Flash data memory. The reactive power includes a deformation power component. The universal energy meter MEg40+ is designed for system, long-term measurements. For this use, it has both usual synchronization of the internal time through the oscillator frequency and synchronization of the internal time through the network voltage frequency. This allows a unified analysis of events in the course and also of long-term measurement campaigns. During a mains failure when internal time synchronization through the network frequency is selected, the time is synchronized by the internal oscillator with f = 50.00 Hz.

In the function of time course recording, the interval to record the measured values can be set from 1.0 sec to 1 hour. Besides average values for the recording interval, it is also possible to store maximum and minimum values of 0.2 sec (10 periods) in the memory, which occurred in the recording interval. It is also possible to record RMS values measured in the time when the recording interval is finished.

In order to protect the data memory from filling with clusters of numerous unimportant events, e.g. in case of voltage oscillations near the specified limits, it is possible to record events on a new page only after it is opened. It does not occur prior to the time defined after the previous page is opened. It allows suppressing the possibility to fill the entire data memory with unimportant data in case of clusters of events.

The standard size of the data memory of the instrument MEg40+ is 4 MB. When average values of all voltages, currents, active and reactive powers, and energies in the summary set of six registers, and up to 50 events per 27 hr 05 min are recorded, it is possible to store data for the time period of 577.3 days in the 4 MB memory with the recording interval of 10 minutes. When the 16 MB memory card is used and the recording is selected for all average values of measured quantities, maximum and minimum voltages, maximum currents and active powers, energies in the set of six registers in the individual phases in

5-minute intervals and for up to 30 events during every 6 hr 45 min, the minimum time of measurement is 573.6 days.

Then both 10-minute voltage quality evaluations and 15-minute energy evaluations can be made from 5-minute intervals.

The organisation of the internal data memory of MEg40+ and the memory card can be circular or linear. When the measured data are stored into the circular data memory, after the memory is full, the oldest data in the range of one page are deleted and new data are recorded on their place. When the measured data are stored into the linear data memory, after the memory is full, the new measured data are not recorded into the memory and the data measured after the measurement is started are stored in the memory permanently. Cooperation of the internal data memory and the memory card is included in the following description of the 16 MB memory card.

An event is registered when the voltage $U_{rms(1/2)}$ of any phase gets out of the preset limits; according to ČSN EN 50160, ed. 3 it is 90 % U_{nom} and 110 % U_{nom}. The beginning and ending time of an event can be recorded with the max. inaccuracy 10 msec. During an event, minimum and maximum voltages $U_{rms(1/2)}$ are evaluated, or also currents of all phases. The event ends when all of the voltages return in accordance with ČSN EN 50160 into the allowable tolerance band narrowed by the hysteresis of 2 % U_{nom}. E.g. if the limits of 90 % U_{nom} and 110 % U_{nom} are selected, then the limits to end an event are 92 % U_{nom} and 108 % U_{nom}. Beside the time when an event occurred, also the duration of the event is recorded. As an event, it is also recorded a measurement failure due to a supply voltage loss, and it is recorded the beginning and ending time of the failure. The universal energy meter measures for 1 sec also in case of a supply voltage failure. Duration of longer failures is measured using the internal backup clock with the time resolution of 1 sec. After the failure ends and the supply voltage is restored, the HW of the instrument MEg40+ is checked for about 1 sec and then the measurement is restored. The duration, during which the measurement is interrupted in case of a longer power failure, is extended by about 1 sec.

When it is required so that the instrument measures also during supply voltage failures, see ČSN EN 61000-4-30, ed. 2, it is possible to order also the uninterruptible power supply MEg102 together with the instrument MEg40+, which can supply the instrument MEg40+ during up to four subsequent supply voltage failures always for the required time of 3 minutes.

In the function of measurement and registration of maximum currents, the maximum currents are searched in the instrument MEg40+ among values measured during the preset measurement interval for each phase and the whole outlet from the beginning of the measurement, which appear only on the display of the instrument together with the time of occurrence.

The user software evaluates maximums for selected recording intervals on the individual phases and also for the whole outlet for the recording interval and 1/4hr maximums. Besides, daily diagrams of average currents are determined for any selected day.

The basic version of the instrument MEg40+ has a bidirectional serial communication USB 2.0. When measurement is stopped and the communication speed increases to 256 kbit/sec, the 4 MB data memory is read within 7 minutes. Measured data are transmitted from the 16 MB memory card to PC using a memory card reader within 4 minutes. For remote communication, optional communication RS232 or RS485 is available. The communication interface USB 2.0 can be converted to the interface RS485 additionally using the USBhost / RS485 converter.

The function of the user program MEg40+ is described in a separate user manual.

4/ DESCRIPTION OF CONTROLS AND DISPLAY

The front panel of the instrument MEg40+ includes a large-area graphic backlit display with 64 × 128 pixels and four environment-resistant foil keys with mechanical response. The function of the keys is preset by the control program of the instrument. There is also a connector of the serial interface USB 2.0 and a covered two-row connector of the 16 MB memory card. The serial number of the instrument and prescribed data are specified on the front panel.

The rear panel includes vents, two rows of terminal blocks with marked individual terminals, rated current and rated voltage data and safety information.

After the supply voltage is applied and the HW function of the instrument is successfully checked, basic data about the control program appear on the display temporarily. Then according to the settings made before the power supply was interrupted, rotating energy registers of the function **Energy meter** or selected measured values of the function **Monitor** are displayed. The display returns to the preset mode always automatically when no of the instrument buttons is activated for 1 minute

The universal energy meter MEg40+ is set by the manufacturer so that after the power is on, values of all energies of all of six registers for the whole outlet can rotate gradually on the display from E_{P+} to $E_{QC/P-}$. The energy values appear on the display in the format with eight digits before the decimal point and three smaller decimal digits after the decimal point. The type and unit of the measured energy is given above the energy value, and the energy code is displayed under the energy value according to OBIS standard. To stop the rotation of register values, use the left outside button **Stop**. You can browse through the registers manually using the other two buttons with up and down arrows (↑ ↓). After the required register is found, the value of the selected register appears on the display for

1 minute. Then the rotation of the registry values is restored. The rotation can be restored using the button Start. When the button **Menu** is enabled, the item **Energy meter** and the item **Monitor** appear. By turning to the item **Energy meter** (inverse display) and pressing the button **Select**, you display the items **Displ. interval**, **Cycle type** and **Higher resolution**. By selecting the item **Displ. interval** you can change the speed of rotation of the displayed register values after 5 s, 10 s, 15 s, 20 s, 30 s, by selecting the item **Cycle type** you can change rotation of all six registers for **Consumption + delivery** or only three registers for **Consumption** or **Delivery**. By selecting the item **Higher resolution** and **yes**, the frozen register values appear for 1 minute with 1 000 times higher resolution, which results also in changes of displayed units. The default resolution is always basic, not increased. In case of the higher resolution, three highest orders are cut off.

After the item **Monitor** is enabled, the items **Measuring instrument**, **Maximum currents**, **Recorder** and **Check of wiring** are displayed and the buttons have assigned the meanings **End**, ↑ - setting one line up, ↓ - setting one line down and Selection. Press the button **End** to complete the preset selection and return the program to the previous selection, i.e. in this case to the display mode of the function **Monitor**. Press the buttons ↑ or ↓ to set the corresponding inversely displayed line and press the button **Select** to select the item on the set line.

After the main item **Measuring instrument** is selected, the following four items appear on the display: **View parameters**, **Voltage measurement parameters**, **Current measurement parameters** and **Instrument parameters**.

By selecting the item **Display parameters** you can display the items **Type**, **Interval** and **Method**. After selecting the item **Type** you can use the buttons ↑ and ↓ to select the display by quantities, by phases or simultaneous display of all outlet quantities. The selected display type is to be confirmed by pressing the button **End**.

When displaying the item **Quantity** and returning to the basic display, you can use the button **U** to continuously display phase or delta values, or the button **I** to display phase currents, and the button **P** to display phase active powers. When measuring in a MV network with a compensation coil MVL (vnL), the outlet power marked **∑P** is displayed instead of phase powers.

By simultaneous pressing more buttons, you display the selected quantities alternately with the preset time of display.

When the item **Phase** is selected, use the dark button of the selected phase to display the voltage, current and active power. According to the pre-selection, phase and delta voltages, phase currents and active powers of the selected phases are displayed. As well in this case, by simultaneous pressing more buttons you can display corresponding phases alternately.

When the item **Outlet** is selected, all three voltages, three currents and three phases or active powers are displayed simultaneously, or the total active power of the outlet.

By selecting the item **Interval** you can select the repeat interval to display new values in seven steps from 0.2 sec to 12.8 sec. By selecting the item **Method**, you can select the display in absolute units or in % of the rated value.

After you select the items **Voltage measurement parameters** and **Current measurement parameters** for the first time, the item **Password** appears to prevent from unauthorized intervention into the setting or displaying of parameters of the voltage and current measuring chain.

The password is four-digit and is set in the form of 3355. Each of the password digits can be selected separately using the buttons ↑ and ↓ and is confirmed by the button **Select**. After entering all of the four password digits, complete the entry by pressing the button **End**. The password can be changed and read by the PC program. Even if the password is not entered correctly, you can browse parameters of the current and voltage chain but possible changes are not realized after you press the button **Select**.

By selecting the item **Voltage measurement parameters**, you display the items **Level**, **Voltage** and $\mathbf{U_{nom}}$. To select the line with the required item, use the buttons ↑ and ↓. After selecting the item **Level** you can use the buttons ↑ and ↓ to set the **LV**, **MV**, **MVL** and **HV** level. After you press the button **Level** selection, the instrument made for the rated voltage 57.7 V will accept MV, MVL or HV levels and the instrument made for the rated voltage of 230 V will accept only the LV level. By selecting the item **Voltage** you can set and select the display of phase or delta voltages. By selecting the item $\mathbf{U_{nom}}$ you can set only the value of 230 V for the LV level, delta voltages of 3 kV, 6 kV, 10 kV, 20 kVA, 22 kV and 35 kV for the MV level and delta voltages of 110 kV, 220 kV and 400 kV for the HV level. The non-standard MV voltage 20 kV can be substituted by any other non-standard real value by changing the program.

By selecting the item **Current measurement parameters** you display the items $\mathbf{I_{prim}}$ and $\mathbf{I_{sec}}$. In the item $\mathbf{I_{prim}}$ you can set one of the standard values of primary currents of the measuring current transformers: 1 A, 5 A, 10 A, 12,5 A, 15 A, 20 A, 25 A, 30 A, 40 A, 50 A, 60 A, 75 A, 100 A, 125 A, 150 A, 200 A, 250 A, 300 A, 400 A, 500 A, 600 A, 750 A, 1000 A, 1250 A, 1500 A, 2000 A, 2500 A. You can also set a non-standard value of the primary current of the current transformer **User**. The item $\mathbf{I_{sec}}$ displays the size of secondary input of the measuring current transformer, for which input current circuits of MEg40+ are prepared. The default values are 1 A or 5 A. When a measuring current split core transformer PTD is used and current inputs of the instrument MEg40+/S1 are connected in the corresponding way, the character **S1** is displayed. The designation **S3** is for the use of flexible sensors AMOSm. When S1 is selected, rated primary currents of transformers PTD can be set at 100 A, 200 A, 300 A, 400 A, 500 A, 600 A a 900 A. When S3 is selected, rated primary currents of sensors AMOSm can be set at 250 A, 500 A, 1000 A a 2000 A.

When you select the item **Instrument parameters**, the instrument MEg40+ displays the basic information about the instrument, i.e. serial number, control program version - FW, date and time of the internal clock and capacity of the Flash data memory of the instrument. When the 16 MB memory card is inserted, the capacity of this card is displayed. To return to the previous selection, use the button **End**.

When you set and select the main item **Maximum currents**, the instrument MEg40+ displays maximum currents for the measurement interval for each phase and maximum value of the sum of phase currents measured by the instrument from the programmed start. As well times and dates are displayed, when the individual maximums occurred.

After the item **Recorder** is selected, information about the course of function is displayed. When the record is not active, the message **Record completed** will appear on the line **Status** or the message **Recording** when the function Recorder is set. When the function Recorder is programmed, also additional lines appear on the display including the recording start time, i.e. hour, minute, second and date, and information that measured data are stored in the memory, i.e. linear or circular memory, including information about the interval when the measured data are stored into the memory.

After you select the item **Check of wiring**, four functions run automatically to check the wiring of connected measuring circuits for correctness. They are the following functions:

- voltage connection check,
- phase sequence check,
- current connection check,
- phase assignment check..

The used checking procedure may not detect double and multiple errors in the wiring and may not be effective even when the wiring is correct, if there is a big voltage or current unbalance or power factors and currents are small. The correct result of the checking function is indicated by **OK**. In case of an ambiguous result, the quantities will be displayed, because of which it was impossible to decide about the correct wiring, and after the button **TEST** is enabled, the result is marked with the question mark. A wiring error is indicated by the word **Error**.

To check voltage connections, phase and delta voltages are checked. This function assumes phase voltages higher than 0.75 Unom. If it is found out that one, two or all three voltages are not connected, the message „Voltage connection error“ will be displayed and the evaluated delta voltages, from which the disconnected voltage can be derived. The **Voltage connection checking** function may not be effective to check the common wire for connection.

The following function checks the **phase sequence**. The check result is the message Phase sequence 123 (clockwise) or Phase sequence 132 (counter-clockwise).

The **Current connection** function checks currents for correct flow through individual circuits of the instrument MEg40⁺ and for correct direction, which must be in phase with the voltage corresponding to the voltage input. The allowable phase shift is ± 80°. If no current flows through the current input or its direction is turned relative to the voltage, then the message **Current connection error** and active powers of the individual phases will be displayed. According to the sign and size of the active power, you can determine the error in the connection of the corresponding current. This function assumes a phase current more than 3 % I_{nom} at the rated voltage.

The last function checks voltages and currents of the individual phases for correct assignment. If the voltage and current assignment is incorrect, the message **Current assignment error** and phase shifts between U1-I1, U2-I2 and U3-I3 will be displayed. The phase shifts in the realized wiring are expressed in degrees. This check is effective when the power factor is higher than 0.65.

5/ INSTALLATION

The universal energy meter MEg40⁺ shall be installed into a square hole of the panel with the dimensions of 92 × 92 mm ± 1 mm to ensure access from both sides to the screw-on terminals and a free space above and below the instrument to remove heat from the instrument and install eccentrics, which attach the instrument to the panel mechanically. White eccentrics are to be inserted into profiled holes in the top and bottom of the black housing of the instrument and turned towards the panel. To take out the eccentrics when disassembling the instrument, turn the eccentrics backwards and remove from the holes.

The voltage inputs of the instrument MEg40⁺ meet requirements of the measurement category IV according to ČSN EN 61010-2-30 and can be connected directly to LV collectors of the transformer station. In cases where the station includes a voltage circuit protection or in cases where it is expected that voltage circuit protection will be realized for other measuring instruments, the manufacturer recommends you to connect also voltage inputs of the instrument MEg40⁺ to the protected circuits. The measured voltages U1, U2 and U3 in LV networks are to be connected through fixed or flexible wires with the minimum cross-section of 0.75 mm^2 with double insulation.

Also in MV networks with resistance and compensated networks (MVL) and HV networks, indirectly measured voltages U1, U2 and U3 are always connected to the phase conductors and the measuring instrument measures phase or delta voltages according to the programmed requirement. To the terminal **Nm** in MV, MVL and HV networks, the ground is always applied. In LW networks, the central conductor is to be connected to the terminal **Nm**.

Current inputs of the instrument MEg40+ shall be always connected indirectly to secondary circuits of the measuring current transformers through fixed or flexible wires with the cross-section of 3 mm^2 with double insulation. It is recommended to connect them through a terminal block with the possibility to short-circuit secondary currents of the measuring current transformers. The secondary current of the measuring current transformer of the phase L1 is brought to the input terminal **I1K** of the instrument MEg40+ and goes out from its output terminal **I1L**. The secondary current of the measuring current transformer of the phase L2 is brought to the input terminal **I2K** of the instrument MEg40+ and goes out from its output terminal **I2L**. The secondary current of the measuring current transformer of the phase L3 is brought to the input terminal **I3K** of the instrument MEg40+ and goes out from its output terminal **I3L**. The current circuits inside the instrument MEg40+ are not galvanically connected, the maximum allowable voltage between the current circuits is 50 V.

When it is measured in LV and MV networks, where measuring current transformers are not installed, measuring split core instrument transformers PTD can be used to measure currents - made according to the pat. No. 286255, with the rated current from 100 A to 900 A and a window size of 68 × 68 mm. Then the universal energy meter is in the version MEg40+/S1.

When it is measured in a LV network, the voltage of 230 V is not allowed to be connected to the current terminals of the instrument in the version MEg40+. Direct current measurement is impossible.

The supply network voltage 230 V / 50 Hz or uninterruptible voltage 230 V / 50 Hz is applied to the terminals **Network 230 V** of the instrument; the position of the phase and central conductor is unimportant. It is also recommended to install a protection element.

After all of the measuring and supply circuits are connected, it is possible to check them for correct connection by activating the function Check of wiring, which is described in the previous chapter.

The instrument MEg40+ can be delivered with the inserted 16 MB memory card. In this case, it is not allowed to take out or handle the memory card during installation. Therefore the card is covered with a sticker by the manufacturer, which shall be removed after the measurements are programmed. If the instrument MEg40+ is not delivered with the memory card, the card slot is covered with a plastic cover. The memory card is described in a separate chapter.

Warning!

⚠ **When the instrument MEg40+ is used in a different way than it is specified by the manufacturer, the protection provided by the instrument MEg40+ can be impaired.**

5.1 Installation of the instrument with the serial communication RS485, RS232

The universal energy meter MEg40+ can be installed also into networks with communication interface RS485 or RS232. The required communication interfaces must be specified in the order.

The modulation rate of the communication interfaces RS485 and RS232 is 115.2 kBd. No data transfer is possible at an increased rate with interruption of the measurement. To interconnect, it is recommended to use a shielded twisted pair. The connection of terminals for RS485 and RS232 communication is as follows:

INSTRUMENT MEg40+ (direction from the instrument)	INTERFACE RS485	INTERFACE RS232
TxD (output)	Rx+ or RxTx+	TxD
RxD (input)	Rx– or RxTx–	RxD
⊥	shielding	⊥

If it is necessary to additionally ensure remote communication with the instrument MEg40+ equipped with the USB 2.0 interface, it is possible to use the USBhost / RS485 converter to convert the USB 2.0 interface to the RS485 interface.

6/ OPERATION OF THE INSTRUMENT MEG40+

Operation of the instrument MEg40+ in the basic version includes programming the measurement, reading the measured data of USB 2.0 communications, and taking out the memory card with measured data and inserting an empty card if 16 MB memory card is used.

The measurement is programmed in the instrument MEg40+ using PC or PDA with the running user program MEg40+ when the PC or PDA are connected to the instrument MEg40+ through the communication cable MEg40+-PC, 1.8 m or 5 m long, with ferrite absorbers. The procedure how to program measurements is included in the description of the program MEg40+. After the function **Recorder** is programmed, the letter **Z** appears permanently in the top R.H. corner, and after the function **Registration of events** is programmed, the letter **U** appears permanently in the top R.H. corner of the display of the instrument MEg40+.

It is possible to read the measured data through the serial communication USB 2.0 without interrupting the measurement when the data are read into a data file in PC at the speed of 115.2 kbit/sec. The measured data can be read into the data file also with interruption of the running measurement, then the communication speed increases automatically to 256 kbit/sec and the communication is not interrupted due to the running measurement.

Thus, the data reading time can be significantly reduced, however the new measured data will be saved into a new data file after the data transfer is completed.

After communication is finished with interruption of measurement, the new measurement must be programmed. Through the serial communication, the measured data can be read both from the internal data memory (4 MB) and from the 16 MB memory card.

However, the data transfer from the 16 MB memory card is more efficient, when the 16 MB memory card is taken out from the instrument MEg40+ and inserted into the memory card reader connected to PC with the active reader control program. Then the data are read at the speed of 921.6 kbit/sec and the full card is read out within 4 minutes. During one reading, you can read gradually up to eight memory cards. The operator does not need PC to take out the 16 MB memory card with the measured data from the instrument MEg40+ and insert the new empty 16 MB memory card into the instrument MEg40+. Then the operator hands on the 16 MB memory cards with the measured data for reading and deleting. A detailed description of the data reading from the 16 MB memory card is given in a separate chapter of this manual.

7/ MAINTENANCE INSTRUCTIONS

The universal energy meter MEg40+ does not include any movable parts, and therefore it does not require any mechanical maintenance other than common cleaning of the panel. To clean, you can only use soft materials and non-aggressive solutions, preferably water with a detergent. It is necessary to ensure that the vents in the rear panel of the instruments are open through.

In demanding climatic and operating conditions, the manufacturer recommends you to check the accuracy of measurements in the interval from 4 to 8 years of operation, depending on the importance of the place of measurement. Accuracy of measurement is checked using a multimeter with accuracy of voltage and current measurement at least one class higher than the accuracy of the instrument MEg40+. The manufacturer of the instrument MEg40+ recommends e.g. multimeter Agilent 34401A. If you detect an error bigger than corresponding to the specification of the instrument, MEg40+ must be recalibrated. You can order the measurement accuracy check and calibration also at the manufacturer of the instrument MEg40+.

8/ CONTENTS OF THE SET

The set of the universal energy meter MEg40+ includes:

- 1 instrument MEg40+,
- 2 eccentrics,

- certificate of guarantee and delivery note,
- CD with the basic user program and manual..

Optional available accessories:

- communication cable MEg40+-PC / 1.8 m or 5 m,
- 16 MB memory card,
- reader of 8 memory cards,
- uninterruptible power supply MEg102,
- USBhost / RS485 converter with cable long 1 m.

The following versions are available for ordering beside the version MEg40+ with USB 2.0 interface:

- version MEg40+ with interface RS485,
- version MEg40+ with interface RS232.

9/ DELIVERY

The place of delivery unless otherwise specified is the seat of the manufacturer. The set of the instrument MEg40+ is delivered in the multilayer cardboard box with a delivery note and a certificate of guarantee. The serial number of the instrument MEg40+ packed inside, its measuring ranges and list of delivered accessories are specified on the packaging.

For transport, it is necessary to protect the front panel of the instrument with the display and inserted memory card against mechanical damage using a multilayer cardboard insert.

10/ GUARANTEE

Two-year standard guarantee is provided for the universal energy meter MEg40+ and its accessories from the date of its sale. Defects incurred during this period due to provably defective construction, defective design or improper materials will be repaired free of charge by the manufacturer; the place of performance of the guarantee is the seat of the manufacturer of the instrument MEg40+.

The guarantee becomes invalid if the user carries out unauthorized modifications or changes on the instrument MEg40+ or its accessories, or connects the instrument incorrectly, mechanical wearing of the instrument is inadequate or the instrument MEg40+ or its accessories was operated contrary to the technical specification.

Defects of the instrument MEg40+ and its accessories incurred during the guarantee period shall be claimed by the user to the manufacturers of the instrument MEg40+. Claims without the enclosed certificate of guarantee shall not be admitted.

The manufacturer shall not bear any responsibility for consequential damages caused by the use of the instrument MEg40+ and its accessories. No responsibility of the manufacturer follows from this guarantee that would exceed the price of the instrument MEg40+.

11/ ORDERING

The order should indicate a number of pieces of the universal instruments MEg40+ with one of the possible parameters:

- voltage range: 57.73 V, 230 V,
- current range: 1 A, 5 A,
- serial communication type: USB 2.0, RS485, RS232
  You can order only one type of the serial communication.

Specify extra:

- requirement for memory CARD 16 MB
- requirement for extended SW,
- number of memory card readers,
- number and length of communication cables MEg40+-PC
- number of uninterruptible power supplies MEg102,
- number of USBhost / RS485 converters.

Note
In the order, you can define the voltage level, rated primary voltages and currents or wiring type in the place of installation of the instrument. The manufacturer will program these data into the instruments before dispatching them. The given data can also be programmed by the orderer during installation of the instrument. You can order also a four-digit password different from the password defined by the manufacturer. (3355). The password can be changed after installation of the instrument either by means of software or from the keyboard. A changed or forgotten password can be read out only using the user program MEg40+.

12/ MANUFACTURER

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Fig. 2: Wiring of the instrument MEg40⁺ in LV network without uninterruptible power supply

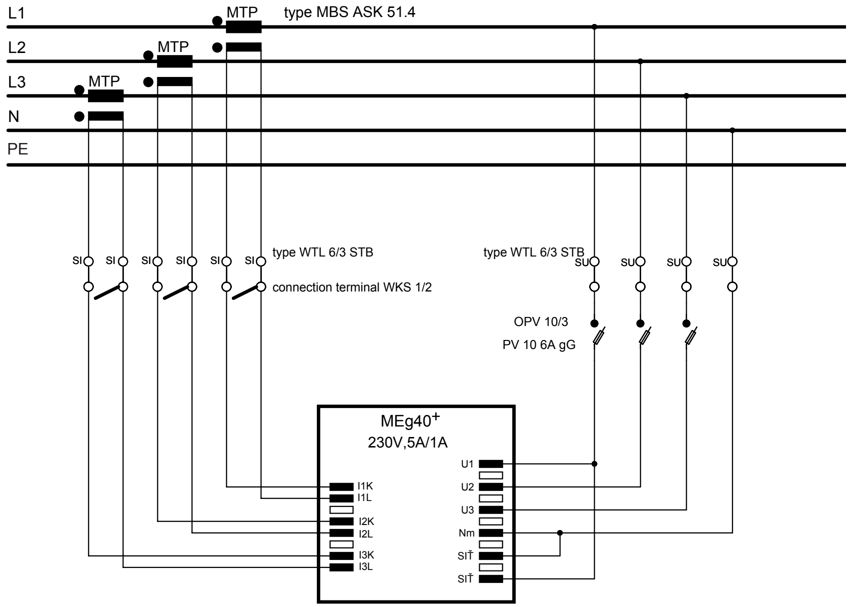


Fig. 3: Wiring of the instrument MEg40⁺ in a LV network with uninterruptible power supply

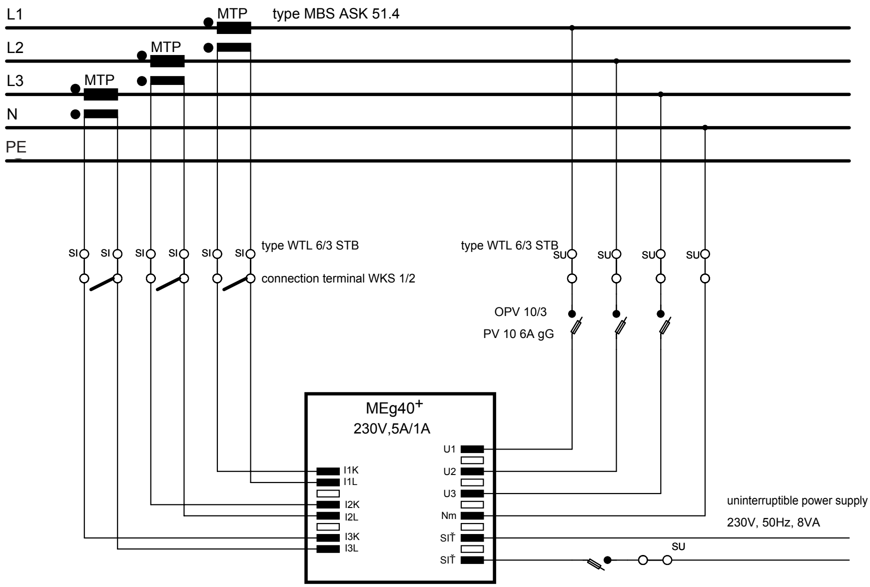


Fig. 4: Dimensions of the instrument unit MEG40+

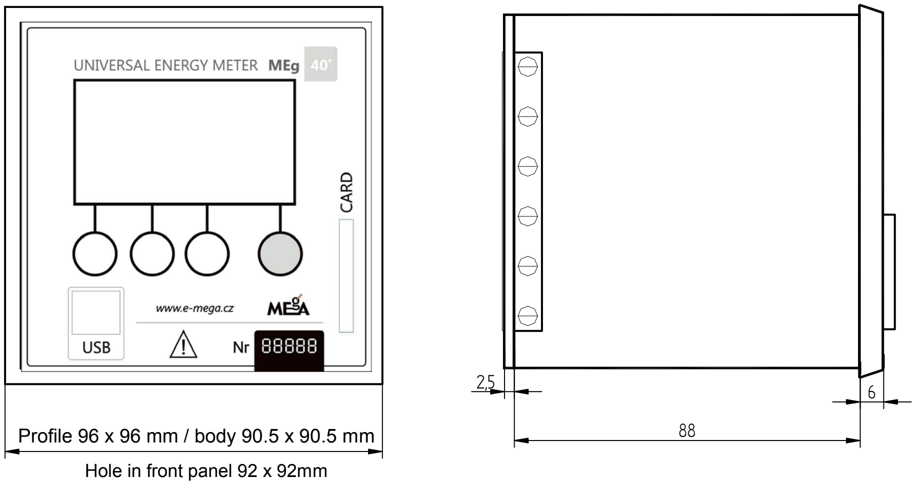


Fig 5: Rear panel of the instrument MEg40+
left: version with USB 2.0 communication
right: version with RS485/RS232 communication

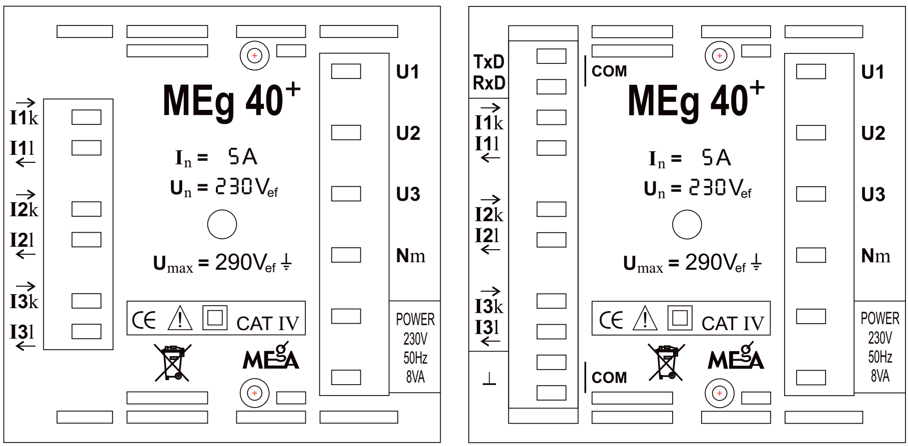
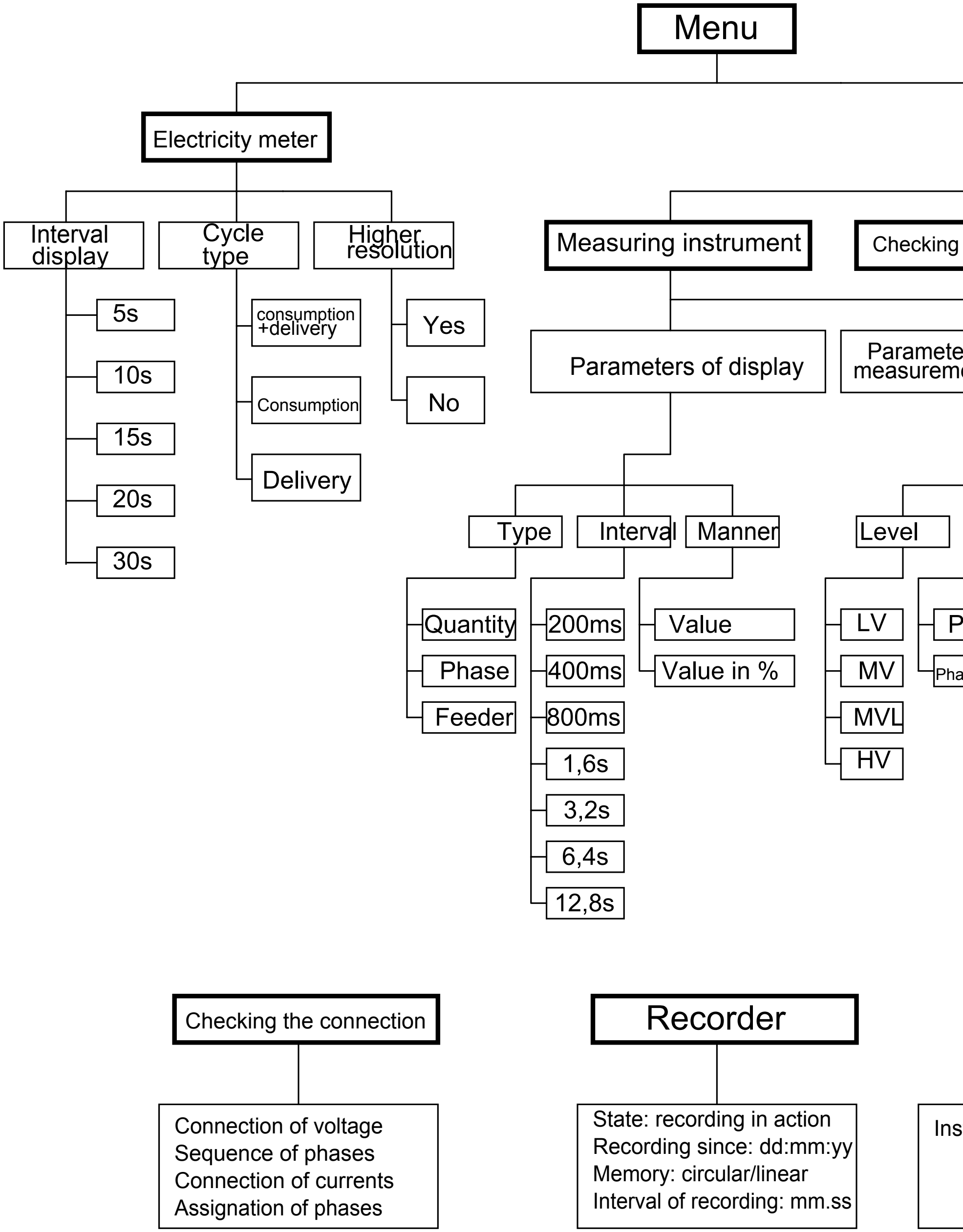
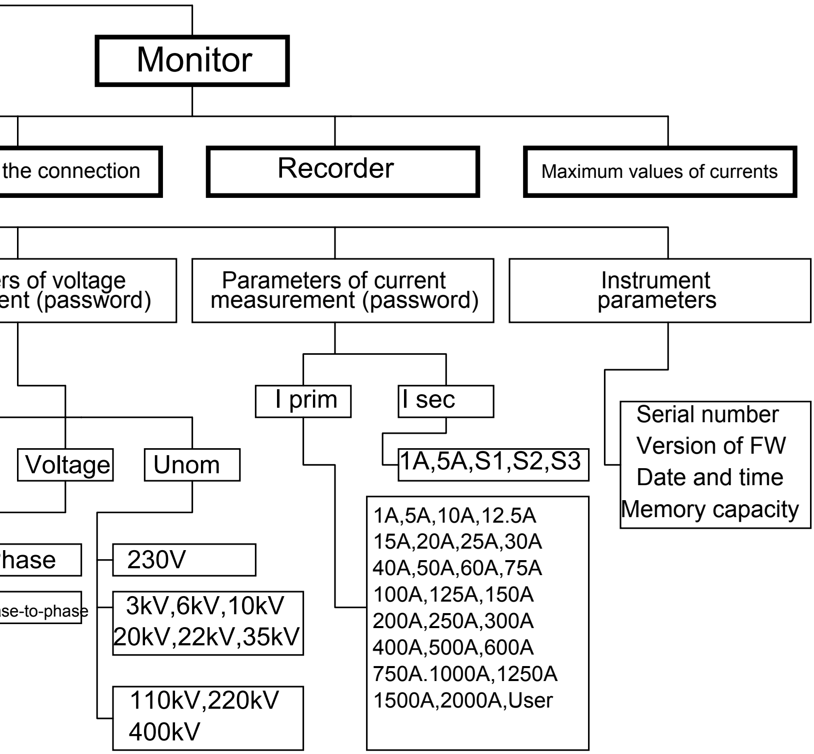
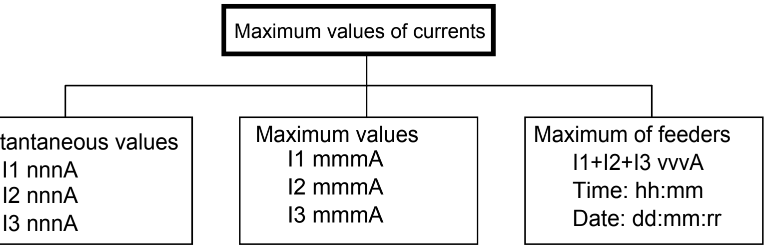


Fig. 6: Function of the control panel of the universal energy meter MEg40+

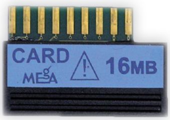



Monitor
the connection
Recorder
Maximum values of currents
rs of voltage
ent (password)
Parameters of current
measurement (password)
Instrument
parameters
I prim
I sec
Serial number
Version of FW
Date and time
Memory capacity
Voltage
Unom
1A,5A,S1,S2,S3
1A,5A,10A,12.5A
15A,20A,25A,30A
40A,50A,60A,75A
100A,125A,150A
200A,250A,300A
400A,500A,600A
750A.1000A,1250A
1500A,2000A,User
hase
230V
se-to-phase
3kV,6kV,10kV
20kV,22kV,35kV
110kV,220kV
400kV


Maximum values of currents
tantaneous values
I1 nnnA
I2 nnnA
I3 nnnA
Maximum values
I1 mmmA
I2 mmmA
I3 mmmA
Maximum of feeders
I1+I2+I3 vvvA
Time: hh:mm
Date: dd:mm:rr

Accessories of the universal instrument MEg40+

16 MB memory card and memory card reader



1/ PURPOSE AND USE

Easy, on time, personnel and technical means undemanding collection of data measured by the instrument MEg40+ is allowed by a special 16 MB memory card with Flash memory and a reader for eight memory cards.

The use of the 16MB memory card allows you to record U_{av}, U_{max}, U_{min}, I_{av}, I_{max}, P_{av}, P_{max}, Q_{av} of all three phases and store energies in the set of six registers with the recording interval of 5 min, register 30 voltage events and record extreme currents in each interval with the length of 9 hr 20 min for the time period longer than 795 days, i.e. longer than 2 years and 2 months.

The universal energy meter MEg40+ will start writing only into a completely deleted 16 MB memory card, onto which at first the measurement head is written. Only this instrument MEg40+ can write down into such a marked memory card. Other instruments detect any discrepancy of measurement heads and report them on the display. After the data are read out from the memory card by the reader and transferred into PC, it is possible to delete the data recorded on the card using a special confirmed command. Then the card can be used to record data in any instrument MEg40+.

2/ OPERATING CONDITIONS OF THE INSTRUMENT MEG40+ WITH 16MB MEMORY CARD

2.1 Programming and start of measurement of the instrument MEg40+ with memory card

The programming and start of the measurement of the instrument MEg40+ equipped with the memory card does not differ from the programming and start of the measurement of the instrument MEg40+ without the memory card. The difference consists in the time during which the memory is deleted; the deletion time of the (16 MB) memory card and the (4 MB) internal data memory MEg40+ increases from the original 20 sec to about 100 sec. We can assume that when the instrument MEg40+ with the memory card is programmed, a wider range of recorded parameters and higher recording frequency will be selected.

2.2 End of measurement of the instrument MEg40+ with memory card

In the linear recording mode, the record is ended after the memory card capacity is used up (the internal data memory capacity is not used) or after the measurement end is instructed by means of the control program from PC.

In the circular recording mode, measured data are permanently recorded only into the memory card and the oldest data pages are overwritten. The measurement is ended after the measurement is ended from PC.

2.3 Data transmission from the instrument MEg40⁺ with memory card

The data transmission from the instrument MEg40⁺ equipped with the memory card to PC can be realized through a serial USB interface similarly as in case of the instrument without a memory card. This method is time consuming and lasts tens of minutes even if the running measurement is stopped.

The procedure used in practise to transmit data measured by the instrument MEg40⁺ and stored on the 16 MB memory card includes taking out the card and subsequent inserting another deleted memory card. Then the memory card with the measured data is to be inserted into a reader connected via the serial USB interface to PC. The reader is supplied from the computer. After the utility of the memory card reader is enabled, the card content is transmitted to PC. This can run in a time independent of the time when the memory card was taken out from MEg40⁺.

Up to eight memory card can be inserted in the card reader simultaneously, their data are automatically gradually read out into the memory of the computer. Before the data are read out, the configuration of the inserted cards is read out and it is possible to view heads of the measured data files on the individual memory card in detail. After the measured data are read out from the memory cards into the computer, you can require verification of the measured data transferred into your computer and data stored on the memory cards and only then using the corresponding confirmed command, you can delete the data and their heads recorded on the individual cards.

2.4 First insertion of 16 MB memory card into the instrument MEg40⁺

The measured data written into the data memory of the instrument MEg40⁺ must be read out before the memory card is inserted.

The deleted 16MB memory card can be inserted into the programmed meter MEg40⁺ any time. From the time when the card was inserted and the measurement head brought on the card, the measured data are stored only on the memory card. After the 16 MB memory card is inserted, the following message appears on the display of the instrument MEg40⁺ for 1.5 sec: „Memory module inserted / Start of recording“.

If a memory card was inserted into the instrument MEg40⁺ that was marked by another instrument and contains a different measurement head, the instrument detects this discrepancy and displays alternately: „Memory module inserted. Module not deleted“. Then the instrument keeps displaying measured quantities alternately, however they are not stored either into the instrument memory or onto the memory card. The modes **Recorder** and **Events** may not be evaluated correctly on the display

2.5 Replacement of 16 MB memory cards in the measuring instrument MEg40+

After the 16 MB memory card is taken out from the measuring instrument MEg40+, the measured data recording is interrupted and this status is displayed alternately with the measured data on the display MEg40+ with the message „Memory module taken out".

Then a new deleted memory card can be inserted, which will be marked by the instrument (with the head of the running measurement) and the instrument shows the message „Memory module inserted. Start of recording" on the display for 1.5 sec. Then it continues storing the measured data onto this card.

It is also possible to insert a not deleted card, which is marked by another instrument. This wrong situation is alternately reported with the message „Memory module inserted. Module not deleted" and measured data are being lost until a deleted card is inserted.

Also repeated insertion of the memory card can be assumed, onto which measured data were recorded before. In this case, the display shows the message „Memory module inserted. Recording restored" and the instrument continues recording the measured data onto the repeatedly inserted memory card. The data measured during the time when the card was not inserted will be lost.

3/ MANUFACTURER

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Uninterruptible power supply MEg102

1/ PURPOSE

The uninterruptible power supply MEg102 serves for short-term power supply of the instrument MEg40+ in case of supply voltage interruptions or drops. In accordance with ČSN EN 61000-4-30 ed. 2, its use is necessary for registration of short-term voltage events up to 3 min.

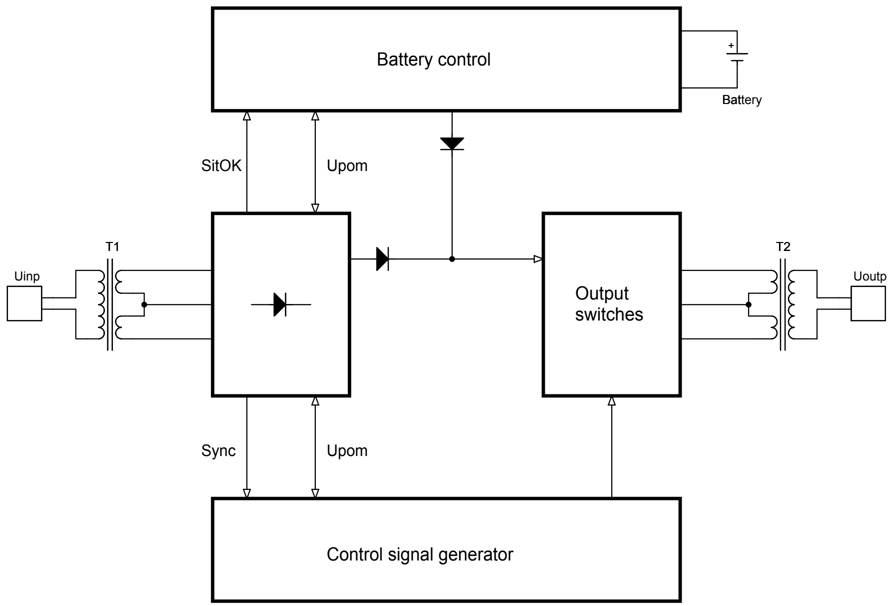
2/ FUNCTION DESCRIPTION

The power supply MEg102 generates rectangular output voltage with a frequency equal to the frequency of the network or with a lower frequency in case of an input voltage failure. The accumulator and its keeping in charged condition is a part of the power supply unit MEg102. The input and output voltages of the power supply unit MEg102 are galvanically isolated by transformers, they are to be connected to the power supply unit using screw-on terminals. There is a button on the outside of the plastic cover to stop the battery operation.

The principle of the uninterruptible power supply MEg102 is represented by the group diagram in Fig. 1. The input voltage U_{inp} applied to the terminals **IN** is converted by the transformer **T1** and the subsequent rectifier to the DC voltage, which is converted by means of a synchronized generator and output switches to the AC pulse voltage and transformed to U_{outp} by the transformer **T2** to power supply the instrument. The voltage U_{outp} is on the terminals of the power supply unit MEg102.

The U_{inp} voltage drop below the lower limit indicates with the **SitOK** signal to the control circuits of the accumulator to change over the battery supply. The battery operation is finished when U_{inp} returns above the lower limit plus necessary hysteresis or when the period set by the internal generator expires (default 180 sec) or when the external button **Battery stop** is pressed for about 2 seconds.

Fig. 1: Group wiring diagram of uninterruptible power supply MEg102.



3/ TECHNICAL PARAMETERS

Input voltage:	$U_{inp\ nom}$ = 230 V / 50 Hz
Maximum input voltage:	253 V
Change to battery operation:	U_{inp} = 180 V
Return to network operation:	U_{inp} = 195 V
Output voltage:	170 V_{ef}, rectangular course, mark-to-space ratio 1:4 in both polarities, $U_{peak\text{-}peak}$ ≈ 450 V
Maximum output power:	1.5 VA
Maximum input power:	10 VA
Accumulator:	NiMH, U_{nom} = 10.5 V / 110 mAh, 3 × 3H110BC (Vinic), or V150H (Varta)
Min. charging current:	about 5 mA
Battery operation time:	4 × 180 s, for MEg40+

Frequency synchronization with the network: for U_{inp} ≥ 100 V

Working conditions

Temperature:	-25 °C to +50 °C
Relative humidity:	5 % to 95 %
Safety:	ČSN EN 61010
Dimensions:	115 × 65 × 40 mm
Weight:	0,4 kg
Ingress protection rating:	IP20

Max. cross-section of input and output wires: 3,0 mm

4/ INSTALLATION INSTRUCTIONS

The supply voltage 230 V ± 10 % with the rated frequency of 50 Hz must be brought to the power supply MEg102 through a 200 mA fuse. The phase conductor is to be connected to the terminal **1** of the double terminal **IN** and the central conductor to the terminal **2**.

The output AC voltage of 170 V_{ef} is on the terminals **3** and **4** of the double terminal **OUT**. It is galvanically isolated from the network circuits and shall be connected to the power supply system of the instrument MEg40+.

The maximum cross-section of the conductors is 3 mm. The conductors shall be with double insulation.

Mechanically, the power supply unit MEg102 is to be placed close to the measuring instrument mounted on the DIN rail TC 35 using a clip. The power supply unit can be also just put on the horizontal surface.

The vents of the unit MEg102 are not allowed to be covered. During installation, it is necessary to respect IP20 protection.

⚠ **When the uninterruptible power supply MEg102 is used in a different way than it is specified by the manufacturer, the protection provided by the power supply unit MEg102 can be impaired.**

5/ MAINTENANCE INSTRUCTIONS

The uninterruptible power supply units MEg102 do not contain any movable parts, and therefore do not require any mechanical maintenance other than common cleaning. To clean you can only use soft materials and non-aggressive solutions. In rough industrial conditions, it is necessary to check that the vents are open through. The instrument includes maintenance-free accumulator NiMH batteries that shall be replaced after 10 years of operation as recommended by the manufacturer and then the power supply unit checked for correct operation.

6/ MANUFACTURER

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USBhost/RS485 converter

1/ PURPOSE

The USBhost/RS485 converter is designed to connect a USB slave unit to the RS485 serial line.

The USBhost/RS485 converter allows you to connect the instrument MEg40⁺ with the USB interface to the RS485 serial bus. It also supplies the USB interface from the instrument MEg40⁺. The RS485 bus is dimensioned for connecting up to 31 units. The maximum bus length is up to 1200 m when the cabling system is correctly designed and has a suitable impedance end.

2/ TECHNICAL PARAMETERS

Power supply

voltage:	+6 V to +16 V
current (MEg40⁺ not connected) :	20 mA
current (MEg40⁺ connected):	60 mA

RS485 interface

max. rate:	1 Mb/s
max. number of connected units	31 (according to RS485 standard)

Connector

screw-on terminal block, with four terminals

USBhost interface

specification:	USB 1.1 USB 2.0 compatible
connector:	type B (M)
power supply slave through USB:	5 V/300 mA

Construction dimensions

length × width × height:	45 × 28 × 18 mm
USB cable length:	1 m
Terminal block, max. ø of wire:	1.5 mm^2
Temperature range:	-40 °C to +85 °C

3/ CONSTRUCTION

The USBhost/RS485 converter according to Fig. 1 with the panel Fig. 2 is installed in a plastic box designed for spaces with the maximum voltage of 50 V_{AC}. There is a 1 m long USB cable with USB B (M) connector running out from the left side. There are 4 screw-on terminals on the right side, 2 for the RS485 serial interface and 2 for the power supply (see Tab. 1). The max. cross-section of connected conductors is 1.5 mm^2.

Tab. 1: Table of USBhost/RS485 converter terminals

Terminals	Description
A (RxTx+)	bidirectional data
B (RxTx–)	bidirectional data
+12 V	supply voltage from + 6 to + 16 V
⊥	signal ground

4/ INSTALLATION

Before installation, FW must be installed in MEg40⁺ allowing the addressing. By default, MEg40⁺ with the USB interface includes FW, for which no addressing is assumed.

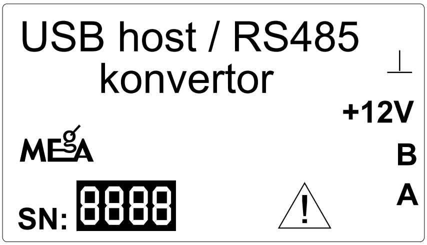
The schematic diagram of converter in communication chain MEg40⁺ → USBhost / RS485 → MEg202.2 is shown in Fig.3. USB cable with connector B (M) is shown in Fig. 2. The USB cable with the connector B (M) is intended to be connected into the universal instrument MEg40⁺. Through this connector, the USB interface of the instrument MEg40⁺ is also supplied as specified by the USB interface standard. Through screw-on terminals, the converter is connected to terminals of the communication unit MEg202.2; for interconnection of the terminals see Table 2.

Tab. 2: Interconnection of USBhost/RS485 converter and communication unit MEg202.2

USBhost / RS485 converter	MEg202.2	
	Chan1	Chan2
A	3	7
B	4	8
+12 V	1	5
⊥	2	6

Fig. 1: USBhost/RS485 converter in version for MEg40+ and MEg202.2

Fig. 2: Detail of type plate of USBhost/RS485 converter and communication unit MEg202.2



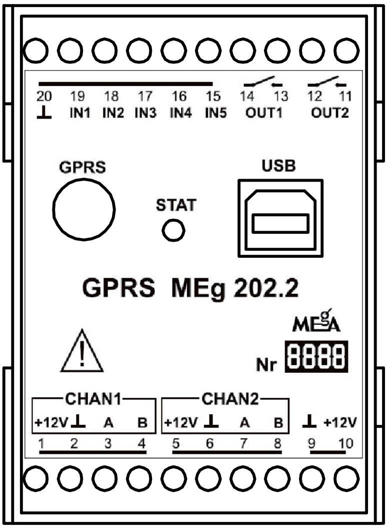
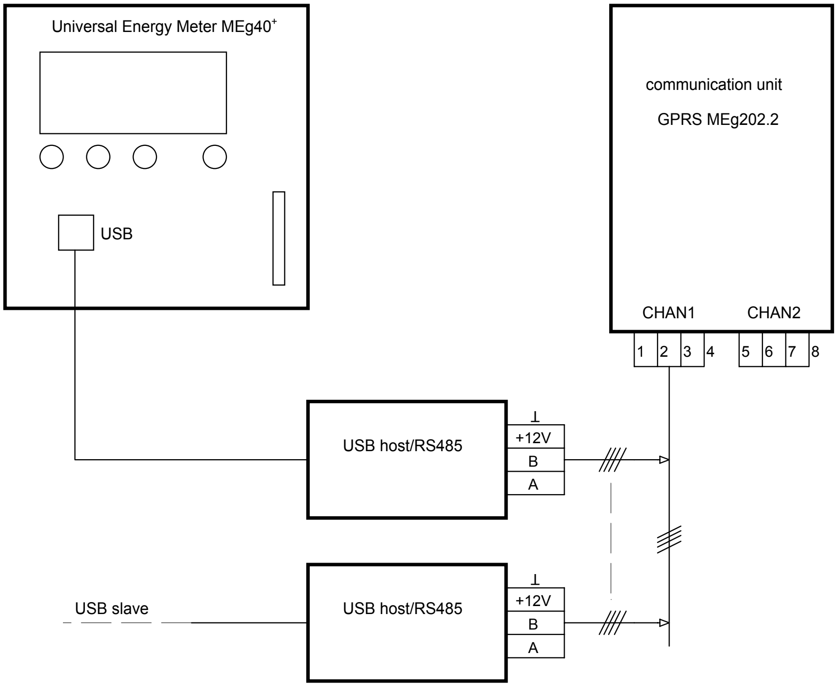


Fig. 3: Interconnection of USBhost/RS485 converter and instrument MEg40+ and communication unit MEg202.2



Appendix No. 1

Methodology of measurement using the monitor MEg40+

Appendix made by prof. Ing. Vladislav Matyáš, CSc. We understand it not only as a universal definition of algorithms of the universal monitors of MEg40+ series but also as a generally valid description of digital measurements.

The monitor MEg40+ performs four different functions simultaneously. All of them are based on measurement of three voltages and three currents in a three-phase system. The basis is numerical measurement of instantaneous values of these voltages and currents in regular time intervals given by the sampling rate that is an integer multiple of the mains frequency. The data sequence $u(k)$ representing instantaneous values of this voltage is derived by sampling and digitalizing from the voltage waveform $u(t)$; where $k = 0, 1, 2, \ldots$ is a serial number. The sequence of instantaneous values $i(k)$ is derived from the current waveform $i(t)$ in the same way.

For three of the monitor functions, the sampling rate is used that is 32-multiple of the mains frequency, and therefore every network period T_s receives 32 data for each voltage and current referring its instantaneous values. The RMS values are calculated from data sequences. So for the voltage from the data sequences $u(k)$ with K data with the serial numbers $k = 0, 1, 2, \ldots, K-1$, the RMS value is calculated using the following formula

$$U = \sqrt{\frac{1}{K}\sum_{k=0}^{K-1} u^2(k)} \tag{1}$$

The formula is gradually used for all three voltages. If instantaneous values $u_1(k)$ of the voltage of phase 1 are used instead of $u(k)$ in the formula, you receive the RMS value U_1 of this voltage that applies to the K given data group. Similarly, from the group of instantaneous values $u_2(k)$ of the voltage in phase 2, you get its RMS value U_2 and from the group of instantaneous values $u_3(k)$ of the voltage in phase 3 you get its RMS value U_3.

It is also possible to evaluate delta voltages instead of phase voltages. When you substitute $u_{12}(k) = u_1(k) - u_2(k)$ in the formula (1) instead of $u(k)$, you can calculate the RMS value U_{12} of the voltage between phases 1 and 2. Similarly, from the instantaneous values $u_{23}(k) = u_2(k) - u_3(k)$ you get the RMS value U_{23} of the voltage between phases 2 and 3 and from the instantaneous values $u_{31}(k) = u_3(k) - u_1(k)$ you get the RMS value U_{31} of the voltage between the phase 3 and 1.

A similar relation as for voltages applies to currents. From the instantaneous current values $i(k)$ with the serial numbers $k = 0, 1, 2, \ldots, K-1$, the RMS current value is calculated according to the formula

$$I = \sqrt{\frac{1}{K}\sum_{k=0}^{K-1} i^2(k)} \tag{2}$$

Using this formula, you calculate the RMS value I_1 of the current in phase 1 from the group of instantaneous values $i_1(k)$ of the current in phase 1, the RMS value I_2 of the current in phase 2 from the group of instantaneous values $i_2(k)$ of the current in phase 2 and the RMS value I_3 of the current in phase 3 from the group of instantaneous values $i_3(k)$ of the current in phase 3.

DETECTION OF EVENTS

In case of this function, RMS values of all three voltages are used, always in the range of the network period T_s, and the interval T_s gradually moves by 0.5 T_s. Because the used sampling rate is 32 times higher than the mains frequency, every interval T_s contains 32 instantaneous values. For calculation, the formula (1) is used where $K = 32$. The obtained RMS values of all three voltages are compared with the preset thresholds. If it is found out that there is a voltage dip, swell or interruption, the extreme voltage value, duration and time of occurrence are recorded.

DETERMINATION OF VOLTAGES, CURRENTS AND POWERS

Voltages and currents in a three-phase system are evaluated according to their RMS values in measuring time intervals T_m lasting 10 network periods, i.e. $T_m = 10T_s$.

These intervals follow immediately one by one but they do not overlap. The sampling runs continuously with a frequency, which is 32 times higher than the network frequency. Therefore 320 instantaneous values fall into each of the measuring time intervals T_m for each of the voltages and currents. To calculate the RMS voltage values, the formula (1) is used where $K = 320$. So the RMS values of phase voltages U_1, U_2, U_3 or delta voltages U_{12}, U_{23}, U_{31} are obtained.

To calculate the RMS phase current values, the formula (2) is used where $K = 320$ to receive RMS phase current values I_1, I_2, I_3.

As well, powers are evaluated in each of the measuring time intervals T_m. The following formula is applied to compute the active power:

$$P = \frac{1}{K} \sum_{k=0}^{K-1} u(k)\, i(k) \tag{3}$$

where $K = 320$. From the values $u_1(k)$ and $i_1(k)$, the active power P_1 in phase 1 is obtained, from the values $u_2(k)$ and $i_2(k)$ the active power P_2 in phase 2 is obtained, from the values $u_3(k)$ and $i_3(k)$, the active power P_3 in phase 3 is obtained.

From the RMS phase voltage value U and from the RMS current value I in the same phase and the same measuring time interval T_m, the apparent power is evaluated.

$$S = UI \tag{4}$$

Particularly $S_1 = U_1 I_1$, $S_2 = U_2 I_2$, $S_3 = U_3 I_3$.

The reactive power (including the deformation one) in each phase and in the same measuring time interval T_m is determined according to the formula

$$Q = \sqrt{S^2 - P^2} \tag{5}$$

So Q_1 is obtained from S_1 and P_1, Q_2 from S_2 and P_2, Q_3 from S_3 and P_3.

To assess the electrical power efficiency in each phase, the coefficient of performance (true power factor) is used:

$$\eta = P / S \tag{6}$$

particularly η_1, η_2, η_3.

The total outlet powers result from the powers in the individual phases.

In case of long-term measurements, a high number of data is obtained in the follow-up measuring time intervals T_m for each voltage and current. Recording of all of these data would be demanding on the monitor memory and would not provide any general overview of measurement results. Therefore, time aggregation of the mentioned data is used. The recording interval T_z is selected, containing L measuring time intervals T_m, i.e. $T_z = L\,T_m$, where L is a natural number. From data measured in the measuring time intervals T_m for the individual voltages, currents and powers, simple data are derived characterizing voltage, current and power values in the individual recording intervals T_z.

If for the given voltage, the RMS values $U(l)$ were obtained in the measuring intervals T_m and with the serial numbers $l = 1, 2, \dots L$, the following total RMS value is corresponding in the recording intervals T_z.

$$U_{zc} = \sqrt{\frac{1}{L}\sum_{l=1}^{L} U^2(l)} \tag{7a}$$

The average effective value is sometimes used instead of the RMS value.

$$U_{zp} = \frac{1}{L}\sum_{l=1}^{L} U(l) \tag{7b}$$

Under normal circumstances, the values U_{zc} and U_{zp} are almost the same. In addition to the total (or average) RMS value, for each value in the range of the recording interval between the values $U(l)$, the minimum and maximum values are searched

$$U_{z\min} = \min_{l} U(l) \qquad U_{z\max} = \max_{l} U(l) \tag{8}$$

These data are obtained for each voltage.

Similarly, for the recording intervals T_z, characteristic phase current values are obtained. From the RMS current values $I(l)$ obtained in the measuring time intervals T_m with the serial numbers $l = 1, 2, \ldots L$, for the recording interval T_z, the total RMS current value is calculated according to the formula

$$I_{zc} = \sqrt{\frac{1}{L}\sum_{l=1}^{L} I^2(l)} \tag{9}$$

or the average RMS current value according to the formula

$$I_{zp} = \frac{1}{L}\sum_{l=1}^{L} I(l) \tag{10}$$

The values I_{zc} and I_{zp} can differ considerably. Besides, the minimum and maximum current values are determined

$$I_{z\min} = \min_{l} I(l) \qquad I_{z\max} = \max_{l} I(l) \tag{11}$$

in the recording intervals T_z

From the active power values $P(l)$ found out in the individual measuring time intervals T_m with the serial numbers $l = 1, 2, \ldots L$, the average active power is obtained for each of the recording intervals T_z

$$P_z = \frac{1}{L}\sum_{l=1}^{L} P(l) \tag{12}$$

and the minimum and maximum active power

$$P_{z\min} = \min_l P(l) \qquad P_{z\max} = \max_l P(l) \tag{13}$$

From the reactive power $Q(l)$ in the measuring intervals T_m, the average reactive power is determined from each of the recording intervals T_z

$$Q_z = \frac{1}{L}\sum_{l=1}^{L} Q(l) \tag{14}$$

and the minimum maximum reactive power values.

During the recording interval T, the active energy

$$E_{PZ} = T_Z P_Z \tag{15}$$

and the reactive energy

$$E_{QZ} = T_Z Q_Z \tag{16}$$

was transmitted.

The above data characteristic for the recording intervals are obtained for all three phases.

DETERMINATION OF THE QUARTER-HOUR MAXIMUM CURRENTS

The algorithm used in the universal monitor MEg40+ with 16 MB memory card in the version with FW and SW 2008 is modified to allow equivalent evaluation of the quarter-hour maximum currents and daily diagrams on the day of occurrence of the quarter-hour maximum current for any selected evaluation period, and besides, the daily diagram evaluation is also possible in any selected day.

DISPLAY AND EVALUATION USING A PERSONAL COMPUTER

The data obtained during operation of the monitor and stored in its memory for further use are transmitted into a personal computer. The simplest operations with the transmitted data include statements. For each of the detected events, place (phase), type, size, time duration and time of occurrence is specified. Another example can be a statement of quarter-hour maximum phase currents with the times of occurrence.

The displayed time courses provide wide application. They include a display of characteristic data obtained gradually in the follow-up recording intervals. For voltages and currents in the individual phases, such data include total or average RMS values, minimum RMS value and maximum RMS value. For the active, reactive and apparent power, they are average, minimum and maximum values, similarly for the coefficient of performance (true power factor). It is also useful to display time curves of the average, minimum and maximum values of the total harmonic distortion and selected harmonics.

Statistical evaluation with subsequent displaying of results in the form of histograms and cumulative diagrams is also considered. This applies to the above mentioned quantities but without their time curves. Simple numerical expression is often sufficient, e.g. what percentage of supply voltages detected in ten minute intervals is outside ± 10 % of the rated value.

The personal computer allows additional processing of displayed data. It is also possible to make additional time aggregation. The period T_v is determined as an M-multiple of the recording interval, i.e. $T_v = M\,T_z$. From the data collected for the recording intervals during the period T_v, the corresponding data are evaluated for the period T_v. Then if $U_{zc}(m)$ are total RMS voltage values belonging in the recording interval with the serial numbers $m = 1, 2, \dots M$ during the time T_v, the voltage during the time T_v has the total RMS value

$$U_v = \sqrt{\frac{1}{M}\sum_{m=1}^{M} U_z^2(m)} \tag{17}$$

minimum and maximum value

$$U_{v\min} = \min_m U_{z\min} \qquad U_{v\max} = \max_m U_{z\max} \tag{18}$$

The same procedure is used for currents. The average active power in the time T_v is

$$P_v = \frac{1}{M}\sum_{m=1}^{M} P_z(m) \tag{19}$$

and the minimum and maximum active power is also computed.

Similar formulas apply to the idle power.

The active energy transmitted during the time T_v is

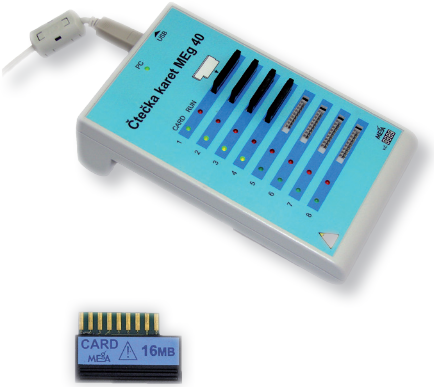
$$E_{PV} = T_V P_V \tag{20}$$

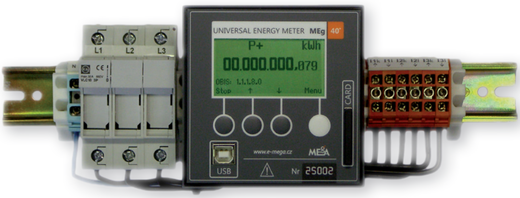
and the reactive energy similarly.

Data from the time interval T_v, can be displayed depending on time and evaluated statistically. It is also possible to use more times T_v for aggregation, with a different position and duration.

MEgA

Universal Energy Meter MEg40+





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