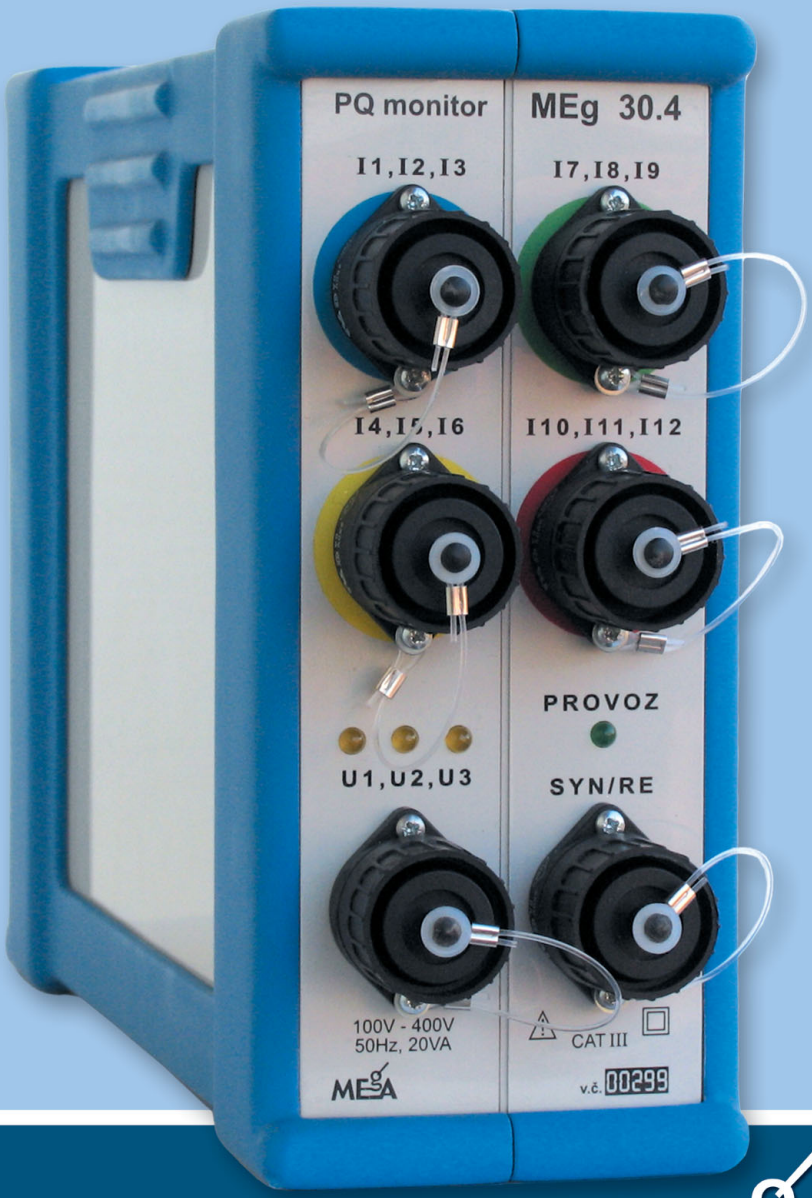
MONITOR PQ MONITOR PQ MONITOR PQ

PQ monitor - MEg 30.4

english version



Měřicí Energetické Aparáty

MEgA

1. Characteristics

The PQ monitor in version MEg30.4 is a multi-function measuring instrument to be used for the measurement and a long-term recording of thirteen currents and four voltages, of an active and reactive power and energies in three-phase four-conductor and five-conductor LV networks. Complying with the EN 50160 standard and with methods of the international standard IEC 61000-4-30 this device analyses all parameters of the voltage quality on a triplet of voltage inputs U1, U2 and U3.

It registers the events, i. e. the voltage dips, swells and interruption and records not only the characteristics defined by the standard but also the shapes of voltages $U_{rms½}$ and of the corresponding currents. In case of events lasting more than 0.8 s it records – when using the memory space effectively – the details of their parts having the greatest informative value, i. e. of the beginning and the end of the given event. Based on the measured shapes of currents the PQ monitor MEg30.4 enables us to assess the direction of the origination of the event as well as of flicker.

By its ability to measure even small voltages on the input U0 the PQ monitor MEg20.4 is also ready for monitoring the voltage between the neutral conductor and ground. On its current input I0 the PQ monitor enables us to carry out the measurement and harmonics analysis of the current of the neutral conductor. Variably, when using a corresponding sensor the I0/T current input can also be used for the measurement of other physical quantities, e. g. for the measurement of temperature.

The following sensors of the alternating currents have been designed for the portable PQ monitor MEg30.4:

- triplet of flexible current sensors AMOS PQ.3 or a simple sensor AMOS PQ.1 with switchable current ranges 30 A, 100 A, 300 A and 1000 A,
- triplet of flexible current sensors AMOS M PQ.3 or a simple sensor AMOS PQ.1 with one of the following ranges: 10 A, 30 A, 100 A, 300 A or 1000 A,
- triplet of clamp measuring current transformers with a permalloy core MT PQ.3 or a single sensor MT PQ.1 with switchable ranges 1 A, 5 A, 30 A, 150 A.

The PQ monitor MEg30.4 has a three-phase supply from all voltages being measured U1 to U3 and it is also possible to provide it with a single-

phase supply through any voltage input. Internal back-up batteries are installed in the PQ monitor MEg30.4 which enable it to be operated during up to 5 minutes without external supply.

The measuring range for phase voltages of the monitors for LV networks is from 0.46 V_{ef} to 400 V_{ef}. Phase-to-phase voltages can be registered and analysed by calculation as well.

The basis of all versions of the PQ monitor is a signal processor with a high-capacity non-destructive data memory which enables a really long-term autonomous performance. The parallel and continuous performance of all measuring, visualization and communication functions represents a sub-stational characteristic of the PQ monitor. A high accuracy and independence on operating conditions is ensured by a high-quality A/D converter with a minimized extent of analog circuits and with a correction of errors of the whole measuring system made by calculation.

2. Principle of measurement and of data processing, organization of the data memory

The measurement of voltages and of currents at frequency 50.00 Hz is based on sampling them with frequency 5120 Hz. The sampling frequency is phase-looped with frequency of the voltage U1. The total number of 1024 values with resolution of 14 bit are always sampled in 200 ms long intervals, following one after another without timeouts. After transformation into the frequency area, 512 complex harmonic components in steps of 5 Hz i. e. 51 harmonic components regarding the multiple of 50 Hz and 461 interharmonic components are then calculated from these values. A Buttervort-type filter of the 3rd order is used in the MEg30.4 monitor for suppressing signal components with a higher frequency. The magnitudes of voltages and currents are calculated from the absolute values of the complete spectrum. Active and reactive power of individual components as well as the unbalance are calculated from complex harmonic components.

The data from the triplets of voltage inputs are processed in the time area for evaluating the events and flicker. The square of the TRMS value for the elapsed period, i. e. the voltage $U_{rms½}$ is calculated after every 10 ms. Frequency is calculated from the data of the channel U1.

Corrections of DC components, corrections of the gain of the current sensors, corrections of frequency characteristics including corrections of

phase shifts between individual measuring channels are made during the calculations.

The Flash-type non-destructive data memory with the capacity of 4 × 4 MB is divided into circularly organized areas. The first area shall be used for recording the development in time of RMS values of measured voltages, currents and power in a complex form. Detailed data on the voltage quality in at least two elapsed weeks shall be stored in the second area. The third data area includes unified data with a list of events according to the methodology of EN 50160 and the fourth data area includes a detailed record of the development of RMS values of the periods of voltages and currents of the last events. The ratios of the ranges of individual areas of the data memories may be mutually changed according to user's needs.

3. Description of measuring functions and of input/output functions of the PQ monitor

3.1 Function time recorder

When the monitor operates in this function, average RMS values for the period of recording are being computed from the RMS values of quantities being measured, calculated in 0.2 s intervals. These average values are then recorded into the Flash type non-destructive memory. The shortest time of recording is 1.0 s, the longest time of recording is 15 min. At the time of recording 1 min the maximum duration of the measurement and of storing the data makes 40 days. According to setting, average values of three voltages, of thirteen currents and of thirteen active and reactive power values are being recorded as standard. Real power factors and energies are then computed from these recorded data using a higher SW. When a suitable sensor is installed, another physical quantity, e. g. the temperature can be recorded instead of the current I0.

3.2 Function of voltage quality (monitor, type QN)

The following ten-minute data can be recorded here:

- average, maximum and minimum 10 s frequency derived from the voltage U1;
- number of cases of exceeding the 10 s values of frequency for four limits defined by the standard EN 50160;
- values of voltage unbalances calculated from the negative-sequence and the positive-sequences components of the voltage and/or from the phase-to-phase voltages;
- values of current unbalances;
- RMS values of voltages U1 to U3, U0 and currents I1 to I12, I0. The maximum and the minimum 0.2 s values of voltages U1 to U3 and the maximum 0.2 s values of currents I1 to I12 are recorded, too;
- total duration of dips, swells and interruptions of voltages U1 to U3;
- values U95percentile of voltages U1 to U3;
- average values of the basic, the 2nd up to the 25th harmonic component of voltages U1 to U3 and of five harmonic components of currents I1 to I12, I0;
- magnitude of THD of voltages U1 to U3, in relation to harmonics and/or in relation to all interharmonic components;
- values of Pst flicker of voltages U1 to U3;
- magnitudes of ripple control signals on voltages U1 to U3.

The recorded data enable us not only to obtain a detailed survey about the voltage quality parameters for the elapsed two weeks but also to evaluate the quality at the assumes changes of standardized requirements.

3.3 Function of recording the events

The function of recording the events operates over the quantities U1 to U3 and I1 to I12. Each new event is recorded into the list of events and into a detailed list. Beside the parameters of events unified by the standard EN 50160, i. e. the time of originating and ending of an event with resolution to 10 ms, the list of events includes the values of the maximum deviations of voltages U1 to U3 from the nominal value.

A detailed list of events includes the shapes of RMS values being calculated after each 10 ms for the elapsed 20 ms for voltages U1 to U3 and currents I0 to I12. The total time of recording the initial detail of an event is 0.6 s, out of which the interval of 0.2 s is recorded prior to origination of the

event. The total time of recording the final detail of an event is 0.6 s, out of which the interval of 0.2 s is recorded after ending of the event. The length of these intervals may be programmably changed.

3.4 Function of oscilloscopic measurement

The function of oscilloscopic measurement serves for checking the correct connection of the set of the PQ monitor MEg30.4, the correct choice of measuring ranges and the correct orientation of current sensors. A notebook with series interface USB II is used for displaying the shapes of voltages U1 to U3, U0 and currents I1 to I12, I0. The recording with duration of 40 ms, i. e. 2 periods may be started individually or repeatedly with the shortest time of repeating equal to 2 s.

3.5 Communication function

The basic communication interface of the PQ monitor is a series interface USB II with the data transmission rate up to 460.8 kbit/s. Another transmission rate (but not more than 921.6 kbit/s) may be chosen as well. The reading out of the content of the 16 MB data memory lasts about 15 minutes.

3.6 External input SYN

The external input SYN is a two-value one and it enables us to connect DC and AC voltages in the range of 0 V to 30 V. The decision making level is the 15 V level. The external input may generate an event without recording the detail of the event. The front edge or the trailing edge of the voltage of the external input may be active according to how this has been programmed.

3.7 Relay output RE

The relay output RE is made by a change-over contact of the polarized relay the state of which is maintained when the supply has been interrupted. One or more of the following meanings may be programmably assigned to the contact of this relay:

- voltage U1 to U3 outside pre-chosen tolerances;
- frequency outside pre-chosen tolerances;
- Pst flicker higher then 1.0;
- selected harmonic component has exceeded the pre-chosen limit;
- THD has exceeded the pre-chosen limit;
- unbalance has exceeded the pre-chosen limit;
- RMS value of the current for 10 periods has exceeded the pre-chosen limit;
- conversion to supply from the internal battery.

3.8 Signalization by LED diodes

The indication of the state of the PQ monitor is signalized by the diode RUN which lights permanently when the monitor is supplied from the external source and lights intermittently with frequency 5 Hz when the monitor is supplied from the internal battery. The lighting of the diode RUN may be programmably assigned to indicating the state of the relay output.

The LED diodes U1, U2 and U3 indicate, by permanent lighting, the state of voltages U1, U2, U3 in a preset tolerance band (90% U_{nom} to 106% U_{nom}) and by intermittent lighting with frequency 1 Hz they signalize that the corresponding voltage is outside the preset tolerance band.

3.9 State of battery charging

Under reference conditions and when being fully charged the internal battery provides the supply to the PQ monitor MEg30.4 for the period of 5 minutes. After the external supply has been interrupted for more than 1 minute, the supply from the internal battery will also be switched-off based on the recommendation of IEC 61000-4-30 and in compliance with the meaning of data measured during the failures in the distribution networks. A total discharging of the energy of the battery at the first interruption of the external supply longer than 5 minutes will thus be avoided and, even after unsuccessful restoration of supply with subsequent switching-off the instrument will be able to record this further interruption as well.

Regarding the saving of energy of the internal battery, it is recommended – before each disconnection of measuring conductors from the supply

voltage made by the personnel – to suppress (for this case) a one-minute secured supply of the monitor which is unnecessary in this case. This shall be carried out via the notebook with the started program of the PQ monitor.

4. Technical data

4.1 Accuracy and ranges of measurement

4.1.1 Measurement of voltages

U1 to U3, U0 as standard.

U_{nom} of phase voltages:	230 V
Highest permissible phase voltage:	400 V_{ef}
Accuracy of voltage measurement:	
	±0.2% of the range at 0.8 U_{nom} to 1.2 U_{nom}
	±0.3% of the range outside 0.8 U_{nom} to 1.2 U_{nom}
Resolution:	0.1% U_{nom} or better
Temperature coefficient:	better than 0.1% U_{nom}/10°C

4.1.2 Measurement of currents

I1 to I12, I0 as standard

Accuracy of current measurement:	0.3% of the range 0.1 I_{nom} to 1.2 I_{nom}
	0.5% of the range at 1.2 I_{nom} to 2 I_{nom}
Resolution:	0.1% I_{nom} or better
Temperature coefficient:	better than 0.1% I_{nom}/10°C
Permissible current overloading:	5 × I_{nom} during 1 s

Measuring system AMOS PQ.3 – MEg30.4

I_{nom} at shape coefficient K=1.11:	30 A, 100 A, 300 A, 1000 A
Range of measurement:	0 to 2 I_{nom}
Accuracy of current measurement:	1.0% I_{nom}
Linearity of current measurement:	better than 0.5% I_{nom}

Change of the indicated value
with the change of position: 1.0% I_{nom}

Measuring system AMOS M PQ.3 – MEg30.4

I_{nom} at shape coefficient K=1.11: 10 A, 30 A, 100 A, 300 A, 1000 A
Range of measurement: 0 to 2 I_{nom}
Accuracy of current measurement: 2.0% I_{nom} for range 10 A and 30 A
1.0%I_{nom} for range 100 A and 300 A and 1000 A
Linearity of current measurement: better than 0.5% I_{nom}
Change of the indicated value
with the change of position: 1.5% I_{nom} for range 10 A and 30 A
1.0%I_{nom} for range 100 A and 300 A and 1000 A

Measuring system MT PQ.3 – MEg30.4

I_{nom} at shape coefficient K=1.11: 1 A, 5 A, 30 A, 150 A
Free space for clamping the conductor: 10 mm × 20 mm
Range of measurement: 0 to 1.2 I_{nom}
Accuracy of current measurement: 0.5% I_{nom} + 0.2% of the indicated value at f=50 Hz
Frequency range: 40 Hz to 2 kHz

4.1.3 Measurement of frequency

Nominal value: f_{nom}=50.0 Hz
Range of measurement: 47.5 Hz to 52.5 Hz
Accuracy of frequency measurement: better than 10 mHz
Resolution: 1 mHz

4.1.4 Measurement of power factor

Range of measurement: 0 to 1.0 in all four quadrants
Accuracy of measurement: better than 0.5% at U_{nom} , I_{nom} and cos $\varphi \geq 0.5$

4.1.5 Measurement of power

Accuracy of measurement:	0.5% P_{nom} at f=50 Hz, 0.8 U_{nom} to 1.2 U_{nom}, 0.1 I_{nom} to 1.2 I_{nom}, cos φ ≥ 0.5

4.1.6 Measurement of voltage unbalance

Range of measurement:	0 to 20%
Accuracy of measurement:	better than 0.2%

4.1.7 Measurement of Pst

Range of measurement:	0 to 5
Accuracy of Pst measurement:	better than 0.1

4.1.8 Measurement of THD

Range of measurement:	0 to 20%
Accuracy of THD measurement:	better than 0.2%

4.1.9 Measurement of Uharm

Range of measurement:	0 to 20%
Accuracy of Uharm measurement:	better than 0.2%

4.2 Reference ambient conditions

Ambient temperature:	20°C ± 2°C
Relative humidity:	40% to 60%
Atmospheric pressure:	86 kPa to 105 kPa

4.3 Ambient conditions

Operating temperature:	–25°C to +55°C
Operation:	in indoor space
Relative humidity:	5% to 95%
Altitude:	up to 2000 m
Operating position:	arbitrary
Protection level:	IP41 (running-down water-proof)
Overvoltage category:	III (ČSN EN 61010-1)
Degree of contamination:	2

Protection under condition of one failure is ensured by protective impedance with a combination of component parts.

4.4 General data

Resolution of A/D convertor:	14 bit
Sampling rate:	5120 Hz, phase feedback loop
Non-destructive data memory:	4 × 4 MB Flash type
Organization of data memory:	circular
Internal clock:	error max. 2 s/24 h
Communication:	USB II, 460.8 kbit/s

4.5 Supply

Supply from any measuring input :	U1 to U3
Supply voltage range:	100 V_{ef} to 400 V_{ef}
Maximum input power:	20 VA

Fuses MST T500 mA/250 V are used in voltage inputs

Back-up supply:	4 × battery SANYO N-50AAA L1×5 up to the period of five 1 minute intervals in average under reference ambient conditions

Battery shall be replaced by manufacturer based on order.
Average time between battery replacement is 3 years.

4.6 External connection the SYN/RE

Terminals S1, S2 of the input signal SYN

Low:	0 V to 5 V DC and AC
High:	20 V to 30 V DC and AC

Terminals galvanicly separated by an optical element with insulation strength 5 kV

Terminals K1, K2, K3 of the change over contact of the polarized relay of the output RE:

Max. DC/AC voltage:	30 V
Max. switched/permanent current:	1 A

4.7 Dimensions and weight

Length × height × width:	340 × 200 × 80 mm (including connectors)
Weight:	3.0 kg

4.8 Technical lifetime

The technical lifetime of the MEg30.4 monitor with its accessories is 10 years. The manufacturer recommends to check the state of the instrument and its accessories every three years during this lifetime beside preventive inspetions carried out by the user.

It is appropriate to update the SW products when the standards and rules for operating the power system have been changed.

5. Design

With regard to its design, the PQ monitor in version MEg30.4 is to be used for the measurement in LV switchboards and substations where the actioning of the running-down water cannot be excluded. For that reason, all connectors of the basic unit have been designed as screwed ones. The unit of the PQ monitor MEg30.4 is placed in a plastic all-insulating case with dimensions 300 × 200 × 30 mm, resistant against running-down water. Four current connectors distinguished in colour, i. e. I1 to I3 (blue), I4 to I6 (yel-

low), I7 to I9 (green), I10 to I12 (red), as well as a voltage connector for U1 to U3 and a signal connector with signals SYN and Re are situated on the front panel of the case. The signalizing LED diode RUN and three LED diodes U1, U2 and U3 indicating the magnitude of connected voltages being measured are also placed on the front panel. The following data and information are given on the front panel: name and type of the instrument, its serial number and another technical information.

A voltage connector U0, a current connector for I0/T and a communication connector USB II are situated on the rear panel of the instrument.

A triplet of flexible sensors AMOS PQ, AMOS M PQ, MT-PQ can be connected to current connectors of the MEg30.4 monitor either directly or by using a measuring current extension cable with length 5 m or 10 m. Even series-connected measuring voltage extension cables with length 5 m or 10 m may be connected to voltage connectors of the MEg30.4 unit. At the end of these extension cables, a three-phase voltage measuring cable U1, U2, U3 and N or a single-phase one U0 with safety banana plugs distinguished in colour and describtion shall be installed. Safety alligator clips distinguished in colour or grips with integrated Legrand type fuse 10 133 01, 1 A/500 V (10 × 38 mm) shall then be installed on these banana plugs depending on the overvoltage category at the point of measurement. For voltage measurements in single-phase LV networks a LV adapter connected into the LV mains plug may be used. Safety banana plugs U1 and N of a three-phase voltage termination shall be connected into safety jacks of the adapter. The measurement of frequency and the phase feedback loop are derived from the voltage U1.

Four triplets of active flexible measuring sensors AMOS PQ.3 or AMOS M PQ.3 are intended to be used for the measurement of alternating currents by means of PQ monitors, version MEg30.4.

The AMOS PQ sensors have a loop with length 40 cm and diameter 16 mm. Two insulation layers distinguished in colour, with total thickness 2 mm are provided on its surface. The minimum permitted radius of the loop curvature is 30 mm. The loop of the AMOS PQ sensor is equipped with a plastic closure. The supply cable between the loop and the converter unit is 150 cm long. The converter unit of the AMOS PQ.3 sensor comprises a four-position switch of the nominal current (30 A, 100 A, 300 A, 1000 A) and a signalization diode RUN which signalizes the supply from the PQ monitor by intermittent lighting. A separate flexible AMOS PQ.1 sensor shall be used for the measurement of the current I0.

Single-range water-proof flexible current sensors AMOS M PQ have a loop with length 30 cm and diameter 8 mm. A double insulation layer distinguished in colour is on the surface of the loop as well. The supply cable of the loop of the AMOS M sensor is 150 cm long and a converter with a marked value of the nominal current is connected at its end. In the AMOS M PQ.3 version, three sensors are terminated with a common round screwing connecter. The AMOS M PQ.1 sensor is also terminated with a round screwing connector to be installed onto connector I0/T of the MEg30.4 monitor.

Precise measuring clamp transformers MT PQ made of permalloy, with free space for clamping the conductor 10 × 20 mm, are to be used for the accurate measurement of small currnets and for the measurement in secondary circuits of the current transformers. The nominal current of MT PQ transformers may be set (1 A, 5 A, 30 A, 150 A) by means of a four-position sliding switch. The length of supply cables for MT PQ is 150 cm. The triplet of MT PQ.3 clamp transformers is terminated with a round current connector. A simple measuring clamp transformer MT PQ.1 with a round cound connector for MEg30.4 may also be ordered.

The current sensors AMOS PQ or MT PQ shall be connected to the MEg30.4 monitor either directly by connecting them into current connectors, or by using current measuring extension cables 5 m or 10 m long. The direction of the current flow through AMOS PQ, AMOS M PQ and MT PQ sensors is indicated by an arrow with integrated marking of the current being measured I1, I2, I3 to I12, I0. The serial numbers of AMOS PQ.3, AMOS M PQ.3 and MT PQ.3 correspond to the serial number of the MEg30.4 unit with which they form a measuring set with a guaranteed accuracy of measurement.

A contact thermometer T-PQ.1 with a electrically insulated temperature sensor can be used for the measurement of temperature by means of MEg30.4. This thermometer shall be connected into the current connector I0/T.

The case of the PQ monitor MEg30.4 is provided with a rubber coating which – together with damping mechanical impacts – creates a grip and feet. The set of the PQ monitor MEg30.4 is delivered in a leatherette bag 49 × 33 × 17 cm.

6. Installation

First of all, a convenient type of current sensors AMOS PQ, AMOS M PQ or MT-PQ shall be chosen. When the measuring current transformers are permanently installed on LV feeders of the MV/LV transformer, its secondary currents (I_{nom} = 1 A or I_{nom} = 5 A) shall be measured by clamp tranformers MT-PQ. If permanently installed measuring transformers are not available, a triplet of AMOS PQ.3 sensors shall be used for the measurement of the currents. The AMOS PQ.3 flexible sensors or single-range flexible sensors AMOS M PQ may be used for the measurement of currents of individual feeders, too.

When installing the current sensors, the agreement of the serial number of the sensors with that of the MEg30.4 unit shall be checked. The current sensors shall be connected into current connectors of the MEg30.4 monitor, marked with identical colour, either directly or by using the current measuring extension cable of the corresponding length. It is recommended to respect the colour marking here as well. When installing the current sensors on conductors with the current being measured, care should be taken of the positive direction of the current corresponding to the direction of arrows on the sensors. A suitable value of I_{nom} shall be preset on the sensor according to the expected magnitude of the currents.

Depending on the point of measurement, either safety alligator clips or grips with an intergated fuse shall be slided onto the safety banana plugs of the three-phase or even single-phase voltage measuring extension cable. The grips with the integrated fuse are to be used for the measurement in unprotected circuits. Red alligator clips shall be slided onto red banana plugs U1 to U3, the black alligator clip shall be slided onto the black conductor N and the blue alligator clip shall be slided onto the red conductor U0. According to the distance of the points of measurement, voltage measuring extension cables of the required length may be connected to measuring terminations. These extension cables shall be connected to the corresponding voltage connector on the MEg30.4 monitor. Finaly, the measuring conductor N shall be first connected to the neutral conductor of the point of measurement and only then the measuring conductors U1, U2, U3 and/or U0 shall be connected. In case of a single-phase or two-phase measurement the not used measuring conductors shall be connected to the conductor N.

The PQ monitor MEg30.4 begins to be supplied by connecting the first conductor of the measuring conductors U1, U2, U3 to a phase voltage higher

than 100 V_{ef}. The supply having been connected, a corect functioning of all circuits shall be checked at first and, after this check has been finished succesfully, the LED diode RUN starts to light permanently. The interruption of the permanent lighting of the LED diode RUN signalizes the loss of the function of the monitor. In case of a possible supply voltage interruption the MEg30.4 monitor continues to measure for the next minute, taking energy from the built-in battery. The LED diode RUN is lighting intermittently with frequency 5 Hz during this time. If the supply of the MEg30.4 monitor is not restored within 1 minute, the monitor stops the measurement and the LED diode RUN will not be lighting.

At the point of measurement, a switched-on notebook with the started program PQ monitor shall be connected to the energized MEg30.4 monitor by means of the cable of the series communication interface USB II. The item Setting the measurement shall be chosen and a correct choice of the nominal value of the current on the current sensors, a correct order of connected voltages and a correct orientation of the current sensors shall be checked. The measuring protocol according to which the PQ monitor MEg30.4 will measure shall then be specified by using the procedure described in user manual for the program PQ monitor.

The PQ monitor MEg30.4 may be also programmed in advance in the laboratory and, at the point of measurement, it shall be only connected into measuring and supply circuits. However, the checking of the correct connection and of the appropriate choice of the range of currents being measured is not then possible.

When disconnecting the monitor from the supply, it is recommended – for saving the energy of the internal battery – to suppress a one-minute secured supply of the monitor which is unnecessary in this case. This shall be carried out by using the notebook will the started program PQ monitor.

6.1 Basic important points relating to the installation

- choice of the type of current sensors
- checking the agreement of serial numbers of the MEg30.4 monitor and of the current sensors
- choice of the range of current measurement
- installation of voltage and current extension cables
- installation of current sensors in a correct direction

- fitting of contact elements on banana plugs of the measuring voltage cables
- connection of the common conductor and then of measuring conductors to points being measured
- checking the lighting of the LED diode RUN and of diodes U1, U2 and U3
- communication between MEg30.4 and PC (program Control of the PQ monitor)
- checking the correct installation of current sensors and of ranges of the current being measured by means of the program.

Using the PQ monitor in version MEg30.4 in another way than in that for which it has been internded may result in impairing the protection provided by the equipment.

7. Demands on maintenance

The MEg30.4 monitor has no demands on forced ventilation, it does not comprise any moving control elements and, except for a routine cleaning of the surface, it has no special demands on maintemance. When cleaning its surface, only soft materials and non-aggressive solutions, preferably water with a detergent shall be used.

The prevevtive inspection of the portable PQ monitor in version MEg30.4 includes:

- checking the undamaged state of the insulation of measuring conductors, alligator clips, current sensors and temperature sensors;
- checking the legibility of marking on the measuring elements;
- checking the mechanically undamaged state of the monitor unit and of complete measuring accessories;
- checking consistency of rubber coatig.

The interval of checking the accuracy of measurement shall be specified by the user of the PQ monitor MEg30.4 according to the importance of measurements for which the monitor has been intended. In case of a portable version of the PQ monitor MEg30.4 it is recommended to check the accuracy of measurement each 3 years on average. The battery of the

internal source of the back-up supply SANYO N-50AAAL 1×5 shall always be replaced when checking the accuracy of measurement.

It is not permitted to dismount mechanical parts, to remove the cover, etc. on the already installed or connected monitors and on their accessories. The removal of the cover of the installed MEg30.4 monitor is dangerous to life.

8. Content of the set of the MEg30.4 monitor

Basic set

1 × PQ monitor MEg30.4 including SW complying with EN 50160 with outputs in format xls
1 × communication cable PQ (USB II/2 m/EMC)
4 × triplet of flexible sensors AMOS PQ.3 (30 A, 100 A, 300 A, 1000 A)[1)]
1 × flexible sensor AMOS PQ.1 (30 A, 100 A, 300 A, 1000 A)[1)]
1 × three-phase measuring voltage termination (U1, U2, U3)/2 m
1 × single-phase measuring voltage termination (U0)/2 m
1 × set of alligator clips LV/III (3 pcs red, 1 pc black, 1 pc blue)
1 × user guide for PQ monitor
1 × program on CD
1 × leatherette bag, dimensions 49 × 33 ×17 cm

Option

Communication cable PQ (USB/5 m/EMC)
Measuring current extension cable/5 m
Measuring current extension cable/10 m
Measuring voltage extension cable/5 m[2)3)]
Measuring voltage extension cable/10 m[2)3)]
Triplet of single-range flexible sensors AMOS M PQ.3
I_{nom} = 10 A, 30 A, 100 A, 300 A, 1000 A[1)]
Single-range flexible sensors AMOS M PQ.1
I_{nom} = 10 A, 30 A, 100 A, 300 A, 1000 A[1)]
Triplet of clamp transfomers MT PQ.3 (1 A, 5 A, 30 A, 150 A)[4)]
Clamp transformer MT PQ.1 (1 A, 5 A, 30 A, 150 A)[4)]
Grip with integrated fuse 1 A/500 V – 10 × 38 mm (red/black/blue)

Adapter for the measurement in single-phase socket
Temperature probe T-PQ.1
Problem-oriented SW for four types of analyses:
- Analysis of time records
- Analysis of voltage events
- Analysis of voltage quality (EN 50160)
- Analysis of current surges and energies

Leatherette bag, dimensions 49 × 33 ×17 cm

[1] Another measuring range may be supplied according to the customer's requirement
[2] It may be arranged into series
[3] It may be used for a three-phase and a single-phase termination
[4] Free space for clamping the conductor: 10 × 20 mm

9. Delivery

The place of delivery is the address of the manufacturer's seat if not otherwise stated. The portable set of the PQ monitor in version MEg30.4 is usually delivered in a leatherette gag with lockable closures. Delivery note and certificate of guarantee with the indicated date of sale are component parts of the delivery.

10. Guarantee

It is not permitted to open the unit of the PQ monitor and its accessories during the guarantee period.

A guarantee in the length of two years since the date of sale is provided for the MEg30.4 monitor and its accessories. Defects originating during this period as a demonstrable result of a defective design, manufacturing or using unproper material will be repaired free of charge by the manufacturer. The place of fulfilment of the guarantee obligations is the seat of the manufacturer of the MEg40 monitor.

The guarantee becomes invalid if the user has broken the seal or carried out unpermitted modifications or changes on the MEg30.4 monitor, if he connects it incorrectly, at its excessive mechanical wear or when the monitor or its accessories have been operated out of keeping with technical conditions.

The defects on the MEg30.4 monitor and on its accessories originating during the guarantee period shall be claimed by the user to the manufacturer of the monitor. The claim without the attached certificate of guarantee will not be accepted.

The manufacturer bears in any case no responsibility for subsequent damages caused by using the MEg30.4 monitor and its accessories. No responsibility which would exceed the price of the MEg30.4 monitor follows for the manufacturer from this guarantee.

11. Manufacturer

MEgA – Měřicí Energetické Aparáty, s.r.o.
Letovická 1412/4
621 00 Brno
Czech Republic

Office:
MEgA – Měřicí Energetické Aparáty, s.r.o.
Okružní 794/29a
638 00 Brno
Phone/fax: 541 225 015
mail: mega@e-mega.cz
web: www.e-mega.cz

Appendix Nr. 1

Measurement and evaluation of data measured by the PQ monitor

The measurement and evaluation have been proposed with due regard to relevant standards.

Mains frequency shall be assessed in the first voltage channel after having passed through the lowpass fiter with treshold frequency 60 Hz. The magnitude of the voltage must be at least 20% of the nominal value. The average value of frequency shall be measured in time intervals of 10 s, resolution is 1 mHz.

Digital measurement of instantaneous values of voltages and currents in individual channels is the starting point for the evaluation. At mains frequency 50 Hz, it is carried out with sampling frequency 5120 Hz so that the frequency range spreads out up to 2555 Hz. The groups falling within the set time intervals, in which RMS values and/or spectra are being evaluated, are taken into consideration from a continuous sequence of data representing the instantaneous values measured in each channel.

Magnitudes of voltages and currents are expressed by RMS values in the intervals of 10 network periods, i. e. for groups each having 1024 data. So in case of the voltage, the RMS value of the voltage shall be calculated from the sequence of data $u(l)$, where l = 0, 1, 2, …, 1023 is the order representing the relative time of the occurrence of instantaneous values:

$$U_{ef} = \sqrt{\frac{1}{1024}\sum_{l=0}^{1023} u^2(l)}$$

The RMS value of the current shall be assessed in the same way.

Assessment of events and of flicker is similarly based on the evaluation of RMS values of the voltage in the intervals of 1 network period.

For evaluating the frequency feateres of voltages and currents, a spectral analysis of the latters shall be carried out. FFT is used for this purpose being always applied to the sequence of 1024 data that represent the instantaneous values falling within the time interval of 10 network periods. A complex spectrum of the respective quantity will be obtained as a result, frequency resolution is 1/10 of the mains frequency. In case of the voltage, a sequence of real parts $U_{re}(k)$ and a sequence of imaginary parts $U_{nom}(k)$, where k = 0, 1, 2, … 511 is the order of spectral components respecting their relative frequency, will be obtained. The basic harmonic component with mains frequency has the order = 10 in this spectrum. The spectrum spreads out up to the 51st harmonic when referred to this component. Similarly, from the time sequence of instantaneous values of the current $i(l)$ we may obtain its spectrum $I_{re}(k)$ and $I_{nom}(k)$. The assessed spectra enable further evaluations to be performed. RMS values can be calculated from the complex spectra. The RMS value of the basic harmonic component of the voltage with mains frequency then is:

$$U_{efz} = \sqrt{2\left[U_{re}{}^{2}(10) + U_{im}{}^{2}(10)\right]}$$

The RMS value of all harmonic equals:

$$U_{efh} = \sqrt{2\sum_{m=1}^{51}\left[U_{re}{}^{2}(10m) + U_{im}{}^{2}(10m)\right]}$$

The RMS value of all components in the spectrum, i. e. of all harmonics and interharmonics alltogether, for $k > 0$ is:

$$U_{efc} = \sqrt{2\sum_{k=1}^{511}\left[U_{re}{}^{2}(k) + U_{im}{}^{2}(k)\right]}$$

The same situation exists in case of RMS values of the currents I_{efz}, I_{efh} and I_{efc}.

Distortion of voltages and currents may be easily evaluated from the above-given RMS value. An ideal shape of the voltage is the harmonic shape. For

that reason its possible distortion is related to its basic harmonic component and the THD shall be evaluated:

$$d_h = \sqrt{\frac{U_{ef\,h}{}^2 - U_{ef\,z}{}^2}{U_{ef\,z}{}^2}}$$

The distortion is sometimes evaluated from all components in the spectrum:

$$d = \sqrt{\frac{U_{ef\,c}{}^2 - U_{ef\,z}{}^2}{U_{ef\,z}{}^2}}$$

In case of the currents the distortion may be evaluated in the same way. However, as the distortion of the currents can be considerable, it may be evaluated with regard to the total RMS value instead of to that of the basic harmonic component. The THD then is:

$$d_{hc} = \sqrt{\frac{I_{ef\,h}{}^2 - I_{ef\,z}{}^2}{I_{ef\,h}{}^2}}$$

or

$$d_c = \sqrt{\frac{I_{ef\,c}{}^2 - I_{ef\,z}{}^2}{I_{ef\,c}{}^2}}$$

Magnitude of the ripple control signal the frequency of which would be identical with that of some interharmonic component would be given by the RMS value of this interharmonic. If it is not the case, the magnitude of the ripple control signal with a known frequency f_{HDO} shall be evaluated as the RMS value of four interharmonics the frequencies of which are most close to the frequency of the signal. The lowest frequency of this group of four interharmonics is own to the interharmonic with serial number $v = C - 1$ where C is the integer part of the value $f_{HDO}/5$. The magnitude of the ripple control signal is taken as follows:

$$U_{HDO} = \sqrt{2\sum_{k=v}^{v+3}\left[U_{re}{}^{2}(k) + U_{im}{}^{2}(k)\right]}$$

Coefficient of unbalance is a three-phase indicator of the quality. It shall be assessed from the basic harmonic components of all the three voltages in a three-phase system. It is defined as the ratio

$$n = \frac{U_{zp}}{U_{so}}$$

where U_{zp} is the magnitude of the negative-sequence component and U_{so} is the magnitude of the positive-sequence component. When the basic harmonic components of phase voltages U_1, U_2, U_3 are known, the magnitudes of the negative-sequence and the positive-sequence components follow from the relations

$$U_{zp} = \left| \bigcup_1 + a^2 \bigcup_2 + a \bigcup_3 \right| / 3, \qquad U_{so} = \left| \bigcup_1 + a \bigcup_2 + a^2 \bigcup_3 \right| / 3$$

where $a = \exp(j2\pi/3)$. Phase-to-phase voltages may be used instead of phase ones. However, it is simpler to use the following formula in such a case:

$$n = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}}; \qquad \beta = \frac{U_{12}^4 + U_{23}^4 + U_{31}^4}{(U_{12}^2 + U_{23}^2 + U_{31}^2)^2}$$

Power in individual phases can be evaluated from the complex spectra of phase voltages and currents. The following active power and reactive power then exist in the given phase at the relative frequency k:

active power $P(k) = 2\left[U_{re}(k)I_{re}(k) + U_{im}(k)I_{im}(k)\right]$

reactive power $Q(k) = 2\left[U_{im}(k)I_{re}(k) - U_{re}(k)I_{im}(k)\right]$

The total power in the given phase may be assessed from these partial power values at individual frequencies. The total power corresponding to all harmonic and/or interharmonic components may then be assessed from the respective sums. By summing up the power values in individual phases the total power in the system may thus be assessed.

Comments to inspections and repairs of the MEg30.4 monitor, serial Nr.:.....				
Date of receipt	Inspection/repair	Description of the repair	Repair carried out by	Date of return

Měřicí Energetické Aparáty, s.r.o. • Letovická 1412/4 • 621 00 Brno • phone/fax +420 541 225 015 • mega@e-mega.cz • www.e-mega.cz