PowerQ and PowerQ *Plus*

MI 2492 and MI 2392

Instruction manual

Version 1.2, Code No. 20 751 276

METREL®

Distributor:

Manufacturer:

METREL d.d.
Ljubljanska cesta 77
1354 Horjul
Slovenia

web site: http://www.metrel.si
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CE Mark on your equipment certifies that this equipment meets the requirements of the EU (European Union) concerning safety and interference causing equipment regulations

Contents

1 PowerQ (MI 2492) and PowerQ *Plus* (MI 2392)

The PowerQ series of instruments (PowerQ and PowerQ *Plus*) are portable multifunction instruments for measurement and analysis of three-phase power systems.

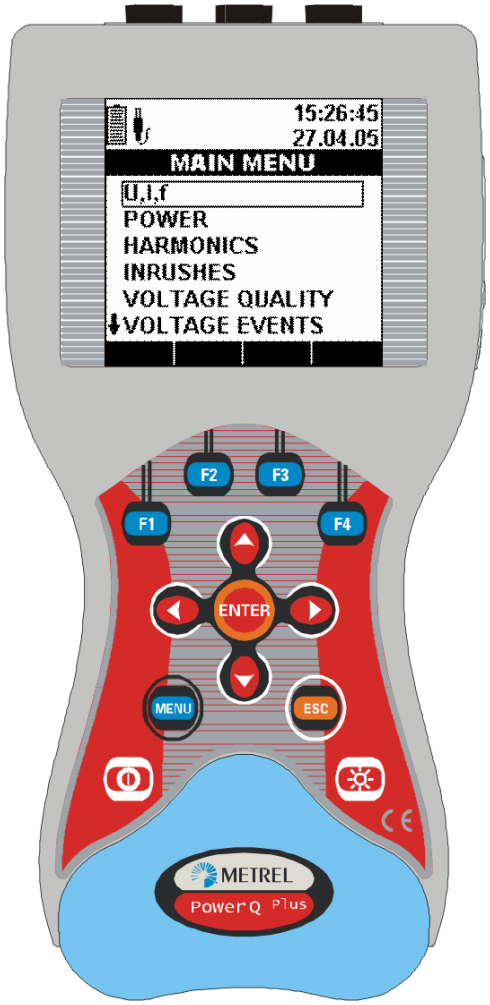


Fig. 1.1: Instrument PowerQ and PowerQ Plus

1.1 Main Features

- Comprehensive real time monitoring, logging and analysis of 3 phase (3φ) power systems.
- Wide range of functions:
  - True RMS voltage and current measurement,
  - Power (Watt, VAr and VA),energy and power factor measurement,
  - Phase diagram and unbalance,
  - Harmonics analysis, up to 50th harmonic
  - Inrush currents*,
  - Voltage events*,
  - Power quality analysis according to the EN 50160*.

*PowerQ Plus only

- Scope mode for displaying real time waveforms
- Current and voltage harmonics distortion analysis up to 50th harmonics
- Energy monitoring and analysis.
- Internal rechargeable batteries.
- RS232 and USB communication ports for connection to a PC.
- Windows software for data analysis and instrument control.
- Memory list mode for displaying stored waveforms

1.2 SAFETY CONSIDERATIONS

General

To ensure operator safety while using the Power Q series of instruments and to minimize the risk of damage to the instrument, please note the following general warnings:

⚠ **The instrument has been designed to ensure maximum operator safety. Usage in a way other than specified in this manual may increase the risk of harm to the operator!**

⚠ **Do not use the instrument and/or any accessories if there is any damage visible!**

⚠ **The instrument contains no user serviceable parts. Only an authorized dealer can carry out service or adjustment!**

⚠ **All normal safety precautions have to be taken in order to avoid risk of electric shock when working on electrical installations!**

⚠ **Only use approved accessories which are available from your distributor!**

⚠ **Instrument contains rechargeable NiMh batteries. The batteries should only be replaced with the same type as defined on the battery placement label or in this manual. Do not use standard batteries while power supply adapter/charger is connected, otherwise they may explode!**

⚠ **Hazardous voltages exist inside the instrument. Disconnect all test leads, remove the power supply cable and switch off the instrument before removing battery compartment cover.**

⚠ **During very long charging (>16 h) in hot (40 °C) environment the battery holder screw might reach maximum allowed temperature for metal part of handle. In such environment it is advisable not to touch the battery cover during or immediately after the charging.**

⚠ **Maximum voltage between any phase and neutral input is 550 V_{RMS}. Maximum voltage between phases is 952 V_{RMS}.**

⚠ **Always short unused voltage inputs (L1, L2, L3) with neutral (N) input to prevent measurement errors due to noise coupling.**

1.3 Applicable standards

The Power Q series of instruments are designed in accordance with the following European standards:

Safety:

- **EN 61010-1 : 2001**

Electromagnetic compatibility (emission and immunity):

- **EN 61326 : 2002**

Measurements according to the European standards:

- **EN 61000-4-30 class B : 2003**
- **EN 50160 : 1999***

* Power Q Plus only

2 Description

2.1 Front panel

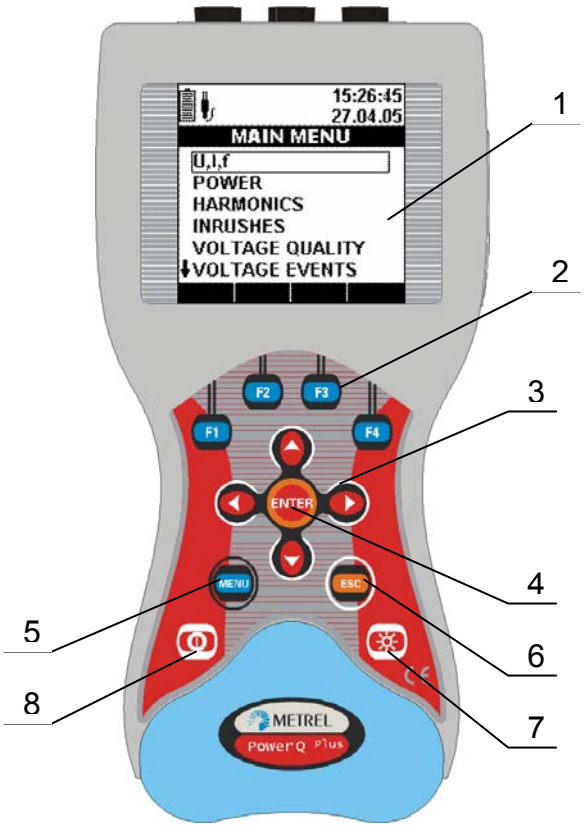
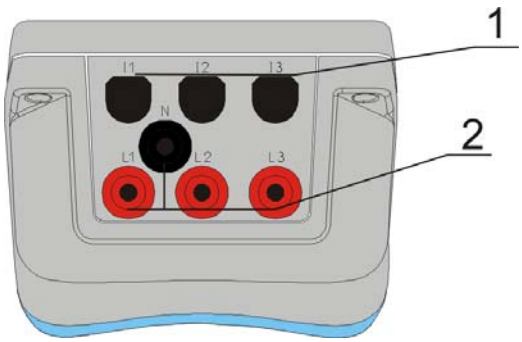


Fig. 2.1: Front panel

Front panel layout:

1.	**LCD**	Graphic display with LED backlight, 160 x 160 pixels.
2.	**F1 – F4**	Function keys.
3.	**ARROW keys**	Move cursor and select parameters.
4.	**ENTER key**	Confirms new settings, starts recording procedure.
5.	**MENU key**	Opens configuration menu.
6.	**ESC key**	Exits any procedure.
7.	**LIGHT key**	LCD backlight on/off (backlight automatically turns off after 30 seconds if no key action occurs). If the *LIGHT* key is pressed for more then 1.5 seconds, CONTRAST menu is displayed, and the contrast can be adjusted with the *LEFT* and *RIGHT* keys.
8.	**ON-OFF key**	Turns on/off the instrument.

2.2 Connector panel



⚠

- Use safety test leads only!
- Max. permissible voltage between voltage input terminals and ground is 600 V_{RMS} !

Fig. 2.2: Connector panel

Connector panel layout:

1 Clamp-on current transformers/Current transformers (I_1, I_2, I_3) input terminals.
2 Voltage (L_1, L_2, L_3, N) input terminals.

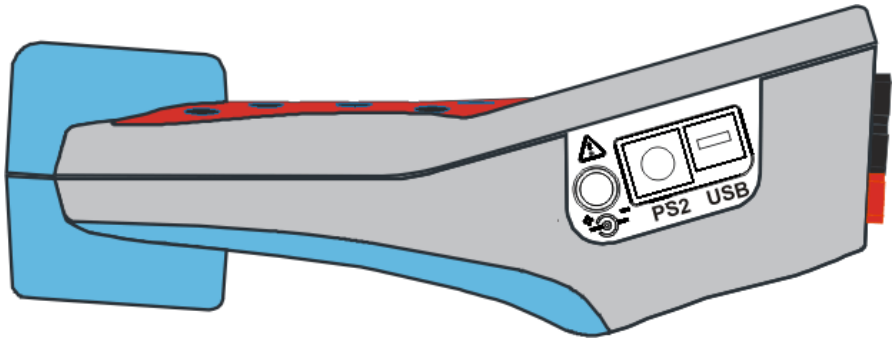


Fig. 2.3: External power socket and communication connector

1 External power socket.
2 PS-2 – RS-232 serial connector.
3 USB – Connector

2.3 Bottom view

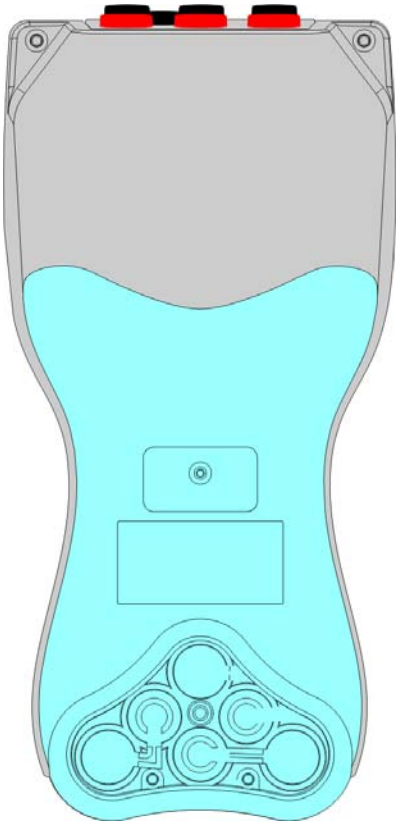


Fig. 2.4: Bottom view

Bottom view layout:

1. Screws (unscrew to open the instrument).
2. Battery compartment.
3. Battery compartment screw (unscrew to replace the batteries).

2.4 ACCESSORIES

2.4.1 Standard accessories

See attached sheet for a list of standard accessories.

2.4.2 Optional accessories

See attached sheet for a list of optional accessories that are available on request from your distributor.

3 Technical specifications[1]

3.1 Measuring system

Configuration	3-phase, 3xI, 3xU input	
Sampling rate	5120 Hz @ 50 Hz	
Basic calculation rates (METER, SCOPE, LOGGER mode)	U,I,f	200 ms, no gaps
	Harmonics	200 ms, 1.5/sec
	Power	200 ms, no gaps
	Energy	200 ms, no gaps

3.2 Measurements

NOTE: Error of external voltage and current transducers is not considered in this specification!

3.2.1 Voltage

Input voltage range: Lx-N 550 V_{RMS} (single phase or 3 phase 4 wire)
Lx-Ly 952 V_{RMS}
Input impedance: Lx-N 3 MΩ, Lx-Ly 3 MΩ

TRMS, AC+DC, Lx-N, connection

Measuring (indication) range	Resolution	Accuracy	Crest factor
Range 1: 3.0 (0.0) V_{RMS} ÷ 70.0 V_{RMS}	0.1 V	±(1 % + 0.5 V)	1.4 min
Range 2: 5.0 (0.0) V_{RMS} ÷ 130.0 V_{RMS}		±(1 % + 0.8 V)	
Range 3: 10.0 (0.0) V_{RMS} ÷ 300.0 V_{RMS}		±(1 % + 1.5 V)	
Range 4: 20.0 (0.0) V_{RMS} ÷ 550.0 V_{RMS}		±(1 % + 2.5 V)	

TRMS, AC+DC, Lx-Ly connection

Measuring (indication) range	Resolution	Accuracy	Crest factor
Range 1: 5.2 (0.0) V_{RMS} ÷ 121.0 V_{RMS}	0.1 V	±(2 % + 1.0 V)	1.4 min
Range 2: 8.6 (0.0) V_{RMS} ÷ 225.0 V_{RMS}		±(2 % + 1.6 V)	
Range 3: 17.3 (0.0) V_{RMS} ÷ 519.0 V_{RMS}		±(2 % + 3.0 V)	
Range 4: 34.6 (0.0) V_{RMS} ÷ 952.0 V_{RMS}		±(2 % + 5.0 V)	

3.2.2 Current

Input impedance : 1 MΩ

TRMS, AC+DC

[1] Derived quantities like power and energy are calculated independently in the instrument or PowerQ Link. Such operation makes possible to provide additional functionalities in PowerQ Link. However, due to the differences in calculation algorithms and numerical precisions the results could vary slightly, but always in less than one LSB digit shown on PowerQ or PowerQ+.

Measuring (indication) range	Resolution	Accuracy	Crest factor
Range 1: 4.0 (0.0) mV_{RMS} ÷ 100 mV_{RMS} (4 ÷ 100) A*	0.1 A	±(2 % + 0.3 A)	2.3 min
Range 2: 0.04 (0.00) V_{RMS} ÷ 1 V_{RMS} (40 ÷ 1000) A*		±(2 % + 3 A)	

- with current clamp A1033

3.2.3 Frequency

Measuring range	Resolution	Accuracy
45.00 Hz ÷ 66.00 Hz	10 mHz	±(0.5 % + 0.02 Hz)

3.2.4 Power (W, VA, VAR)

Product of Urange, UinpK, Irange and IinpK	Measuring range (W, VA, Var)	Resolution (W, VA, Var)	Accuracy*	Comment
7 ÷ 999	0.000 k ÷ 0.999 k	1	±(3 % + 3 dig)	Four quadrant results
1,000 ÷ 9,999	0.00 k ÷ 9.99 k	10		
10,000 ÷ 999,999	0.0 k ÷ 999.9 k	100		
1,000,000 ÷ 9,999,999	0.000 M ÷ 9.999 M	1 k		
10,000,000 ÷ 99,999,999	0.00 M ÷ 99.99 M	10 k		
100,000,000 ÷ 999,999,999	0.0 M ÷ 999.9 M	100 k		
1,000,000,000 ÷ 9,999,999,999	0.000 G ÷ 9.999 G	1 M		
10,000,000,000 ÷ 40,000,000,000	0.00 G ÷ 40.00 G	10 M		

**Accuracy values are valid if cos φ ≥ 0.40, PF ≥ 0.40, I ≥ 10 % I_N and U ≥ 10 % U_N, otherwise stated values should be multiplied by two.*

3.2.5 Power factor

Measuring range	Resolution	Accuracy	Comment
0.00 ÷ 0.39	0.01	±0.06	Four quadrant results
0.40 ÷ 1.00	0.01	±0.03	Four quadrant results

3.2.6 Cosinus φ

Measuring range	Resolution	Accuracy	Comment
0.00 ÷ 0.39	0.01	±0.06	Four quadrant results
0.40 ÷ 1.00	0.01	±0.03	Four quadrant results

3.2.7 Energy (Wh, VAh, VArh)

Product of Urange, UinpK, Irange and IinpK	Measuring range (Wh, VAh, Varh)	Resolution (Wh, VAh, Varh)	Accuracy*	Comment
7 ÷ 999	0.000 k ÷ 40,000,000.000 k	1	±(3 % + 3 Wh)	Four quadrant results
1,000 ÷ 9,999			±(3 % + 30 Wh)	
10,000 ÷ 999,999			±(3 % + 300 Wh)	
1,000,000 ÷ 9,999,999			±(3 % + 3 kWh)	
10,000,000 ÷ 99,999,999	0.000 k ÷ 40,000,000.000 k	1	±(3 % + 30 kWh)	Four quadrant results
100,000,000 ÷ 999,999,999			±(3 % + 300 kWh)	
1,000,000,000 ÷ 9,999,999,999			±(3 % + 3 MWh)	
10,000,000,000 ÷ 40,000,000,000			±(3 % + 30 MWh)	

** Accuracy values are valid if cos φ ≥ 0.40, PF ≥ 0.40, I ≥ 10 % I_N and U ≥ 10 % U_N, otherwise stated values should be multiplied by two..*

3.2.8 Voltage harmonics

Measuring range	Resolution	Accuracy
U_M > 3 % U_N	0.1 %	5 % U_M (3 % for DC)
U_M < 3 % U_N	0.1 %	0.15 % U_N

U_N: nominal voltage (TRMS)
U_M: measured harmonic voltage h_M: 1^{st} ÷ 50^{th}

3.2.9 Current harmonics

Harmonics range	Resolution	Accuracy
I_M > 3 % I_N	0.1 %	5 % I_M (3 % for DC)
I_M < 3 % I_N	0.1 %	0.15 % I_N

I_N: nominal range (TRMS)
I_M: harmonic current h_M: 1^{st} ÷ 50^{th}

3.2.10 Unbalance

		Unbalance range	Resolution	Accuracy
SymU	$U_+/U-$	0.0 ÷ 5.0%	0.1 %	0.15%
SymI	$I_+/I-$	0.0 ÷ 20%	0.1 %	1%

SymU: voltage unbalance (%)
SymI: current unbalance (%)
U_+: positive sequence voltage
U-: negative sequence voltage
I_+: positive sequence current
I-: negative seqence current

3.3 Loggings

3.3.1 Voltage, current logger

Signals: selectable U1, U2, U3, I1, I2, I3
Interval: selectable, (1, 2, 5, 10, 15, 30) sec, (1, 2, 5, 10, 15, 30) min
Logger length: depends on selected interval (calculated time is displayed)
Displayed data: average, min and max value of interval
Accuracy: refer to section **Technical specifications / Voltage, Current**

3.3.2 Power logger

Signals: selectable L1, L2, L3, TOTAL
Interval: selectable, (1, 2, 5, 10, 15, 30) sec, (1, 2, 5, 10, 15, 30) min
Logger length: depends on selected interval (calculated time is displayed)
Displayed data: average, min and max value of interval (for all four quadrants)
Accuracy: refer to section **Technical specifications / Power**

3.3.3 Harmonics logger

Signals: selectable THDI1, THDI2, THDI3, THDU1, THDU2, THDU3 (or THDU12, THDU23, THDU31)
Interval: selectable, (1, 2, 5, 10, 15, 30) sec, (1, 2, 5, 10, 15, 30) min
Logger length: depends on selected interval (calculated time is displayed)
Displayed data: average, min and max value of interval (for all four quadrants)
Accuracy : refer to section **Technical specifications / Voltage harmonics, Current harmonics**

3.3.4 Inrushes*

Signals: selectable U1, U2, U3 (or U12, U23, U31), I1, I2, I3
Interval: selectable, (10, 20, 100, 200) ms
Trigger channels: I1, I2, I3
Trigger level: selectable, 2 % ÷ 100 % of current range (in steps of 0.1 % of current range),
Logger length: depends on selected interval (calculated time is displayed)
Displayed data: average, min and max value of interval

Voltage

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 5.0 V_{RMS} ÷ 70.0 V_{RMS}	0.1 V	±(5 % + 1 V)	1.4 min
Range 2: 10.0 V_{RMS} ÷ 130.0 V_{RMS}		±(5 % + 1.5 V)	
Range 3: 20.0 V_{RMS} ÷ 300.0 V_{RMS}		±(5 % + 3 V)	
Range 4: 30.0 V_{RMS} ÷ 550.0 V_{RMS}		±(5 % + 5 V)	

Current

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 4.0 (0.0) mV_{RMS} ÷ 100 mV_{RMS} (4 ÷ 100) A	0.1 A	±(5 % + 0.6 A)	2.3 min
Range 2: 0.04 (0.00) V_{RMS} ÷ 1 V_{RMS} (40 ÷ 1000) A		±(5 % + 6 A)	

3.3.5 Voltage events*

Signals: selectable U1, U2, U3 (or U12, U23, U31)
Swell limit: (1 % ÷ 35 %) .U_N
Dip limit: (-35 % ÷ -1 %) . U_N
Interruption limit: (1 % ÷ 20 %) . U_N
Logging time: manual stop, (1, 2, 5, 10, 30) min,
(1, 2, 5, 10, 30, 50, 75) hour,
Hysteresis: 1 % of U_N.

Voltage

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 5.0 V_{RMS} ÷ 70.0 V_{RMS}	0.1 V	±(5 % + 1 V)	1.4 min
Range 2: 10.0 V_{RMS} ÷ 130.0 V_{RMS}		±(5 % + 1.5 V)	
Range 3: 20.0 V_{RMS} ÷ 300.0 V_{RMS}		±(5 % + 3 V)	
Range 4: 30.0 V_{RMS} ÷ 550.0 V_{RMS}		±(5 % + 5 V)	

3.3.6 Voltage quality*

Signals: selectable U1, U2, U3, THDU1, THDU2, THDU3, SYM, Freq
(or U12, U23, U31, THDU12, THDU23, THDU31, SYM, Freq)
Swell limit: (1 % ÷ 35 %) .U_N

* Power Q Plus only

Dip limit: (-35 % ÷ -1 %) . U_N
Interruption limit: (1 % ÷ 20 %) . U_N
Logging time: 16h 48min, 33h 36min, 3.5 days, 7 days, in 1008 intervals of (1, 2, 5, 10) min,
Hysteresis: 1 % of U_N.

Voltage

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 5.0 V_{RMS} ÷ 70.0 V_{RMS}	0.1 V	±(5 % + 1 V)	1.4 min
Range 2: 10.0 V_{RMS} ÷ 130.0 V_{RMS}		±(5 % + 1.5 V)	
Range 3: 20.0 V_{RMS} ÷ 300.0 V_{RMS}		±(5 % + 3 V)	
Range 4: 30.0 V_{RMS} ÷ 550.0 V_{RMS}		±(5 % + 5 V)	

Voltage harmonic distortion

Measuring range	Resolution	Accuracy
U_M > 3 % U_N	0.1 %	5 % U_M (3 % for DC)
U_M < 3 % U_N	0.1 %	0.15 % U_N

U_N: nominal voltage (TRMS)
U_M: measured harmonic voltage h_M: 1^{st} ÷ 50^{th}

Frequency

Measuring range	Resolution	Accuracy
45.00 Hz ÷ 66.00 Hz	10 mHz	±(0.5 % + 0.02 Hz)

3.4 General specifications

Working temperature range: -10 °C ÷ +50 °C
Storage temperature range: -20 °C ÷ +70 °C
Max. humidity: 95 % RH (0 °C ÷ 40 °C), non-condensing
Pollution degree: 2
Protection classification: double insulation
Over voltage category: voltage inputs: CAT III 600 V
Protection degree: IP 42
Dimensions: (220 x 115 x 90) mm
Weight (without accessories): 0.65 kg
External DC supply: 12 V, 1 A
Maximum power consumption: 4.5 W

3.5 Communication

3.5.1 RS-232 serial interface

Baud rate: 2400 baud ÷ 115200 baud
Connector: 9 pin D-type

3.5.2 USB interface

Baud rate:	2400 baud ÷ 921600 baud
Connector:	Standard USB Type B

3.6 Display

Display: graphic liquid crystal display with backlight, 160 x 160 dots.

3.7 Non - Volatile memory

1 MB Flash

3.8 DC Power supply

Internal 6 x 1.2 V NiMh rechargeable AA batteries provide full operation for up to 12 hours.
Nominal charging time is 16 hours. The charging time and the operating hours are given for batteries with a nominal capacity of 2100 mAh.

⚠ Use only charger supplied by Metrel.
⚠ Disconnect power supply adapter if you use standard (non-rechargeable) batteries.

3.8.1 Inserting batteries into the instrument

1. Make sure that the power supply adapter/charger and measurement leads are disconnected and the instrument is off.
2. Insert batteries as shown in figure bellow (insert batteries correctly, otherwise the instrument will not operate and the batteries could be discharged or damaged).

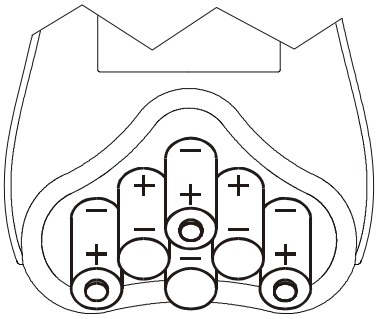


Fig. 3.1: Battery placement

3. Turn the display side of the instrument lower than the battery holder (*see figure below*) and put the cover on the batteries.

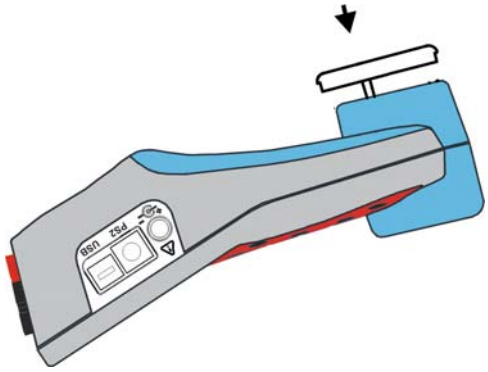


Fig. 3.2: Closing the battery holder

4. Screw the cover on the instrument.

If the instrument is not to be used for a long period of time remove all batteries from the battery holder. The enclosed batteries can supply the instrument for approx. 12 hours.

⚠ **Warnings!**

- **When battery cells have to be replaced, turn off the instrument before opening battery compartment cover.**
- **Hazardous voltages exist inside the instrument. Disconnect all test leads and remove the power supply cable before removing battery compartment cover.**
- **Use only power supply adapter/charger delivered from manufacturer or distributor of the equipment to avoid possible fire or electric shock.**
- **Rechargeable NiMH batteries (size AA) are recommended. The charging time and the operating hours are given for batteries with a nominal capacity of 2100 mAh.**
- **Do not use standard batteries while power supply adapter/charger is connected, otherwise they may explode!**
- **Do not mix batteries of different types, brands, ages, or charge levels.**
- **When charging batteries for the first time, make sure to charge batteries for at least 16 hours before switching on the instrument.**

3.9 Maintenance

3.9.1 Batteries

Instrument contains rechargeable NiMh batteries. These batteries should only be replaced with the same type as defined on the battery placement label or in this manual.

If it is necessary to replace batteries, all six have to be replaced. Ensure that the batteries are inserted with the correct polarity; incorrect polarity can damage the batteries and/or the instrument.
There may exist special environmental regulations concerning the disposal of the batteries. These have to be followed.

PRECAUTIONS ON CHARGING NEW BATTERIES OR BATTERIES UNUSED FOR A LONGER PERIOD

Unpredictable chemical processes can occur during charging new batteries or batteries that were unused for a longer period of time (more than 3 months). NiMH and NiCd batteries are affected to a various degree (sometimes called as memory effect). As a result the instrument operation time can be significantly reduced at the initial charging/discharging cycles.

Therefore it is recommended:
- To completely charge the batteries (at least 14h with in built charger).
- To completely discharge the batteries (can be performed with normal working with the instrument).
- Repeating the charge/discharge cycle for at least two times (four cycles are recommended).

When using external intelligent battery chargers one complete discharging /charging cycle is performed automatically.

After performing this procedure a normal battery capacity is restored. The operation time of the instrument now meets the data in the technical specifications.

NOTES

The charger in the instrument is a pack cell charger. This means that the batteries are connected in series during the charging so all batteries have to be in similar state (similarly charged, same type and age).
Even one deteriorated battery (or just of an another type) can cause an improper charging of the entire battery pack (heating of the battery pack, significantly decreased operation time).

If no improvement is achieved after performing several charging/discharging cycles the state of individual batteries should be determined (by comparing battery voltages, checking them in a cell charger etc). It is very likely that only some of the batteries are deteriorated.

The effects described above should not be mixed with normal battery capacity decrease over time. All charging batteries lose some of their capacity when repeatedly charged/discharged. The actual decrease of capacity versus number of charging cycles depends on battery type and is provided in the technical specification of batteries provided by battery manufacturer.

3.9.2 Power supply considerations

When using the original power supply adapter/charger the instrument is fully operational immediately after switching it on. The batteries are charged at the same time, nominal charging time is 16 hours.
The batteries are charged whenever the power supply adapter/charger is connected to the instrument. Inbuilt protection circuit controls the charging procedure and assure maximal battery lifetime.
If the instrument is left without batteries and charger for more than 10 minutes, time and date settings are reset.

3.9.3 Cleaning

To clean the surface of the instrument use a soft cloth slightly moistened with soapy water or alcohol. Then leave the instrument to dry totally before use.

- **Do not use liquids based on petrol or hydrocarbons!**
- **Do not spill cleaning liquid over the instrument!**

3.9.4 Periodic calibration

To ensure correct measurement, it is essential that the instrument is regularly calibrated. If used continuously on a daily basis, a six-month calibration period is recommended, otherwise annual calibration is sufficient.

3.9.5 Service

For repairs under or out of warranty please contact your distributor for further information.

3.9.6 Troubleshooting

If *Esc* button is pressed when switching on the instrument, the instrument will not start. You have to remove batteries and put them back. After that the instrument starts normally.

Manufacturer address:

METREL d.d.
Ljubljanska 77,
SI-1354 Horjul,
Slovenia
Tel: +(386) 1 75 58 200
Fax: +(386) 1 75 49 095
Email: metrel@metrel.si
http://www.metrel.si

Operation manual

4 General

This section describes how to operate the instrument.

The instrument front panel consists of a graphic LCD display and keypad. Measured data and instrument status are shown on the display.

Fig. 4.1: Keypad

F1	Freezes display in METER and SCOPE functions. Starts, stops and saves logging in LOGGER modes. Switches to previous memory position in MEMORY LIST mode.
F2	Switches between displaying available voltage, current and power signals in METER, SCOPE and LOGGER (except POWER LOGGER) functions. Switches between displaying available power signals in POWER LOGGER. Clears currently selected memory position.
F3	Saves frozen display in METER and SCOPE functions. Clears just finished logging in LOGGER modes. Selects or deselects channels in LOGGER setting modes. Toggles between logging display and settings during logging function. Switches to next memory position in MEMORY LIST mode.
F4	Switches between SCOPE, METER and LOGGER screens. Toggles between motor and generator signals in POWER LOGGER. Shows currently selected memory position in MEMORY LIST mode.
ENTER	Switches between displaying voltages, currents and voltage–current pairs in SCOPE and LOGGER (except POWER LOGGER) functions. Switches between displaying odd, even and all harmonics.
▲ ▼	Scale displayed waveform by amplitude in SCOPE screens. Scroll over individual harmonics in HARMONICS mode. Scroll over memory positions in MEMORY LIST mode. Select measuring mode or any other submenu.
◀ ▶	Scale displayed waveform by base – time in SCOPE screens. Scroll the cursor along logged data in LOGGER mode.

MENU	Opens sub menu.
ESC	Exits any procedure. Returns to the MAIN MENU.
	Backlight on/off (Backlight automatically turns off after 30 seconds if no key action occurs and instrument has only battery supply). If the *LIGHT* key is pressed for more then 1.5 seconds, CONTRAST menu is displayed, and the contrast can be adjusted with the *LEFT* and *RIGHT* keys.
+	Printing screen on printer. See section **Error! Reference source not found.** for details.
	Switches the instrument on and off.

NOTE: Assure that all voltage clips are connected during measurement and logging period. Unconnected voltage clips are susceptible to EMI and can lead astray. It is advisable to disconnect unused voltage clips from instrument or to short them with instrument neutral voltage input.

4.1 Instrument Main Menu

After powering on the instrument the MAIN MENU is displayed. From this menu all instrument functions can be selected.

To switch off the instrument *ON-OFF* key has to be pressed. All recorded data is saved in non-volatile memory.

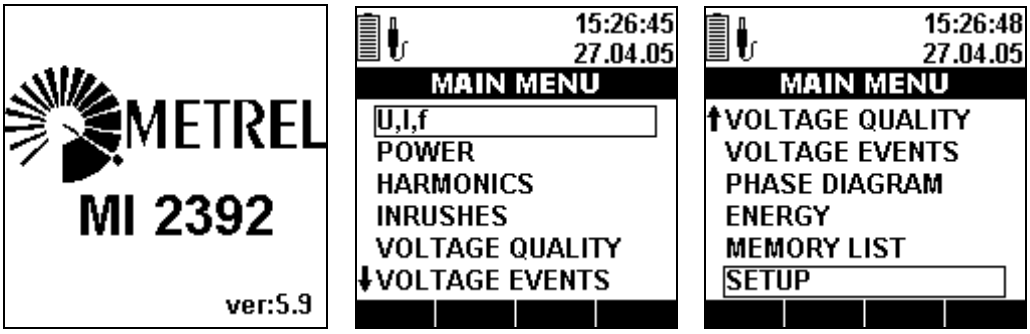


Fig. 4.2: MAIN MENU

Keys:

	Select function from the MAIN MENU.
ENTER	Enters selected function.

4.2 Setup Menu

From the SETUP menu general instrument parameters can be reviewed, configured and saved.

Fig. 4.3: SETUP menu

Options:

Instrument info	Information about the instrument.
Measuring setup	Select measurement parameters.
Communication	Select communication baud rate.
Time & Date	Set time and date.
Language	Select language.
Clear	Clear memory or energy counters.

Keys:

	Select function from the SETUP menu.
	Enters the selected item.
	Back to the MAIN MENU.

4.2.1 Instrument info

Basic information concerning the instrument can be viewed in this menu: company, user data, serial number, firmware version and hardware version.

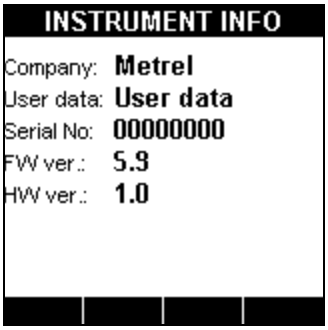


Fig. 4.4: INSTRUMENT INFO screen

Keys:

ESC	Back to the SETUP menu.

4.2.2 Measuring setup

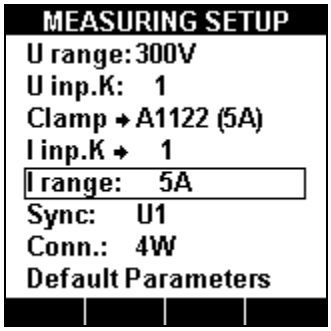


Fig. 4.5: MEASURING SETUP screen

	Description	
U range	input voltage range	**4W connection:** Input voltage ranges (70 V, 130 V, 300 V and 550 V) **3W connection:** Input voltage ranges (121V, 225V, 519V and 952V)
U inp.K	voltage transformation ratio	Scaling factor for voltage inputs. By using this factor external voltage transformers or dividers are taken into account, so readings are related to the primary. Example: for 11 kV / 110 V transformer the scaling factor has to be set to 100. Standard and default value is 1(no external device is used). At 300 V and 550 V range the U inp. K is automatically set to 1. Maximum value is limited to 4000. Displayed full scale voltage range is $U_{nomin.} * U_{inp.K.}$.
Clamp	Current clamp selection	Current clamps selection: A1033, A1069, A1120, A1099, A1122, etc . See section 14.3 for details.
I inp.K	current transformation ratio	Depending of selected clamps two options are possible. See section 14.3 for details. 5A clamps: Primary current transformer ratio settings Other clamps: Measuring current on 1 cable of N parallel cables
I range	input current range	Current range. Selection can be made between: - 10% of measurement range - 100% of measurement range. See section 14.3 for details.

Sync	frequency synchronisation input	Frequency synchronisation input. Input selection is determined by type of voltage connection. For connection type: **4W**: U1, U2, U3, I1, I2 or I3. U1 is used by default. **3W**: U12, U21, U31, I1, I2 or I3. U12 is used by default.
Conn.	type of voltage connection	Method of connecting the instrument to 3 phase systems. **4W**: 3-phase 4-wire system (with neutral conductor). All voltage and current inputs are used. **3W**: 3-phase 3-wire system (without neutral conductor), 3 current transformers are used.
Default parameters	default measuring parameters	U range: 300 V; U inp.K: 1; I range: 1000 A; I inp.K: 1; Sync: U1; Conn: 4W

Keys:

	Change selected parameter value.
	Select measuring parameter.
	➔ Enter into submenu Save MEASUREMENT setup and back to SETUP Menu.
	Back to the SETUP menu.

Figure below shows submenus for direct clamps measurement.

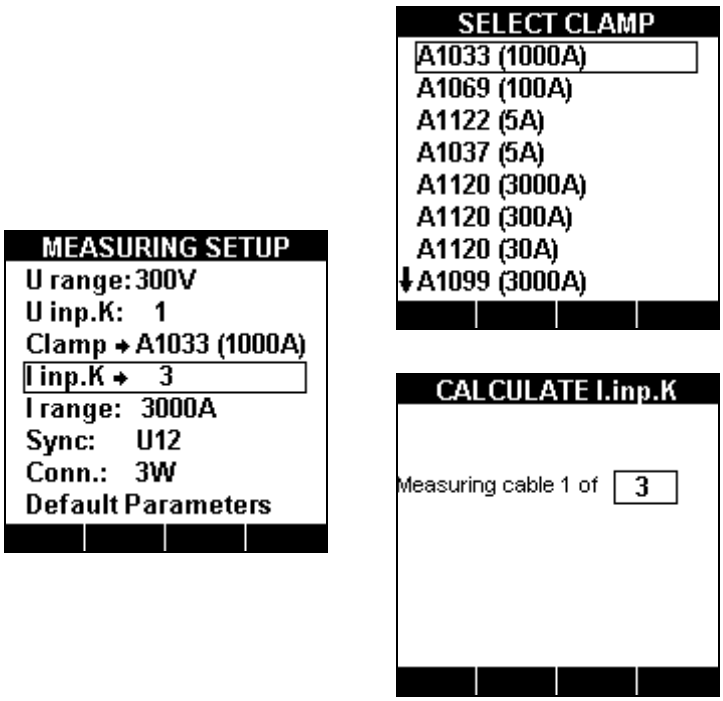


Fig. 4.6: Current clamps selection for direct current measurement

Figure below shows submenus for indirect clamps measurement. Measurement can be performed with one of following clamps: A 1122 (1000A), A1037 (5A).

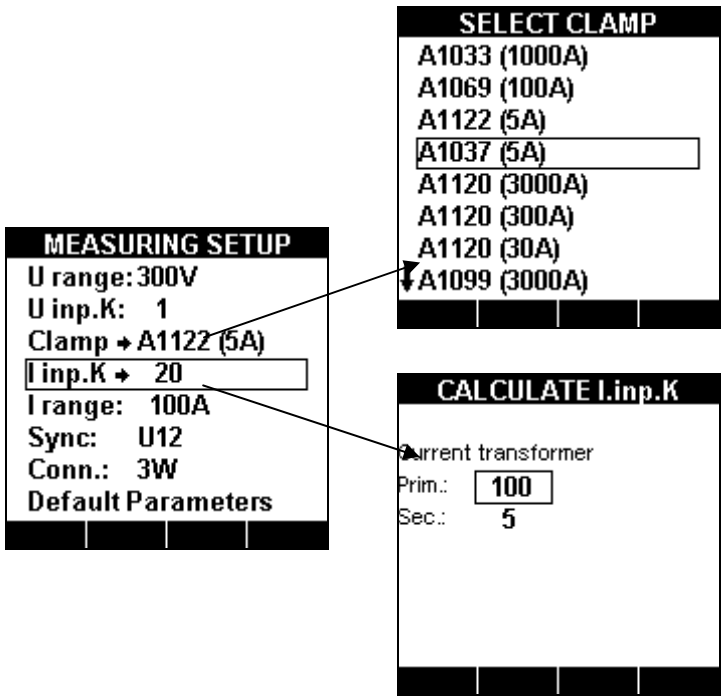


Fig. 4.7: Current clamps selection for indirect current measurement

Keys:

	CALCULATE I.inp.K submenu: Change number of cables or primary current transformer ratio.
	Select parameter.
	Confirms the selected parameter and enter/exit from current menu.
	Back to the SETUP menu.

4.2.3 Communication

Communication source (RS232 or USB) and communication speed can be set in this menu.

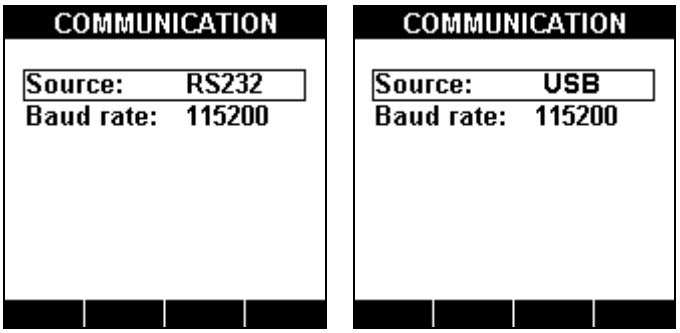


Fig. 4.8: COMMUNICATION screens

Keys:

	Change communication speed from 2400 baud to 115200 baud for RS232 and from 2400 baud to 921600 baud for USB.
	Switch between source and baud rate.
	Confirms the selected speed.
	Back to the SETUP menu.

4.2.4 Time & Date

Time and date can be set in this menu.

Fig. 4.9: TIME & DATE screen

Keys:

	Select hour, minute, second, day, mount or year to be set.
	Change value of the selected item.
	Confirms changes and returns to the SETUP menu.
	Back to the SETUP menu without changing time and date.

4.2.5 Language

Different languages can be selected in this menu.

Fig. 4.10: LANGUAGE screen

Keys:

	Select language.
	Confirms the selected language.
	Back to the SETUP menu.

4.2.6 Clear

Instrument memory and energy counters can be cleared in this menu.

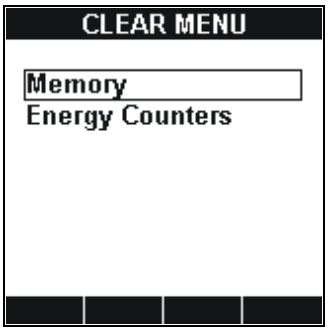


Fig. 4.11: CLEAR screen

	Select “Memory” or “Energy counters” to be cleared.
	Confirms the selected option.
	Back to the SETUP menu.

4.3 Setting display contrast and backlight

4.3.1 Setting contrast

Contrast can be set from any menu by pressing and holding the *LIGHT* key for 1.5 sec. The CONTRAST dialog will open *(see figure below)*.

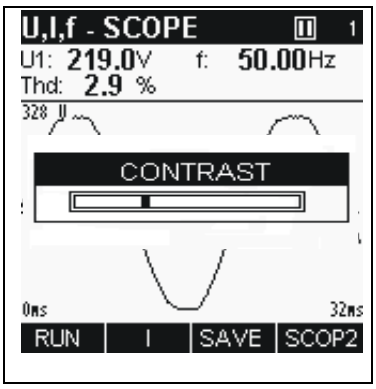


Fig. 4.12: Example of CONTRAST dialog

Keys:

	Change the contrast level.
	Confirms set contrast and exits dialog box.
	Exit dialog box without changes.

4.3.2 Activating backlight

Backlight can be switched on/off anytime by pressing the *LIGHT* key. If backlight is lit and there is no key activity during 30 seconds, backlight is switched off.

4.4 Printing measured data

PowerQ and PowerQ+ from firmware version 9.2 has support for printing. Currently Seiko DPU 414 printer is supported.
Before printer can be used,

- it should be supplied with supplied AC adapter or batteries. Refer to the section 2.1 of DPU 414 user guide,
- paper should be load. Refer to the section 2.2 of DPU 414 user guide.

4.4.1 Printer connection

Printer is connected to the PowerQ instrument with RS-232 cable and adapter, as shown on figure below.

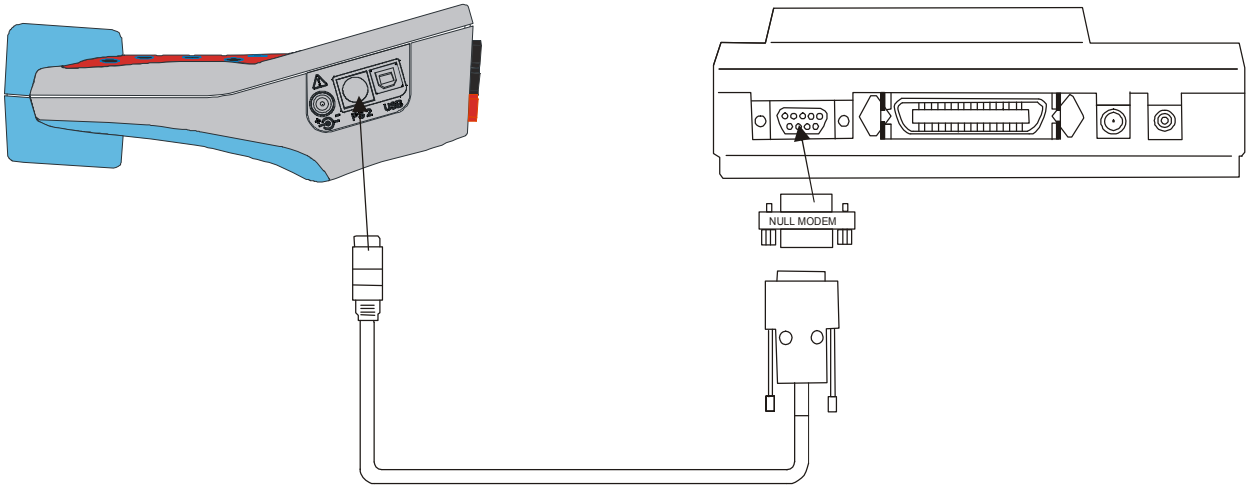


Fig. 4.13: Connecting printer to PowerQ+

4.4.2 Printer settings

Before printing can be started, printer software dips switches should be checked. Refer to the section 2.3 of DPU 414 user guide, to see how to check current DPU-414 settings. Usually printers supplied by Metrel are already properly configured. Other users should configure their printer according to the following table:
Table 1: DPU-414 soft switch settings

SW No.	Dip SW-1		Dip SW-2:		Dip SW-3	
1.	OFF	Input = Serial	ON	Printing Colums = 40	ON	Data Length = 8 bits
2.	ON	Printing Speed = High	ON	User Font Back-up = ON	ON	Parity setting = No
3.	ON	Auto Loading = ON	ON	Character Sel. = Normal	ON	Parity condition = Odd
4.	OFF	Auto LF = OFF	ON	Zero = Normal	OFF	Busy Control = XON/XOFF
5.	OFF	Setting Cmd. = Disable	ON	International	OFF	Baud Rate Select = 19200 bps
6.	OFF	Printing Density = 100%	ON	Character Set U.S.A.	ON	
7.	ON		ON		ON	
8.	ON		OFF		OFF	

4.4.3 Using printer

Printing functionality enable user to print screen on printer. Therefore everything seen on display can be print. Printing is started by pressing keys  and  for half of second. A characteristic “beep” signal indicates that printing is started.

Note: Do not try to print while instrument is connected to PC.

Note: DPU 414 can hold max. 2 screens print in buffer. It is advisable to wait printer for finish printing, before new printing is started. Otherwise instrument will “freeze” until printing is not finished. During this period, periodic “beep” signal will indicate that instrument is sending data to the printer.

Note: In order to save printer batteries, it is advisable to turn on printer just before printing, and turn it off immediately after printing job is finished.

Printing form can be seen on figure bellow. It is consisted from printer header and screen dump.

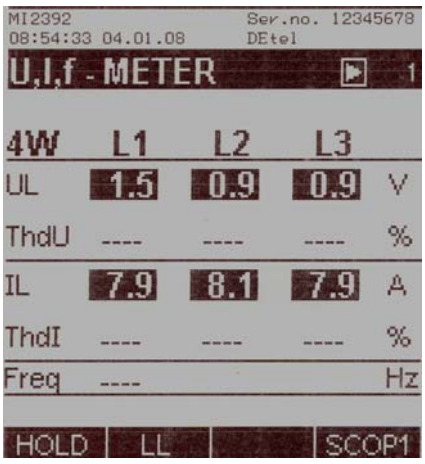


Fig. 4.14: Printed measurement

5 U, I, F

All important voltage, current and frequency parameters in a 3-phase system can be observed in the U,I,f MENU. The results can be viewed in a tabelaric (METER) or two graphic (SCOPE1, SCOPE2) forms.
The LOGGER function allows to log the signals over a predefined time frame. Maximal, minimum and average values of each interval are stored.
All results can be saved to the instrument memory.

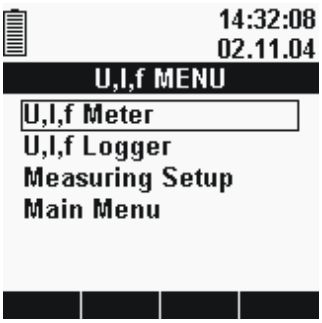


Fig. 5.1: U,I,f – menu

Options:

U,I,f Meter	Tabular or graphic presentation of U,I,f quantities.
U,I,f Logger	Histograms of U,I,f quantities.
Measuring setup	Shortcut to the MEASURING SETUP menu.
Main Menu	Back to the MAIN menu.

Keys:

	Enters the U,I,f MENU.
	Select measuring mode.
	Enters selected function.
	Back to the MAIN MENU.

Switching between U,I,f - METER and U,I,f - LOGGER function can be performed by pressing *MENU* key in any screen (METER, SCOPE or LOGGER).

If voltage and current results are out of input range, the results are shown in inverted form.

5.1 U,I,f METER function

The U,I,f - METER function consists of three sections:
- U,I,f - METER screen, data in tabular form,
- U,I,f - SCOPE1 screen, presentation of signals in graphical form, one graph,
- U,I,f - SCOPE2 screen, presentation of signals in graphical form, two graphs.

5.1.1 U,I,f – METER tabular screen

By entering U,I,f MENU from MAIN MENU the U,I,f - METER tabular screen is shown by default *(see figure below)*.
The display format and units (V, kV, A, kA) are automatically selected according to the measured values. The following quantities are displayed:

- Phase-neutral RMS voltage (U_1, U_2, U_3) or phase-phase RMS voltage (U_{12}, U_{23}, U_{13}),
- Phase RMS current (I_1, I_2, I_3),
- Voltage and current total harmonic distortion (ThdU, ThdI),
- System frequency (Freq, shown in the column of selected synchronisation input).

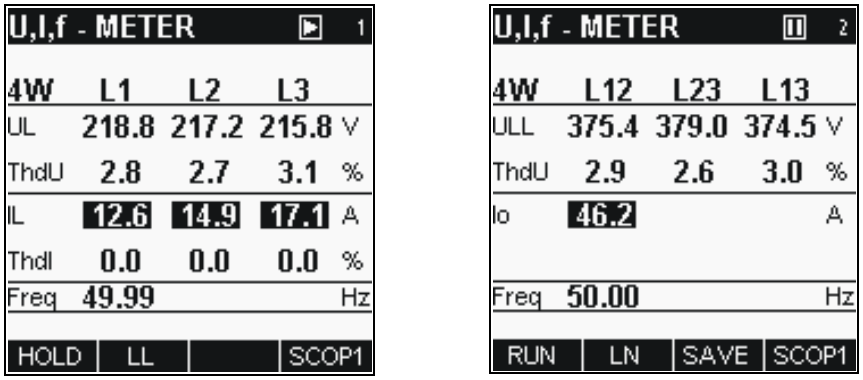


Fig. 5.2: U,I,f - METER tabular screen

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Toggles between LL (phase-phase) and LN (phase-neutral) RMS voltages (only in 4W measuring mode).
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from METER tabular screen to SCOPE1 graphic (single scope) screen.
MENU	Opens the dialog box for selecting U,I,f - METER, U,I,f - LOGGER or MEASURING SETUP.
ESC	Back to the U,I,f - METER.

5.1.2 U,I,f – SCOPE1 screen (single graph)

This function displays signal waveforms together with their summary details *(see figure below)*.

Available signal combinations are:

U_X	single voltage (x = 1 ÷ 3).
I_X	single current (x = 1 ÷ 3).
U_XI_X	single voltage and current pairs (x = 1 ÷ 3).
$U_1U_2U_3$	all phase voltages.
$I_1I_2I_3$	all phase currents.

Up to 10 signal periods of each signal can be observed.
The displayed signals are auto-scaled by default.

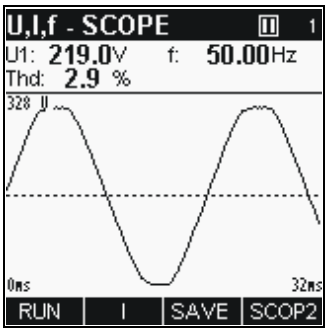


Fig. 5.3: U,I,f - SCOPE screen

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Selects U (voltages), I (currents) and U+I (voltage – current pairs) for display.
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from SCOPE1 single scope screen to SCOPE2 dual scope screen.
ENTER	Selects voltage and current combinations for display (see list of available signal combinations).
▲ ▼	Scale displayed waveform by amplitude.
◀ ▶	Scale time base of displayed waveform. 32 ms is used by default. If the scaling is set to display 32 ms and instrument is in HOLD mode, further use of *RIGHT* & *LEFT* keys scrolls waveform through its 10 periods.
MENU	Opens the dialog box to select U,I,f - METER, U,I,f - LOGGER, MAIN MENU or MEASURING SETUP.
ESC	Returns to the MAIN MENU.

5.1.3 U,I,f – SCOPE2 screen (dual graph)

This function displays two signal waveforms together with the belonging summary details for each waveform *(see figure below).*

Available signal combinations are:

$U_X I_Y$ single voltage and current pairs (x,y = 1 ÷ 3)

The U,I,f – dual screen feature allows viewing signal pairs of different sources simultaneously thus enabling comparison of signals.

Up to 10 signal periods can be observed.
The displayed signals are auto-scaled by default.

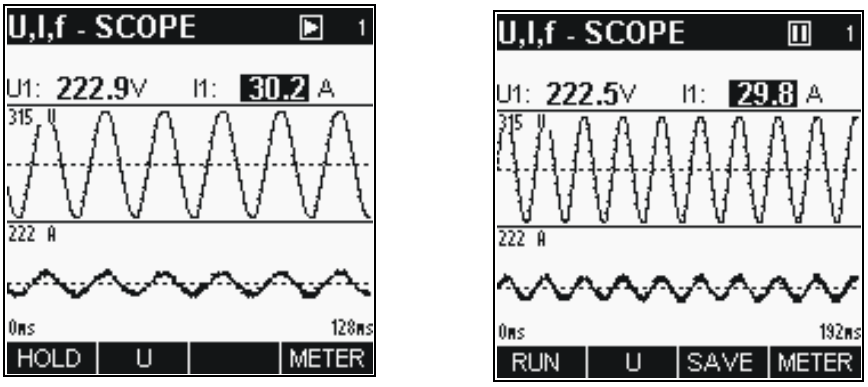


Fig. 5.4: U,I,f – SCOPE (dual) screen

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Toggles between upper graph U (voltages) and lower graph I (currents).
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from SCOPE2 graphic (dual scope) screen to METER tabular screen.
ENTER	Selects between U_1, U_2, U_3 for voltages and I_1, I_2, I_3 for currents.
▲ ▼	Scale displayed current waveform by amplitude.
◀ ▶	Scale time base of displayed waveform. 32 ms is used by default. If the scaling is set to display 32 ms and instrument is in HOLD mode, further use of *RIGHT* & *LEFT* keys scrolls waveform through its 10 periods.
MENU	Opens the dialog box to select U,I,f - METER, U,I,f - LOGGER, MAIN MENU or MEASURING SETUP.
ESC	Returns to the MAIN MENU.

5.2 U,I,f LOGGER function

The U,I,f LOGGER function consists 4 screen sections:

- U,I,f - LOGGER SETUP screen, logger parameters setup,
- U,I,f - LOGGER RUN screen, running histogram,
- U,I,f - LOGGER STOP SINGLE screen, review of logged signals, one histogram,
- U,I,f - LOGGER STOP DUAL screen, review of logged signals, two histograms.

5.2.1 U,I,f – LOGGER SETUP screen

After selecting U,I,f LOGGER in U,I,f MENU the U,I,f – LOGGER setup screen is shown *(see figure below).*
In this menu different logging parameters can be set.

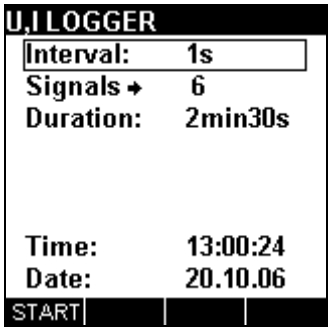
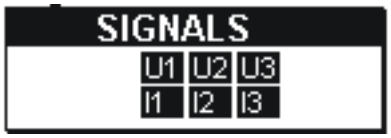


Fig. 5.5: U,I,f – LOGGER setup screen

Settings:

Interval	Logging interval setup (from 1 sec to 30 min). Total logging time is displayed in “Duration” field.
	Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear.
Duration	Total logging time (indicator only).
Time & Date	Actual time and date (can be set in SETUP menu, see section 5.2.4).

Keys:

	Starts logging. The U,I,f LOGGER RUN screen is displayed.
	Toggles between ON (selected) and OFF (deselected) of highlighted logging signal (if SIGNALS dialog box is opened).
	Opens SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signal can be selected for logging.
	Select “Interval” and “Signals” options. Scroll between voltages and currents (if SIGNALS dialog box is opened).
	Change interval period (in “Interval” setup). Select individual U or I signal (in SIGNALS dialog box).
	Returns to U,I,f MENU.
	Returns to U,I,f MENU. Closes the SIGNALS dialog box (if SIGNALS dialog box is open).

5.2.2 U,I,f – LOGGER RUN screens

When the user starts logging this screen opens automatically.
In this function signal histograms together with the belonging summary details are displayed.

Available signal combinations are:

$U_{Xmin}U_{Xmax}U_{Xavg}$	single voltage (x = 1 ÷ 3).
$I_{Xmin}I_{Xmax}I_{Xavg}$	single current (x = 1 ÷ 3).
$U_{Xavg}I_{Xavg}$	single voltage and current pairs (x = 1 ÷ 3).
$U_{1avg}U_{2avg}U_{3avg}$	all phase average voltages.
$I_{1avg}I_{2avg}I_{3avg}$	all phase average currents.

In the upper data field the following values are displayed:
- Minimum, maximum and average data of the last concluded interval,
- Elapsed time.

Data of all concluded intervals are displayed as a graphical histogram too. The latest interval appears on the right and rolls to the left as new intervals are concluded and displayed. The measurement is completed when the first interval data reaches the left side of the display (after 150 intervals) or if stopped manually.

The displayed histograms are always auto-scaled by default. Unlike in the scope modes the signals can not be scaled manually.

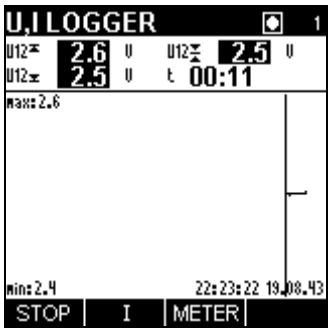


Fig. 5.6: U,I,f – LOGGER RUN screen

Keys:

F1	Stops logging. U,I,f LOGGER STOP SINGLE screens is opened. Otherwise the logging is finished after completion of 150 intervals.
F2	Selects displaying U (voltages), I (currents) and U+I (voltage – current pairs).
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Enter or Esc key for return
ENTER	Selects voltage and current combinations for display (see list of available signal combinations).

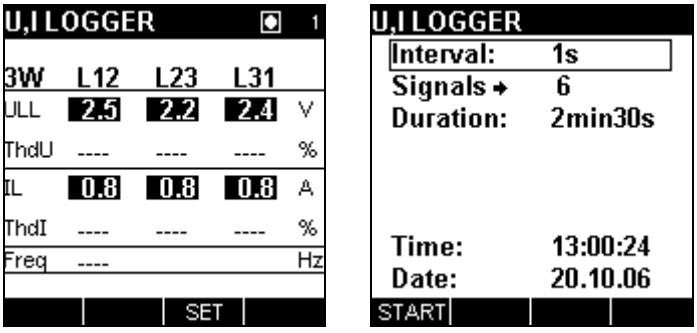


Fig. 5.7: U,I,f – – METER AND PRESET screens

5.2.3 U,I,f – LOGGER LOG1 screens (single graph)

This function becomes active after a logging is completed or if logging is stopped by user. The recorded signal trace can be scrolled and reviewed with a cursor.

Available signal combinations are:

$U_{Xmin}U_{Xmax}U_{Xavg}$	single voltage (x = 1 ÷ 3)
$I_{Xmin}I_{Xmax}I_{Xavg}$	single current (x = 1 ÷ 3).
$U_{Xavg}I_{Xavg}$	single voltage and current pairs (x = 1 ÷ 3).
$U_{1avg}U_{2avg}U_{3avg}$	all phase average voltages.
$I_{1avg}I_{2avg}I_{3avg}$	all phase average currents.

Data are displayed in graphical (logger histogram) and in numeric (interval data) form. The following values can be displayed in the upper data field:
- Minimum, maximum and average data of the interval selected with the cursor,
- Elapsed time of the selected interval.

Complete trace of a selected signal can be viewed in the histogram.

The results can be saved to the instrument memory.

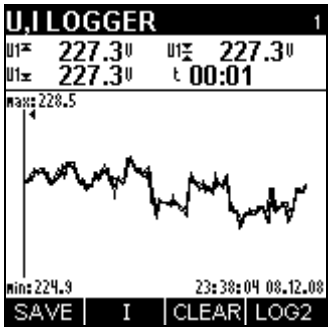


Fig. 5.8: U,I,f - LOGGER LOG1 screen (single)

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects U (voltages), I (currents) and U+I (voltage–current pairs) for display.
F3	Clears logged values and returns to U,I,f LOGGER SETUP screen.
F4	Switches between single and dual histogram display.
ENTER	Selects voltage and current combinations for display (see table of available signal combinations).
◄ ►	Scroll the cursor along logged data.
MENU	Opens the U,I,f MENU (described in section 6).
ESC	Returns to the MAIN MENU.

5.2.4 U,I,f – LOGGER LOG2 screens (dual graph)

In this function two displayed traces can be scrolled through with a cursor, reviewed and compared.

Available signal combinations are:

$U_{Xmin}U_{Xmax}U_{Xavg}$	single voltage (x = 1 ÷ 3).
$I_{Xmin}I_{Xmax}I_{Xavg}$	single current (x = 1 ÷ 3).
$U_{1avg}U_{2avg}U_{3avg}$	all phase average voltages.
$I_{1avg}I_{2avg}I_{3avg}$	all phase average currents.

Data are displayed in graphical (2 histograms) and in numeric (interval data) form.
The following values can be displayed in the upper data field:
- Minimum, maximum and average data of the interval selected with the cursor (of the active histogram),
- Elapsed time of the selected interval (of the active histogram).

Complete trace of a selected signal can be reviewed in the active histogram.

The results can be saved to the instrument memory.

Fig. 5.9: U,I,f - LOGGER LOG2 screen (dual)

Keys:

F1	Saves logged data to non-volatile memory (together with histograms).
F2	Toggles between upper (voltage) and lower (current) histograms.
F3	Clears logged values and returns to U,I,f LOGGER SETUP screen.
F4	Switches between dual and single histogram display.
ENTER	Selects voltage and current combinations for display (see list of available signal combinations).
◀ ▶	Scroll the cursor along logged data (on the active histogram).
MENU	Opens the U,I,f MENU (described in section 6).
ESC	Returns to the MAIN MENU.

6 Power

Active power is divided into two parts: import (positive) and export (negative). Reactive power and power factor are divided into four quantities: positive inductive (+i), positive capacitive (+c), negative inductive (-i) and negative capacitive (-c). Neutral conductor current (I_0) is ignored when measuring in 3-wire connection.

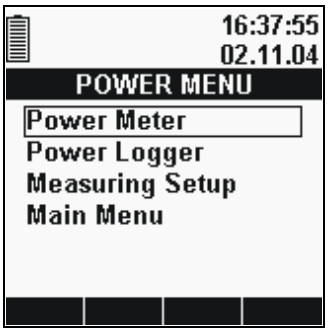


Fig. 6.1: POWER MENU screen

Options:

Power Meter	Tabular or graphic presentation of power quantities.
Power Logger	Histograms of power quantities.
Measuring setup	Shortcut to the MEASURING SETUP menu.
Main Menu	Back to the MAIN MENU.

Keys:

	Select measuring mode.
	Enters selected mode.
	Back to the POWER METER.

To activate POWER MENU press the *MENU* key in any POWER METER screen.

If voltage and current results are out of input range, the results are shown in inverted form.

6.1 Power meter functions

The POWER METER function consists of two screen sections:

- POWER - METER screen, data in tabular form,
- POWER - SCOPE screen, graphic presentation of measured voltages or currents with displayed quantities of P, Q and S.

6.1.1 Power meter

By entering POWER from MAIN MENU the POWER METER tabular screen is shown *(see figure below)*. Note that phase power screen (left figure) is shown only for 4W connection.

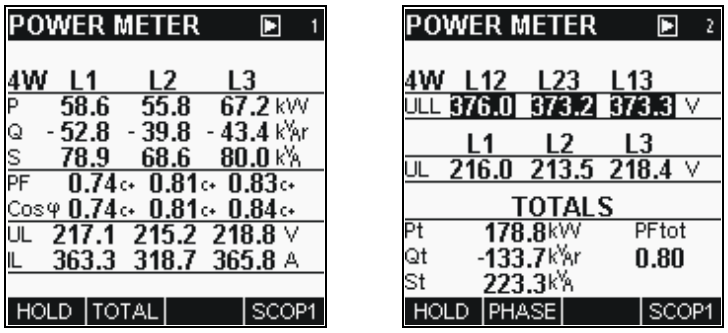


Fig. 6.2: POWER METER screens

The display format and units are automatically ranged according to the measured values. The following quantities are displayed:

- Active power for each phase (P) or total active power (P_{TOT}),
- Reactive power for each phase (Q) or total reactive power (Q_{TOT}),
- Apparent power for each phase (S) or total apparent power (S_{TOT}),
- Phase RMS voltage (U_L) and/or phase-to-phase RMS voltage (U_{LL}),
- Phase RMS current (I_L),
- Power factor for each phase (PF) or total power factor (PF_{TOT}),
- Cosinus φ factor (cos), for each phase.

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Toggles between PHASE and TOTAL POWER screens (valid only in 4W)
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from METER to SCOPE screen
MENU	Opens the POWER MENU (described in section 7).
ESC	Returns to the MAIN MENU

6.1.2 Power scope

This function displays selected phase voltage and current waveforms together with values of P, Q and S *(see figure below)*. The displayed signals are auto-scaled. Note that for 3W connection only total power is calculated.

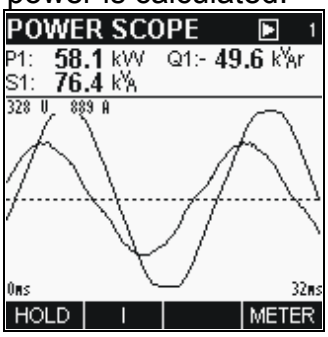


Fig. 6.3: POWER SCOPE screen

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Toggles between U and I traces.
F3	Saves momentary quantity values in non-volatile memory (in HOLD mode).
F4	Changes from POWER SCOPE screen to POWER METER screen.
ENTER	Toggles between phases (valid only for 4W connection)
▲ ▼	Scale displayed waveform by amplitude.
◀ ▶	Scale time base of displayed waveforms. If this scaling is set to show 32 ms and instrument is in HOLD mode, further usage of *RIGHT* & *LEFT* keys scrolls waveform through its 10 periods.
MENU	Opens the POWER MENU (described in section 7).
ESC	Returns to the MAIN MENU.

6.2 Power logger function

The POWER LOGGER function consists 4 sections:

- POWER LOGGER setup screen, logger parameters setup,
- POWER LOGGER screen, running histogram,
- POWER LOGGER screen, review of logged signals, one histogram,

6.2.1 Power logger setup screen

After selecting POWER LOGGER in POWER MENU the POWER LOGGER SETUP screen is shown *(see figure below)*.

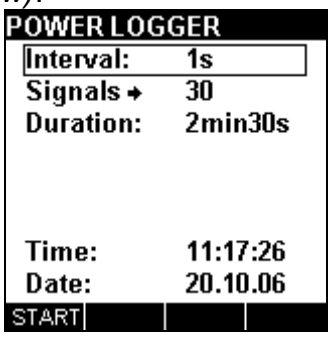
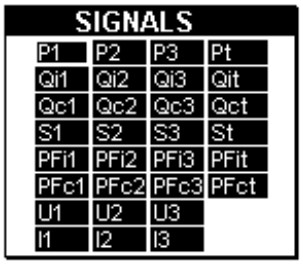


Fig. 6.4: POWER LOGGER setup

Settings:

Interval	Logging interval setup (from 1 sec to 30 min). Total logging time is displayed in “Duration” field.
	Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear. **Note:** In 3W measurement following signals are available for logging: P_t, S_t, Q_{it}, Q_{ct}, PF_{it}, PF_{ct}, U_{12}, U_{23}, U_{31}, I_1, I_2, I_3
Duration	Total logging time (indicator only).
Time & Date	Actual time and date (can be set in SETUP menu, see section 5.2.4).

Keys:

F1	Starts logging. The POWER LOGGER RUN screen is displayed.
F3	Toggles between ON (selected) and OFF (deselected) for highlighted logging signal (if SIGNALS dialog box is opened).
ENTER	Opens SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signals can be selected for logging.
▲ ▼	Select “Interval” and “Signals” settings. Select logging signal (in SIGNALS dialog box).
◄ ►	Change interval period (in INTERVAL setup). Select logging signal (in SIGNALS dialog box).
MENU	Returns to the POWER MENU.
ESC	Returns to the POWER MENU.

6.2.2 Power logger run screens

When the user starts logging, this screen opens automatically.
In this function signal histograms together with the belonging details are displayed.

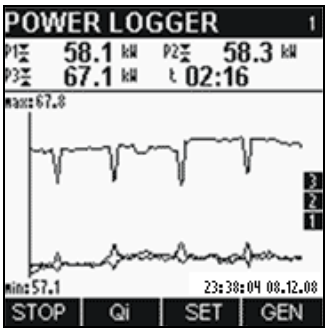


Fig. 6.5: POWER LOGGER RUN screen (motor)

Available signal combinations are:

$P_{Xmin}P_{Xmax}P_{Xavg}$	single phase active power (x = 1 ÷ 3).
$Q_{iXmin}Q_{iXmax}Q_{iXavg}$	single phase inductive reactive power (x = 1 ÷ 3).
$Q_{cXmin}Q_{cXmax}Q_{cXavg}$	single phase capacitive reactive power (x = 1 ÷ 3).
$S_{Xmin}S_{Xmax}S_{Xavg}$	single phase apparent power (x = 1 ÷ 3).
$PF_{iXmin}PF_{iXmax}PF_{iXavg}$	single phase inductive power factor (x = 1 ÷ 3).
$PF_{cXmin}PF_{cXmax}PF_{cXavg}$	single phase capacitive power factor (x = 1 ÷ 3).
$P_{TOTmin}P_{TOTmax}P_{TOTavg}$	total active power.
$Q_{iTOTmin}Q_{iTOTmax}Q_{cTOTavg}$	total capacitive reactive power.
$Q_{cTOTmin}Q_{cTOTmax}Q_{cTOTavg}$	total inductive reactive power.
$S_{TOTmin}S_{TOTmax}S_{TOTavg}$	total apparent power.
E_{TOT}	total energy.
$U_{Xmin}U_{Xmax}U_{Xavg}$	single phase voltage (x = 1 ÷ 3).
$I_{Xmin}I_{Xmax}I_{Xavg}$	single phase current (x = 1 ÷ 3).
$P_{1avg}P_{2avg}P_{3avg}$	average active power for all phases.
$Q_{1iavg}Q_{2iavg}Q_{3iavg}$	average inductive reactive power for all phases.
$Q_{1cavg}Q_{2cavg}Q_{3cavg}$	average capacitive reactive power for all phases.
$S_{1avg}S_{2avg}S_{3avg}$	average apparent power for all phases.
$U_{1avg}U_{2avg}U_{3avg}$	average voltage for all phases.
$I_{1avg}I_{2avg}I_{3avg}$	average current for all phases.

Note: In 3W measurement only total power signals (P_{totxxx}, S_{totxxx}, etc..) are avalible.

All signals can be displayed in GENERATOR (generated (-)) or MOTOR (absorbed (+)) mode.

Data of all concluded intervals are displayed as a graphical histogram too. The latest interval appears on the right and rolls to the left as new intervals are concluded and displayed. The measurement is completed when the first interval reaches the left side of the display (after 150 intervals) or if stopped manually.

The displayed histograms are always auto-scaled. Unlike in the scope modes the signals can not be scaled manually.

Keys:

F1	Stops logging. U,I,f LOGGER STOP SINGLE screens is opened. Otherwise the logging is finished after completion of 150 intervals.
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Enter or Esc key for return
ENTER	Selects available combination of signals for display.
F4	Changes from POWER LOGGER MOTOR screens to POWER LOGGER GENERATOR screens.

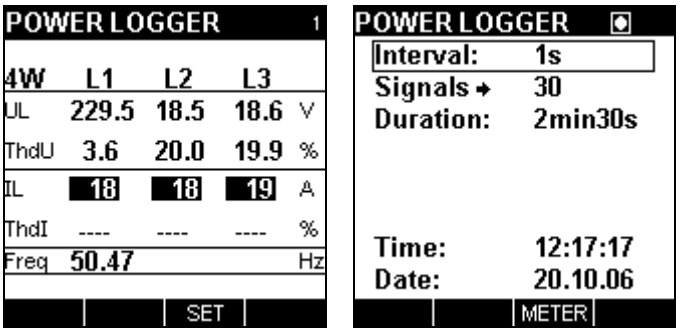


Fig. 6.6:Power logger – METER AND PRESET screens

6.2.3 Power logger stop screens

This function becomes active after a logging is complete.
The recorded signal trace can be scrolled through and reviewed with a cursor.

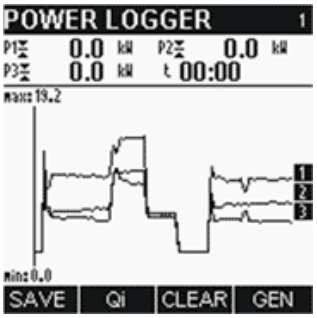


Fig. 6.7: POWER LOGGER MOTOR screen

Available signal combinations are:

$P_{Xmin}P_{Xmax}P_{Xavg}$	single phase active power (x = 1 ÷ 3).
$Q_{Ximin}Q_{Ximax}Q_{Xiavg}$	single phase inductive reactive power (x = 1 ÷ 3).
$Q_{Xcmin}Q_{Xcmax}Q_{Xcavg}$	single phase capacitive reactive power (x = 1 ÷ 3).
$S_{Xmin}S_{Xmax}S_{Xavg}$	single phase apparent power (x = 1 ÷ 3).
$PF_{Ximin}PF_{Ximax}PF_{Xiavg}$	single phase inductive power factor (x = 1 ÷ 3).
$PF_{Xcmin}PF_{Xcmax}PF_{Xcavg}$	single phase capacitive power factor (x = 1 ÷ 3).
$U_{Xmin}U_{Xmax}U_{Xavg}$	single phase voltage (x = 1 ÷ 3).

$I_{Xmin} I_{Xmax} I_{Xavg}$	single phase current (x = 1 ÷ 3).
$P_{1avg} P_{2avg} P_{3avg}$	average active power for all phases.
$Q_{1iavg} Q_{2iavg} Q_{3iavg}$	average inductive reactive power for all phases.
$Q_{1cavg} Q_{2cavg} Q_{3cavg}$	average capacitive reactive power for all phases.
$S_{1avg} S_{2avg} S_{3avg}$	average apparent power for all phases.
$U_{1avg} U_{2avg} U_{3avg}$	average voltage for all phases.
$I_{1avg} I_{2avg} I_{3avg}$	average current for all phases.
$P_{TOTmin} P_{TOTmax} P_{TOTavg}$	total active power.
$Q_{iTOTmin} Q_{iTOTmax} Q_{cTOTavg}$	total capacitive reactive power.
$Q_{cTOTmin} Q_{cTOTmax} Q_{cTOTavg}$	total inductive reactive power.
$S_{TOTmin} S_{TOTmax} S_{TOTavg}$	total apparent power.
E_{TOT}	total energy.

Note: In 3W measurement only total power signals (P_{totxxx}, S_{totxxx}, etc..) are avalible.

All signals can be displayed in GENERATOR (generated (-)) or MOTOR (absorbed (+)) mode.
Data are displayed in graphical (logger histogram) and in numeric (interval data) form.
Complete trace of selected signal can be viewed in the histogram.

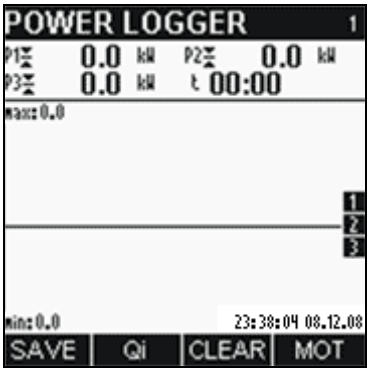


Fig. 6.8: POWER LOGGER GENERATOR screen

All results can be saved to the instrument memory.

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects **P, Qi, Qc, S, PFi, PFc, TOT, U, I, ENG.**
F3	Clears logged values and returns to the POWER LOGGER SETUP screen.
F4	Changes from POWER LOGGER MOTOR screens to POWER LOGGER GENERATOR screens.
◀ ▶	Scroll cursor along logged data. Data at cursor along with time is shown on the top lines.
MENU	Opens the POWER MENU (described in section 7).
ESC	Returns to the MAIN MENU.

7 Harmonics

Harmonics function presents voltage and current signals as sum of sinusoids of power frequency and its integer multiples. Power frequency is called fundamental frequency. Sinusoidal wave with frequency k times higher than fundamental (k is an integer) is called harmonic wave and is denoted with amplitude and a phase shift (phase angle) to a fundamental frequency signal.

Calculation called discrete Fourier transformation (DFT) or its faster version fast Fourier transformation (FFT) is used to translate a sequence of input data to sinusoidal components.

Harmonics function displays the results of fast Fourier transformation (FFT) calculations in numeric and graphic mode.

Fig. 7.1: HARMONICS MENU screen

Options:

Harmonics Meter	Tabular or graphic presentation of harmonics quantities.
THD Logger	Histograms of harmonics quantities.
Measuring setup	Shortcut to the MEASURING SETUP menu.
Main Menu	Back to the MAIN MENU.

Switching between HARMONICS METER and HARMONICS LOGGER function can be performed by pressing *MENU* key in any screen (METER/SCOPE or LOGGER).

If voltage and current results are out of input range, the results are shown in inverted form.

7.1 Harmonics meter function

HARMONICS METER function consists of three screen sections:

- HARMONICS - METER screens, data in tabular form,
- HARMONICS - SCOPE1 screens, presentation of signals in graphical form, one graph,
- HARMONICS - SCOPE2 screens, presentation of signals in graphical form, two graphs.

7.1.1 HARMONICS METER tabular screen

By entering HARMONICS menu from MAIN MENU the HARMONICS – METER tabular screen is shown *(see figure below)*.

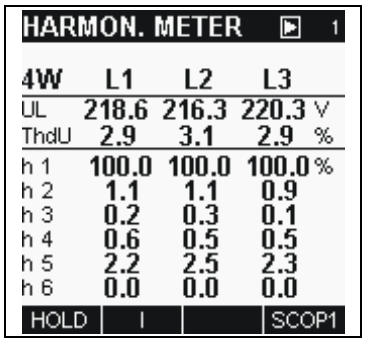


Fig. 7.2: HARMONICS METER tabular screen

The display format and units (V, kV, A, kA) are automatically selected according to the measured values. The following quantities are displayed:

- Phase RMS voltage (U_L) or phase-to-phase RMS voltage (U_{LL}) for each phase,
- Phase RMS current (I_L).
- Total harmonic distortion for voltage (ThdU) and current (ThdI).
- All / even / odd harmonics up to 50th in percentage of U_{nom} / I_{nom} or RMS.

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) mode.
F2	Selects U (voltages) or I (currents) harmonics view for display.
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from METER tabular screen to SCOPE1 graphic (single scope) screen.
▲ ▼	Shift through harmonic components.
ENTER	Toggles between all / even / odd harmonics display.
MENU	Opens the HARMONICS MENU (described in section 8).
ESC	Returns to the MAIN MENU

7.1.2 HARMONICS SCOPE1 (single graph) screen

This function displays the results of fast Fourier transformation (FFT) calculations in numeric and graphic mode. The displayed bar graph is auto-scaled by default.

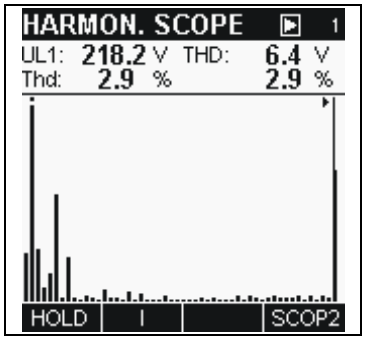


Fig. 7.3: HARMONICS SCOPE (single) screen

The top line provides information about selected input (U_1, U_2, U_3, I_1, I_2, I_3), its RMS value and value of cursor-pointed harmonic / DC value / THD in percentage and RMS of nominal input value.
Graph consists of 52 bars - first bar showing DC value, next 50 showing harmonics and 52nd representing THD.
If one bar extends over visible range a marker (dot) is set above it.

Keys:

F1	Toggles between HOLD (the results are frozen on the display) **and** RUN (results are updated once per second) modes.
F2	Selects U (voltage) or I (current) harmonics for display.
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from SCOPE1 graphic (single scope) screen to SCOPE2 graphic (dual scope) screen.
ENTER	Toggles between phases.
▲ ▼	Scale displayed bar graph by amplitude for better viewing.
◄ ►	Move cursor between harmonic components.
MENU	Opens the HARMONICS MENU (described in section 8).
ESC	Returns to the MAIN MENU.

7.1.3 HARMONICS SCOPE2 (dual graph)

This function displays **U** and **I** harmonics scopes in the same screen. Upper scope shows voltage harmonics, lower shows current harmonics. The top line provides information about selected phase (U_1, U_2, U_3, I_1, I_2, I_3) - RMS value and value of cursor-pointed harmonic / DC value / THD in percentage and RMS of nominal input value *(see figure below)*.

The displayed bar graphs are always auto-scaled.

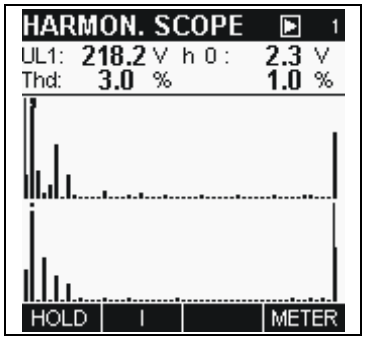


Fig. 7.4: HARMONICS SCOPE (dual) screen

Each scope containing 52 bars - 1st bar showing DC value, next 50 showing harmonics and 52nd representing THD.

If any bar extends over visible range a marker (dot) is set above it (see *Fig. 7.4*, *Harmonics scope (dual) screen*).

Keys:

F1	Toggles between HOLD (the results are frozen on the display) and RUN (results are updated once per second) modes.
F2	Switches between display of voltage or current harmonics values.
F3	Saves displayed values in non-volatile memory (in HOLD mode).
F4	Switches from SCOPE2 graphic (dual scope) screen to METER tabular screen.
ENTER	Toggles between phases.
▲ ▼	Scale selected bar graph (voltage or current) by amplitude.
◀ ▶	Move cursor between harmonics components.
MENU	Opens the HARMONICS MENU (described in section 8).
ESC	Returns to the MAIN MENU.

7.2 THD LOGGER function

THD LOGGER function consists 4 screen sections:

- THD - LOGGER SETUP screen, logger parameters setup,
- THD - LOGGER RUN screens, running histogram,
- THD – LOGGER LOG1 screens, review of logged signals, one bar graph,
- THD - LOGGER LOG2 screens, review of logged signals, two bar graphs.

7.2.1 THD LOGGER SETUP screen

After selecting THD LOGGER in HARMONICS MENU the THD LOGGER SETUP screen is shown *(see figure below)*.

Fig. 7.5: THD LOGGER SETUP

Settings:

Interval:	Logging interval setup (from 1 sec to 30 min). Total logging time is displayed in the “Duration” field.
	Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear.
Duration:	Total logging time (indicator only).

Keys:

	Starts logging. The THD LOGGER RUN screens is displayed.
	Toggles between ON (selected) and OFF (unselected) for actual logging channel (if SIGNALS dialog box is opened).
	Select “Interval” and “Signals” settings. If in SIGNALS dialog, scrolls between logging signals.
	Change interval period (in INTERVAL setup). If in SIGNALS dialog, scrolls between logging signals.

ENTER	Opens SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signals can be selected for logging.
MENU	Opens the HARMONIC MENU (described in section 8).
ESC	Returns to the MAIN MENU. Closes the SIGNALS dialog box (if SIGNALS dialog box is opened).

7.2.2 THD LOGGER RUN screens

This screen opens automatically when the user starts logging.
In this function signal histograms together with the summary details are displayed.

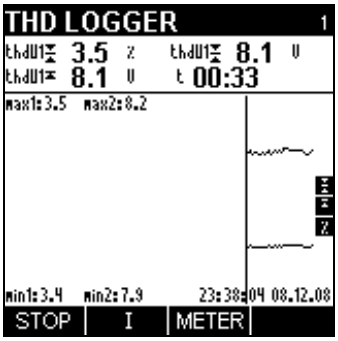


Fig. 7.6: THD LOGGER RUN screen

Available signal combinations are:

$thdU_{Xavg}$ (%) $thdU_{Xavg}$ (V) $thdU_{Xmax}$ (V)	Single phase voltage THD and RMS values (x = 1 ÷ 3).
$thdI_{Xavg}$ (%) $thdI_{Xavg}$ (A) $thdI_{Xmax}$ (A)	Single phase current THD and RMS values (x = 1 ÷ 3).
$thdU_{1avg}$ (%) $thdU_{2avg}$ (%) $thdU_{3avg}$ (%)	voltage THD values for all phases.
$thdU_{1avg}$ (V) $thdU_{2avg}$ (V) $thdU_{3avg}$ (V)	voltage RMS values for all phases.
$thdI_{1avg}$ (%) $thdI_{2avg}$ (%) $thdI_{3avg}$ (%)	current THD values for all phases.
$thdI_{1avg}$ (A) $thdI_{2avg}$ (A) $thdI_{3avg}$ (A)	current RMS values for all phases.

In the upper data field the following values are displayed:

- Voltage and current THD values in percentage of U_{nom} or I_{nom} and RMS,
- Elapsed time.

Data of all concluded intervals are displayed as a graphical histogram. The latest interval data appear on the right and rolls to the left as new intervals are concluded and displayed. The measurement is completed when the first interval data reach the left side of the display (after 150 intervals) or if stopped manually.
The displayed quantities are equal to shown in the data field.

Keys:

F1	Stops logging. THD LOGGER LOG1 screen is displayed.
F2	Selects U (voltages) or I (currents) THD histograms for display.
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Enter or Esc key for return
ENTER	Selects available THD signals for display.

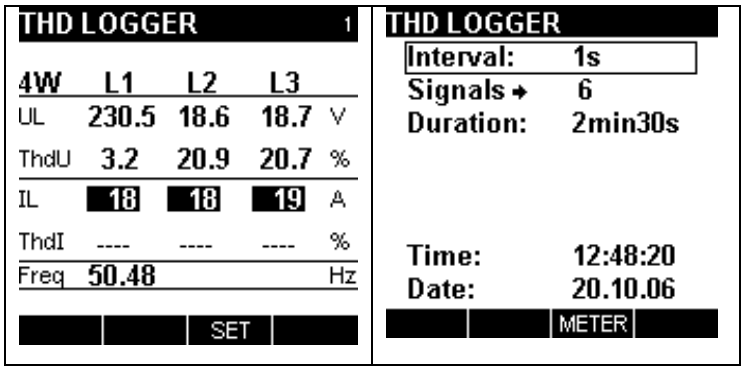


Fig. 7.7:THD logger – METER AND PRESET screens

7.2.3 THD LOGGER LOG1 screens

This function becomes active after a logging is completed.
The recorded signal trace can be scrolled and reviewed with a cursor.

Available signal combinations are:

$thdU_{Xavg}$ (%) $thdU_{Xavg}$ (V) $thdU_{Xmax}$ (V)	Single phase voltage THD and RMS values (x = 1 ÷ 3).
$thdI_{Xavg}$ (%) $thdI_{Xavg}$ (A) $thdI_{Xmax}$ (A)	Single phase current THD and RMS values (x = 1 ÷ 3).
$thdU_{1avg}$ (%) $thdU_{2avg}$ (%) $thdU_{3avg}$ (%)	voltage THD values for all phases.
$thdU_{1avg}$ (V) $thdU_{2avg}$ (V) $thdU_{3avg}$ (V)	voltage RMS values for all phases.
$thdI_{1avg}$ (%) $thdI_{2avg}$ (%) $thdI_{3avg}$ (%)	current THD values for all phases.
$thdI_{1avg}$ (A) $thdI_{2avg}$ (A) $thdI_{3avg}$ (A)	current RMS values for all phases.

Complete trace of selected signal can be viewed in the histogram. All data are displayed graphically (logger scope) and in values (top line).

All results can be saved to the instrument memory.

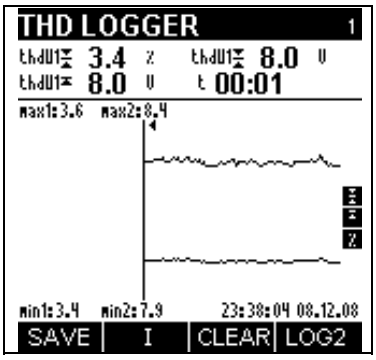


Fig. 7.8: THD LOGGER LOG1 (Single screen)

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects U (voltages) or I (currents) THD values for display.
F3	Clears logged values and returns to U,I,f LOGGER SETUP screen.
F4	Switches from THD - LOGGER STOP SINGLE (single histogram) to THD - LOGGER STOP DUAL (dual histogram).
ENTER	Selects THD signals monitored during logging (voltage or current THD values).
◀ ▶	Scroll cursor along logged data. Data at cursor position along with time is shown in the top line.
MENU	Opens the HARMONICS MENU (described in section 8).
ESC	Returns to the MAIN MENU

7.2.4 THD LOGGER LOG2 screens

In this function two displayed histograms can be scrolled through with a cursor, reviewed and compared.

Available signal combinations are:

$thdU_{Xavg}$ (%) $thdU_{Xavg}$ (V) $thdU_{Xmax}$ (V)	Single phase voltage THD and RMS values (x = 1 ÷ 3).
$thdI_{Xavg}$ (%) $thdI_{Xavg}$ (A) $thdI_{Xmax}$ (A)	Single phase current THD and RMS values (x = 1 ÷ 3).
$thdU_{1avg}$ (%) $thdU_{2avg}$ (%) $thdU_{3avg}$ (%)	voltage THD values for all phases.
$thdU_{1avg}$ (V) $thdU_{2avg}$ (V) $thdU_{3avg}$ (V)	voltage RMS values for all phases.
$thdI_{1avg}$ (%) $thdI_{2avg}$ (%) $thdI_{3avg}$ (%)	current THD values for all phases.
$thdI_{1avg}$ (A) $thdI_{2avg}$ (A) $thdI_{3avg}$ (A)	current RMS values for all phases.

Data are displayed in graphical (2 histograms) and in numeric form.

Complete trace of selected signal can be viewed on the active histogram. The cursor is positioned to the selected interval and can be scrolled over all intervals.

All results can be saved to the instrument memory.

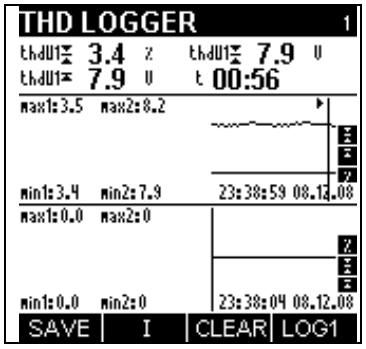


Fig. 7.9: THD LOGGER LOG2 (Dual screen)

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects U (voltages) or I (currents) THD values for display in upper data field.
F3	Clears logged values and returns to THD LOGGER SETUP screen.
F4	Switches from THD LOGGER LOG2 screens to THD LOGGER LOG1 screens.
◀ ▶	Scroll the cursor along logged data on selected (active) logger scope. Data at cursor along with time is shown on top line.
MENU	Opens the HARMONICS MENU (described in section 8).
ESC	Returns to MAIN MENU.

8 Inrushes*

High inrush currents of motors can cause breakers to trip or fuses to open. Maximum expected current during the inrush might be 6 to 14 times greater then the full load current of the motor.

This function is based on principle of logging data exceeding the set level with positive or negative slope on any current input.

When such event (inrush) occurs, data after trigger and in pretriggering time (1/5 of user selected "Duration" time) is logged until the end of selected "Duration" time.

The INRUSH LOGGER function consists of 4 screen sections:

- INRUSH - LOGGER SETUP screen, logger parameters setup,
- INRUSH - LOGGER RUN screens, running histogram,
- INRUSH - LOGGER LOG1 screens, review of logged signals, one histogram,
- INRUSH - LOGGER LOG2 screens, review of logged signals, two histograms.

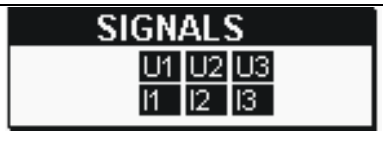
If voltage and current results are out of input range, the results are shown in inverted form.

8.1 INRUSH LOGGER setup screen

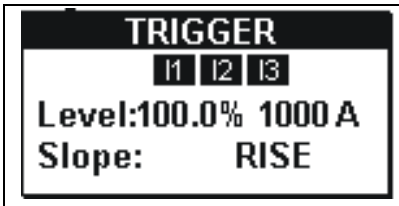
By entering INRUSHES menu from the MAIN MENU the INRUSH LOGGER SETUP screen is shown *(see figure below)*.

Fig. 8.1: INRUSH LOGGER SETUP

Settings:

Interval	Logging interval setup (from 10 ms to 200 ms). Total logging time is displayed in the “Duration” field.
Duration	Total logging time (indicator only).
	Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear.

* Power Q Plus only

	Trigger set up: - Current input for trigger source, - Trigger level at which inrush logging will start, - Trigger slope direction.

Keys:

	Starts logging. INRUSH LOGGER RUN screens is displayed.
	Toggles between ON (selected) and OFF (deselected) for highlighted logging channel in CHANNELS and for highlighted trigger source in TRIGGER dialog
	Select “Interval”, “Signals” or “Trigger” settings. If in “Signals” dialog, scroll between voltage and current values. If in “Trigger” dialog, scroll between trigger source, trigger level and trigger slope.
	If “Interval” is selected, change interval period. If “Signals” dialog is open, scroll through all channels. If “Trigger” dialog is open, scroll through trigger sources / change trigger level / change trigger slope.
	Opens SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signals can be selected for logging. Opens TRIGGER dialog box (if “Trigger” is selected). In this dialog box the trigger channels can be selected, level and slope of the trigger signal can be defined for triggering.
	Returns to the MAIN MENU. Closes the “Signals” or “Trigger” dialog box (if dialog box is open).

8.2 INRUSH LOGGER run screens

This screen opens when the user starts logging.
This function displays signal waveforms together with their summary details *(see figure below)*.

Available signal combinations are:

U_X	single voltage (x = 1 ÷ 3).
I_X	single current (x = 1 ÷ 3).
$U_1U_2U_3$	all phase voltages.
$I_1I_2I_3$	all phase currents.

Up to 10 signal periods of each signal can be observed.
The displayed signals are auto-scaled.

Fig. 8.2: INRUSH LOGGER RUN screen

Note: If user forces inrush logging to stop no data is recorded.
Logging of data only occurs when trigger is activated.

Keys:

F1	Stops logging. INRUSH RECORD STOP SINGLE screens opens.
F2	Selects U (voltages), I (currents) and U+I (voltage – current pairs) for display.
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Enter or Esc key for return
ENTER	Selects available signal combinations for display.

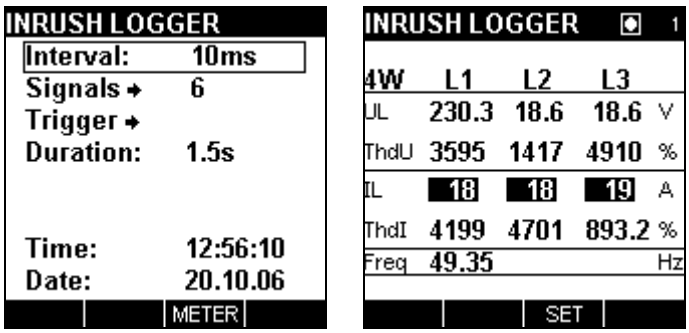


Fig. 8.3:INRUSH logger – METER AND PRESET screens

8.3 INRUSH LOGGER LOG1 screen

This function becomes active after a logging is completed.
The recorded signal trace can be scrolled through and reviewed with a cursor.

Data are displayed in graphical (logger histogram) and in numeric (interval data) form.

The following values can be displayed in the data fields:

- Minimum, maximum and average data of the interval selected with the cursor,
- Time relative to the trigger-event time.

Complete trace of selected signal can be viewed on the histogram. The cursor is positioned to the selected interval and can be scrolled over all intervals.

All results can be saved to the instrument memory.

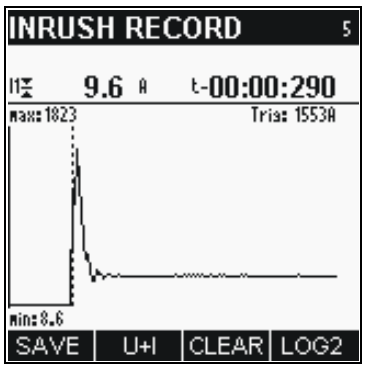


Fig. 8.4: INRUSH RECORD LOG1 screen

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects U (voltages), I (currents) and U+I (voltage – current pairs) for display.
F3	Clears logged values and returns to INRUSH LOGGER SETUP screen.
F4	Switches from INRUSH RECORD LOG1 (Single screens) to INRUSH RECORD LOG2 (Dual screen).
ENTER	Selects available signal combinations for display.
◀ ▶	Scroll the cursor along logged data. Data at cursor along with the time is shown in the top line.
ESC	Returns to the MAIN MENU.

8.4 INRUSH LOGGER LOG2 screen

Logged data can be reviewed and compared in two different histograms.

The data are displayed in graphical (2 histograms) and in numeric (interval data) form.

The following values can be displayed in the data fields:
- Minimum, maximum and average data of the interval selected with the cursor (of the active histogram),
- Time relative to the trigger-event time.

Complete trace of selected signal can be viewed on the active histogram. The cursor is positioned to the selected interval and can be scrolled over all intervals.

All results can be saved to the instrument memory.

Fig. 8.5: INRUSH RECORD LOG2 screen

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects U (voltages), I (currents) or U+I (voltage – current pairs) for display.
F3	Clears screen values and returns to THD LOGGER SETUP screen.
F4	Switches from THD LOGGER LOG2 screens to THD LOGGER LOG1 screens.
ENTER	Selects available signal combinations for display.
◀ ▶	Scroll the cursor along logged data (in the active histogram). Data at cursor along with the time relative to the trigger-event time is shown in the top line.
MENU	Returns to the INRUSH SETUP menu.
ESC	Returns to the MAIN MENU.

9 Voltage quality*

Voltage quality function stores and evaluates following parameters: U_{avg}, dips, swells interrupts, frequency, THD, and unbalance deviation. They are all calculated according to the international standard EN 50160:1999 “Voltage characteristics of electricity supplied by public distribution networks”. See section 15.7 for EN 50160 details. User can define nominal voltage and integration period. Additionally he can choose predefined (EN 50160) or customized thresholds values for voltage deviations, dips, swell and interrupt. During and after measurement, bar graph is used to evaluate results and their compliance with the standard. In bar graph following values can be observed (Fig. 9.3):

- U: represent phase voltages deviation from nominal voltage in three bars (L1, L2, L3). Lover (filled) part of bar represent deviation for 95% of data (data: voltage average over logging interval) from nominal voltage in respect to given threshold. Lower this filled bar is, lower is deviation from nominal voltage. However, if this filled bar intersect Lim line on graph, it means that, threshold is crossed and less than 95% data are within given threshold range ±10%. Measured values are not according to the EN 50160 standard,
  Upper, unfilled part of voltage bar (Fig. 9.3) represent maximal deviation from U_{nom} for all data (100%). If this bar doesn’t intersect 100% limit line, it means that all data are within +10%, -15%. EN 50160 additionally requires that all measured voltage should be wthin +10%, -15% range.
- THD: represents total harmonic distortion in three bars (L1, L2, L3), one per each phase. Limit lines (Lim, 100%) shows 8% of THD distortion. Lower, filled part of bar represent 95% of collected data, while upper unfilled bar represent statistic for all data. Therefore, if filled bar doesn’t cross Lim line (Fig. 9.3), it mean’s that THD is according to EN 50160 standard. If unfilled bar doesn’t intersect 100% line, it means that THD was less than 8%, during complete log.
- INTER.: represents interrupts in three bars (L1, L2, L3), one per each phase, limit line shows 100 interrupts.
- EVENTS: represents dips + swells in three bars (L1, L2, L3), one per each phase, limit line shows 100 events.
- SYM: represents symmetry (unbalance) for three phase system. Limit lines (Lim, 100%) shows if unbalance was greater than 2%. Lower part of bar represent 95% of data, while upper bar represent all data. If unfilled bar doesn’t intersect Lim line, it means that all data are within 2% range. Therefore, if filled bar doesn’t cross Lim line (Fig. 9.3), it mean’s that unbalance is according to EN 50160 standard. If unfilled bar doesn’t intersect 100% line, it means that unbalance was less than 2%, during complete log.
- f: represents frequency deviation, limit line shows 1% of 50Hz. Lower (filled) part of bar (Fig. 9.3) represent 95.5% of data, while upper bar represent all data. If filed bar doesn’t intersect Lim line, it means that 99.5% of data are within 1% range. If unfilled bar doesn’t intersect 100% line on graph, it means that frequency deviation was never more than 1%. Therefore, if filled bar doesn’t cross Lim line (Fig. 9.3), and unfilles bar doesn’t cross 100% line (Fig. 9.3) mean’s that frequency is according to EN 50160 standard.

* Power Q Plus only

In following table overview of all limits given by EN 50160 is shown

Measured value	Limits for 95% of all measured values	Limits for all measured values (100%)
RMS Voltage	±10%	+10% ÷ -15%
Voltage THD	±8%	Not specified
Unbalance (SYM)	2%	Not specified
Frequency	1%	+4% ÷ -6%

9.1 VOLTAGE QUALITY LOGGER setup screen

By entering VOLTAGE QUALITY menu from MAIN MENU the VOLTAGE QUALITY LOGGER SETUP screen is shown by default *(see figure below)*. By pressing function key F3 user can choose predefined EN 50160 settings, or CUSTOM settings, where thresholds can be manually defined. See 15.7 for further details.

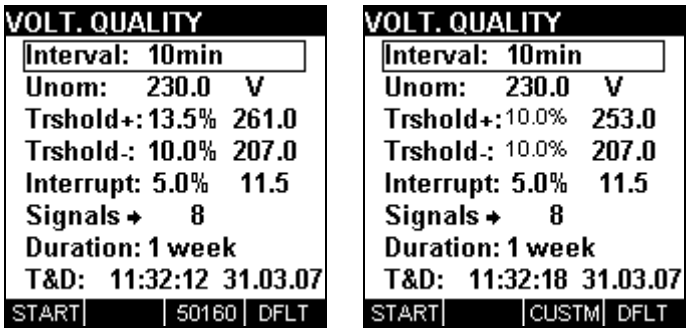


Fig. 9.1: VOLTAGE QUALITY LOGGER setup screen

Settings:

Interval	Setting of logging interval. Available are: 1min 2min 5min 10min
Unom	Nominal voltage can be set from 1.0 V to 90% of selected voltage range (U range – see measuring setup section).
Trshold+	Upper limit can be set from 1 % to 35 % of Unom (swell).
Trshold-	Lower limit can be set from 1 % to 35 % of Unom (dip).
Interrupt	Interruption limit can be set from 1 % to 20 % of Unom.

<table>
<tr><td> 
</td><td>Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear.
Note: Symmetry can be selected only if all three phase/line voltage signals are selected!

F3 — Toggles between ON (selected) and OFF (deselected) for highlighted logging channel.

F4 — Toggles between ALL ON (selected) and ALL OFF (deselected) for all logging channel.

ENTER — Confirm signal selection and returns to Voltage quality menu

ESC — Discard signal selection and returns to Voltage quality menu</td></tr>
<tr><td>Duration</td><td>Shows total logging time (indicator only).</td></tr>
<tr><td>Time, Date</td><td>Actual time and date (can be set in the SETUP menu, described in section 5.2.4).</td></tr>
</table>

Note: Frequency can be logged only if voltage channel (U_1, U_2, etc) is selected for synchronization in Measuring setup. If user select current channel for synchronization, frequency logging is not possible, and instrument will automatically deselect frequency after current channel is select for synchronization. We suggest that user always check selected channels before measurement.

Keys:

F1	Starts logging. The VOLTAGE QUALITY LOGGER RUN screen is displayed (bar graph).
F3	Toggles between custom and EN 50160 power quality logger. See 15.7.7 and 15.7.8 for details.
F4	Retrieves factory default settings.
▲ ▼	Select settings in SETUP menu.
◄ ►	Change parameters of selected option.
ENTER	Opens INTERVAL and SIGNALS dialog box (if "Interval" or “Signals” is selected). In this dialog box the individual signals can be selected for logging.
ESC	Returns to the MAIN MENU.

9.2 VOLTAGE QUALITY LOGGER run screen

This screen opens when the user starts logging.

In logging mode a bar graph is shown. When first interval is logging, a message "Waiting first result" is shown. Otherwise, a normal bar graph is displayed. Note that 100% limit line is shown only if EN 50160 voltage quality mode was chosen.

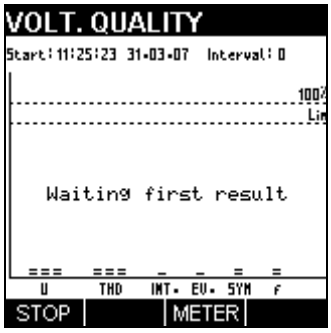


Fig. 9.2: VOLTAGE QUALITY RUN screen while waiting

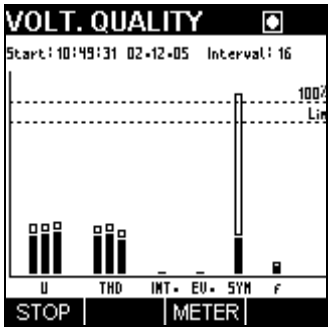


Fig. 9.3: VOLTAGE QUALITY RUN screen

Keys:

F1	Stops logging. LOGGER STOP screen is opened. Otherwise the logging is finished after completion of 1008 intervals.
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Esc key for return

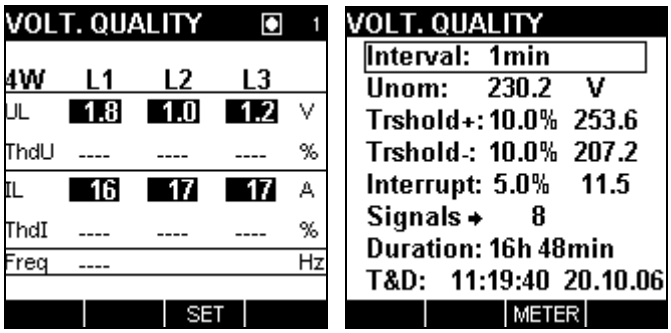


Fig. 9.4: VOLTAGE QUALITY – METER AND PRESET screens

9.3 VOLTAGE QUALITY LOGGER stop screens

This function becomes active after a logging is completed.
Measured data are displayed both in table and bar graph form.

Table data:

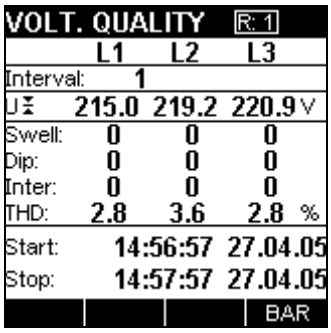


Fig. 9.5: VOLTAGE QUALITY LOGGER STOP statistical screen

Bar graph data:

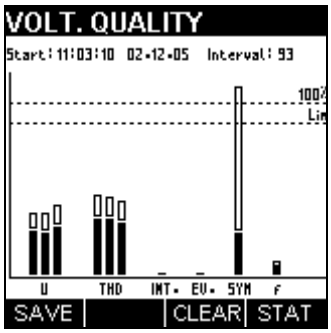


Fig. 9.6: VOLTAGE QUALITY LOGGER STOP statistical screen

All results can be saved to the instrument memory.

Keys:

F1	Saves logged data to non-volatile memory.
F3	Clears logged values and returns to the VOLTAGE QUALITY LOGGER SETUP screen.
F4	Toggles between table data and bar graph data (statistic).
◀ ▶	Scroll through recorded intervals (only in table data).
ESC	Returns to the MAIN MENU.

10 Voltage events*

Three voltage event parameters are logged in this function: dips, swells and interruptions. They are called voltage anomalies.

Swell is a temporary voltage increase above upper voltage limit threshold+.
Dip is a temporary reduction of a voltage below lower voltage limit threshold-.
Interruption is a temporary reduction of a voltage below interruption limit.

If voltage results are out of input range, the results are shown in inverted form.

10.1 VOLTAGE EVENTS LOGGER setup screen

By entering VOLTAGE EVENTS menu from MAIN MENU the VOLTAGE EVENTS LOGGER SETUP screen is shown by default *(see figure below)*.

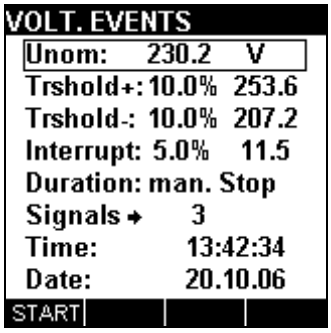
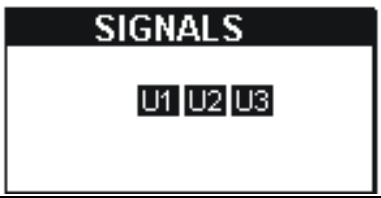


Fig. 10.1: VOLTAGE QUALITY LOGGER setup screen

Settings:

Unom	Nominal voltage can be set from 1.0 V to 90% of selected voltage range (U range – see measuring setup section).
Trshold+	Upper limit can be set from 1 % to 35 % of Unom (swell).
Trshold-	Lower limit can be set from 1 % to 35 % of Unom (dip).
Interrupt	Interruption limit can be set from 1 % to 20 % of Unom.
Duration	Available are: 1 min, 2 min, 5 min, 10 min, 30 min, 1 h, 2 h, 5 h, 10 h, 30 h, 50 h, 75 h, manual stop
	- Number after arrow (➔) represent number of selected signals. By pressing ENTER, submenu for logging signals selection appear.
Time, Date	Actual time and date (can be set in the SETUP menu, described in section 5.2.4).

Keys:

F1	Starts logging. The VOLTAGE EVENTS LOGGER RUN screen is displayed.
F3	Toggles between ON (selected) and OFF (deselected) for highlighted logging channel (if SIGNALS dialog box is opened).
▲ ▼	Select settings in SETUP menu.
◄ ►	Change parameters of selected option.
ENTER	Opens SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signals can be selected for logging.
ESC	Returns to the MAIN MENU.

10.2 VOLTAGE EVENTS LOGGER run screen

This screen opens when the user starts logging.

In run mode anomalies are counted and presented in a table form separately for swells, dips and interruptions.

Current anomaly is framed.

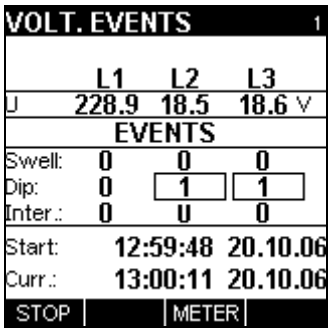


Fig. 10.2: VOLTAGE EVENTS RUN screen

Keys:

F1	Stops logging. LOGGER STOP screen is opened. Otherwise the logging is finished after completion of 150 intervals.
F3	Cycle two screens *(see figure below)*: - current voltages and current measurement values - preset parameters. Use Enter or Esc key for return.

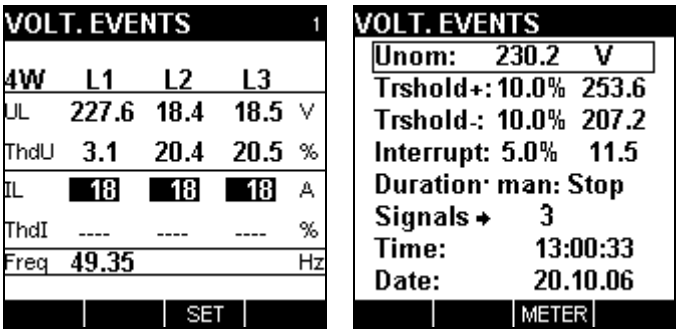


Fig. 10.3:VOLTAGE EVENTS logger – METER AND PRESET screens

10.3 VOLTAGE EVENTS LOGGER stop screens

This function becomes active after a logging is completed.
Measured data are displayed in report form.

The following information are displayed for each anomaly:

- type of anomaly,
- voltage value,
- start and end time (hour:min:sec:msec year:month),
- duration.

In order to distinguish dip only event from dip where also interrupt appear, instrument use following notation on display:

-  – Dip only event

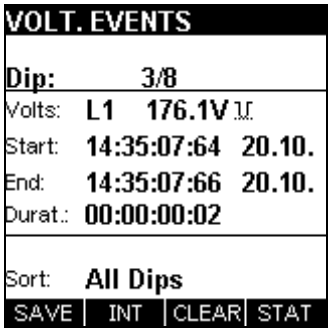


Fig. 10.4: VOLTAGE dip only EVENT LOGGER STOP screen

-  – Dip event which contains interrupt event. Dip voltage shown on the screen is **dip entry voltage**. Data for interrupt part of event, can be found, by browsing interrupts events table INT.

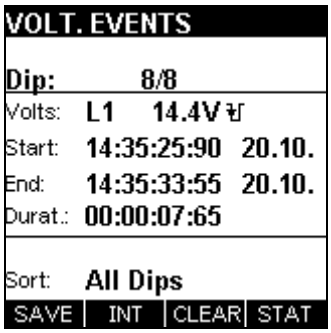


Fig. 10.5: VOLTAGE dip with swell event LOGGER STOP screen

All results can be saved to the instrument memory.

Keys:

F1	Saves logged data to non-volatile memory.
F2	Selects swells, dips and interruptions for display (only if at least one anomaly of that type was logged).
F3	Clears logged values and returns to the VOLTAGE EVENTS LOGGER SETUP screen.
F4	Toggles between list of individual anomaly details and statistics of all anomalies.
ENTER	Selects anomalies of different phases for display.
▲ ▼	Scroll through selected record of anomalies.
ESC	Returns to the MAIN MENU.

11 Phase diagram

The most common cause of incorrect measured or logged data is a faulty connection. With the Power Q series of instrument the user can check the connection before measurement is performed.

This function displays:

- Graphical presentation of voltage and current phase angles of the measured system,
- Symmetry of the measured system.

If voltage and current results are out of input range, the results are shown in inverted form.

11.1 U – I Phase diagram screen

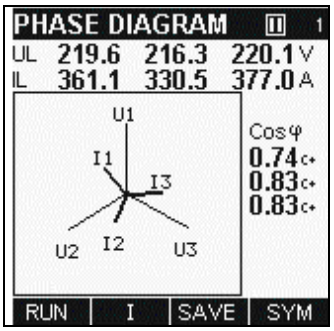


Fig. 11.1: PHASE DIAGRAM screen

Keys:

F1	Switches between HOLD/RUN mode.
F2	Selects U (voltages) and I (currents) for scaling.
F3	If in HOLD mode, saves measured values in non-volatile memory.
F4	Changes between line voltage & current vector diagram and symmetry vector diagram
▲ ▼	Scale selected signals by amplitude.
ESC	Returns to the MAIN MENU
ENTER	4W connection only: Switches angle representation between Cos φ and φ (in degrees).

11.2 SYMMETRY Phase diagram screen

Phase diagram (SYM) is intended for representing current and voltage symmetry (balance) of the measuring system.
Supply voltage and current asymmetry arises when RMS values or phase angles between consecutive phases are not equal.

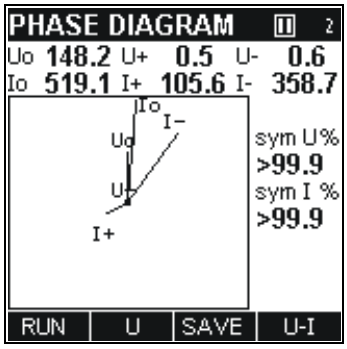


Fig. 11.2: SYMMETRY PHASE DIAGRAM screen

12 Energy

This function includes thee energy counters:

- TOTAL COUNTER (all energy measured with the instrument),
- SUBTOTAL COUNTER (energy measured during last logging),
- LAST INTERVAL COUNTER (energy of last measured interval).

12.1 Energy setup function

After selecting ENERGY menu from the MAIN MENU the ENERGY SETUP menu screen is shown *(see figure below)*.

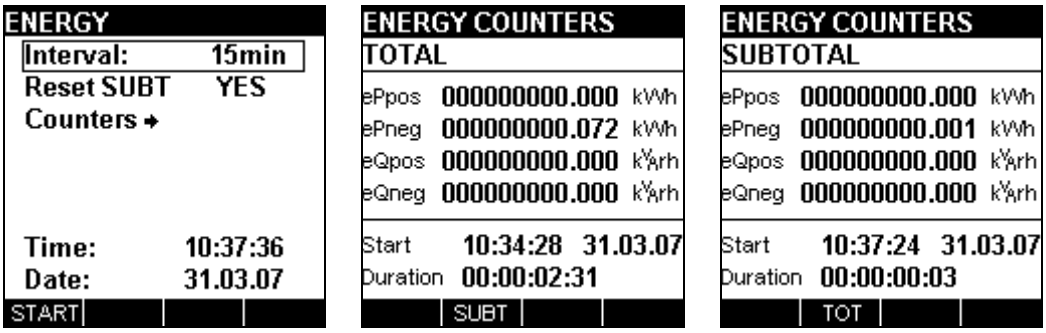


Fig. 12.1: ENERGY SETUP screens

Settings:

Interval	Logging interval setup (from 1 min to 15 min).
Reset SUBT	Reset (YES) or not (NO) the SUBTOTAL counter at the beginning of counting.
Counters	Review TOTAL and SUBTOTAL counters.
Time, Date	Actual time and date (can be set in the SETUP menu, described in section 5.2.4).

Keys:

F1	Starts counting. The ENERGY COUNTER RUN screen is displayed.
▲ ▼	Select settings in SETUP menu.
◄ ►	Change parameters of selected option.
ENTER	Opens COUNTERS dialog box (if “Counters” is selected). In this dialog box the TOTAL and SUBTOTAL counters can be reviewed.
ESC	Returns to the MAIN MENU.

12.2 ENERGY run screens

This screen opens when the user starts energy counting. This function displays TOTAL, SUBTOTAL and LAST INTERVAL counters.

Each counter includes three different energies:
- ePpos (active positive or consumed energy),
- ePneg (active negative or generated energy)
- eQpos (reactive positive energy),
- eQneg (reactive negative energy).

The following information are displayed for each counter:
- Start (time of the last reset of the counters);
- Duration (TOTAL, SUBTOTAL: duration of counting from the last reset of the counters, LAST INTERVAL: duration of the actual period).

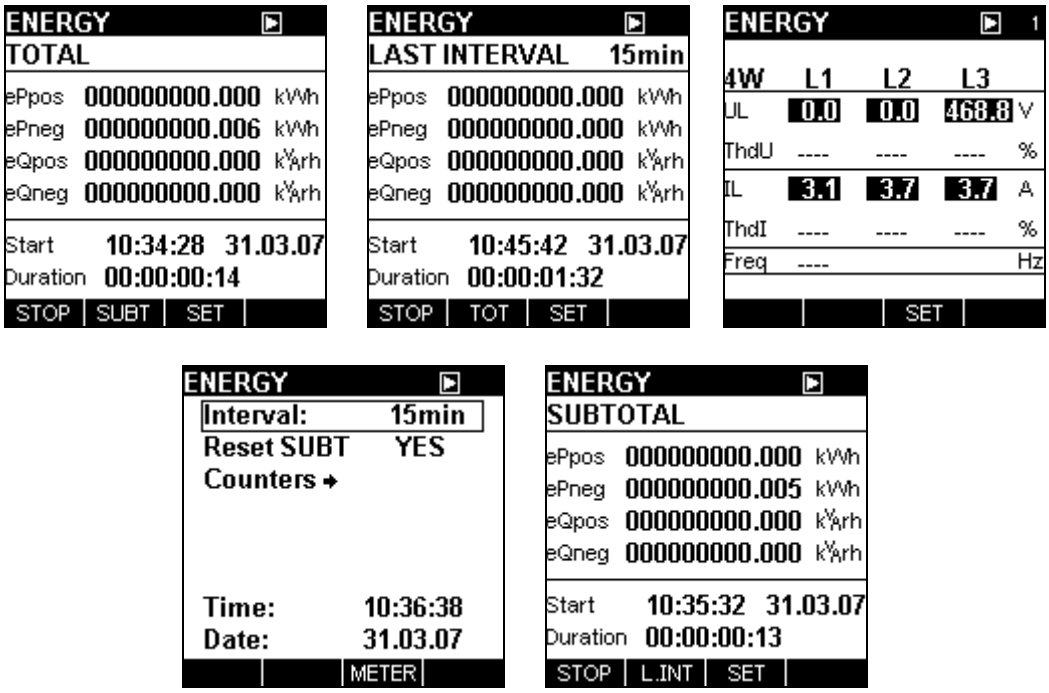


Fig. 12.2: ENERGY RUN screens

Keys:

F1	Stops energy counting.
F2	Selects TOT (total), SUBT (subtotal) or L.INT (last interval) energy counter for display.
F3	Shows preset parameters or measured currents and voltages.

12.3 ENERGY stop SCREEN

This function becomes active after a counting is completed. The information is the same as in ENERGY RUN screen.
The screen displays TOTAL, SUBTOTAL and LAST INTERVAL counters:

- ePpos (active positive or consumed energy),
- ePneg (active negative or generated energy)
- eQpos (reactive positive energy),
- eQneg (reactive negative energy).

The following information are displayed for each counter:

- Start (time of the last reset of the counters);
- Duration (TOTAL, SUBTOTAL: duration of counting from the last reset of the counters, LAST INTERVAL: duration of the last period).

Fig. 12.3: ENERGY STOP screen

Keys:

F2	Selects TOT (total), SUBT (subtotal) or L.INT (last interval) energy counter for display.
ESC	Returns to the ENERGY SETUP menu.

13 Memory list

In this menu the user can browse through all saved data.
By entering this menu a short information list is shown giving general information about number of saved records, free memory space and currently browsed record.

If there is no record, number of saved records is 0. All other fields are blank.

Fig. 13.1: MEMORY LIST screen

Keys:

F2	Clears current record.
◀ ▶	Browse through records (next or previous record).
ENTER	Shows current record.
ESC	Returns to the MAIN MENU.

When a selected record is opened the meanings of the function keys are the same as in the function where the record was saved.

14 Connection to the Power Systems

14.1 General Recommendations

This instrument can be connected to the 3-phase system in 2 ways:

- 3-phase four-wire system L_1, L_2, L_3, N; I_1, I_2, I_3
- 3-phase three-wire system L_{12}, L_{23}, L_{31}; I_1, I_2, I_3

The actual connection scheme has to be defined in MEASURING SETUP menu (see Fig. below).

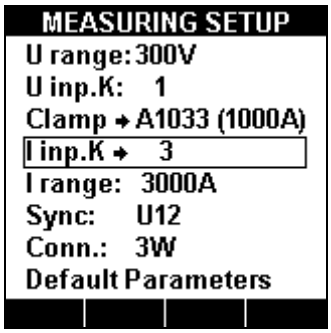


Fig. 14.1: Measuring configuration menu

When connecting the instrument it is essential that both current and voltage connections are correct. In particular the following rules have to be observed:

Current clamp-on current transformers

- The arrow marked on the clamp-on current transformer has to point in the direction of current flow, from supply to load.
- If the clamp-on current transformer is connected in reverse the measured power in that phase would normally appear negative.

Phase relationships

- The clamp-on current transformer connected to current input connector I_1 has to measure the current in the phase line to which the voltage probe from L_1 is connected.

Wiring connections are shown in figures bellow.

In systems where voltage is measured at the secondary side of a voltage transformer (say 11 kV / 110 V), a scaling factor of that voltage transformer ratio has to be entered in order to ensure correct measurement.

1. 3-phase 4-wire system (with neutral conductor)

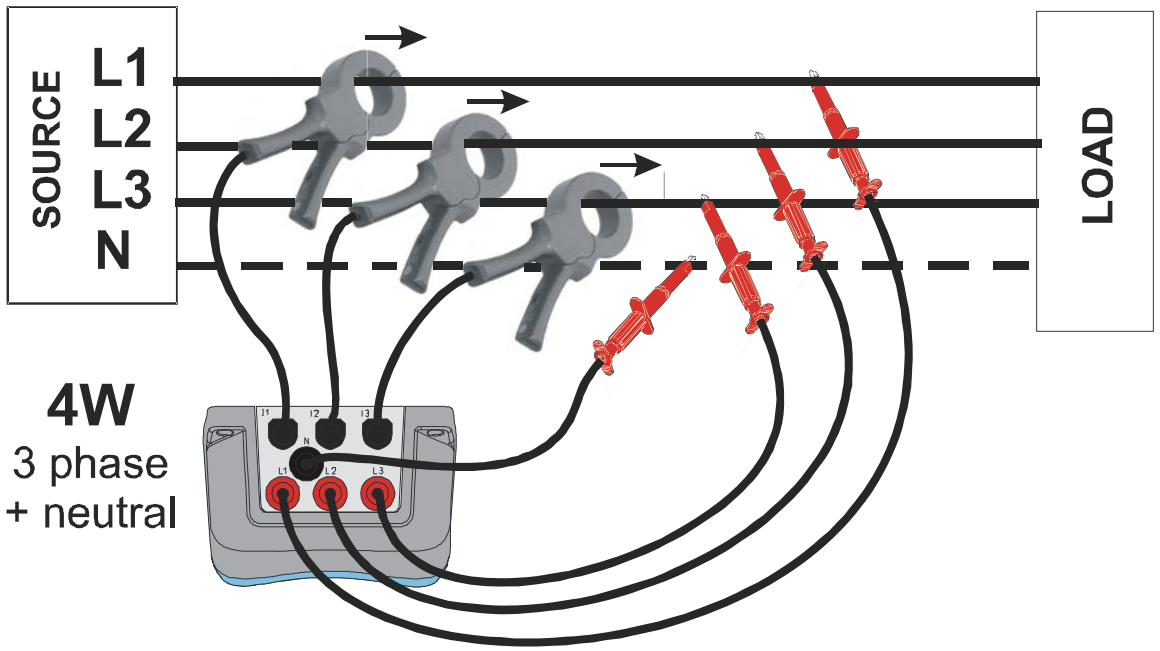


Fig. 14.2: 3-phase 4-wire system

2. 3 phase 3-wire system (without neutral conductor)

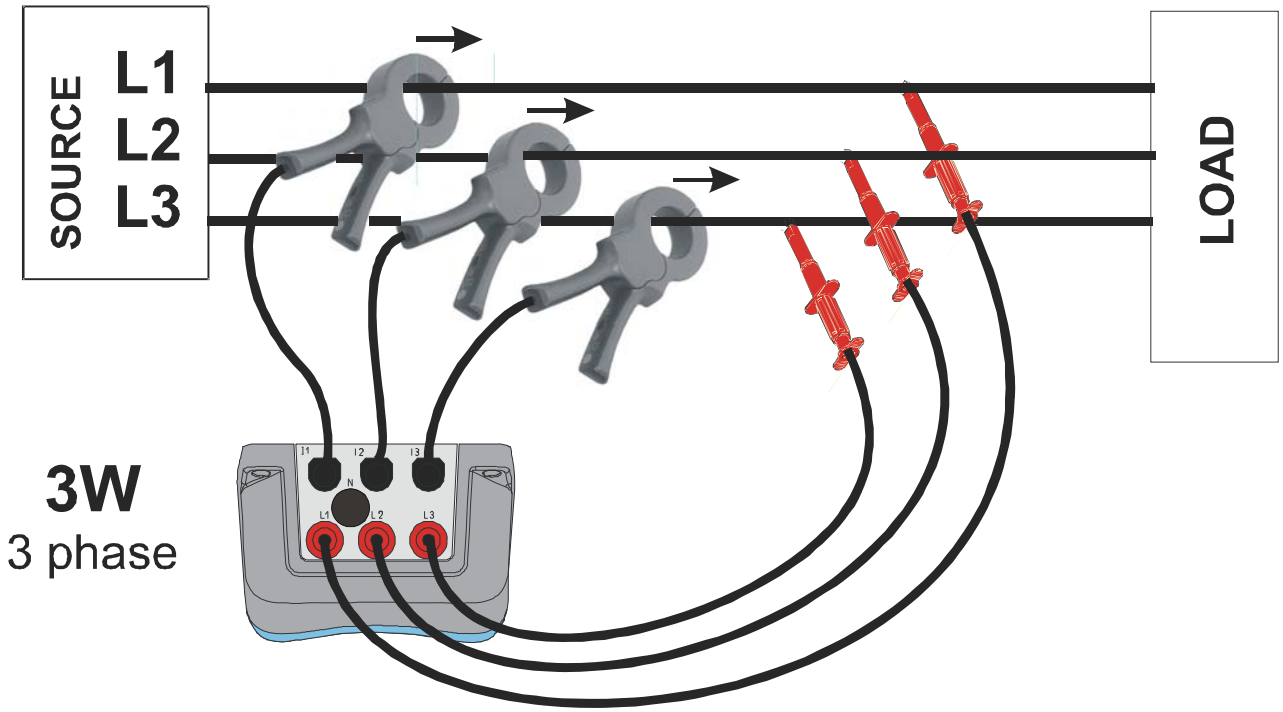


Fig. 14.3: 3-phase 3-wire system

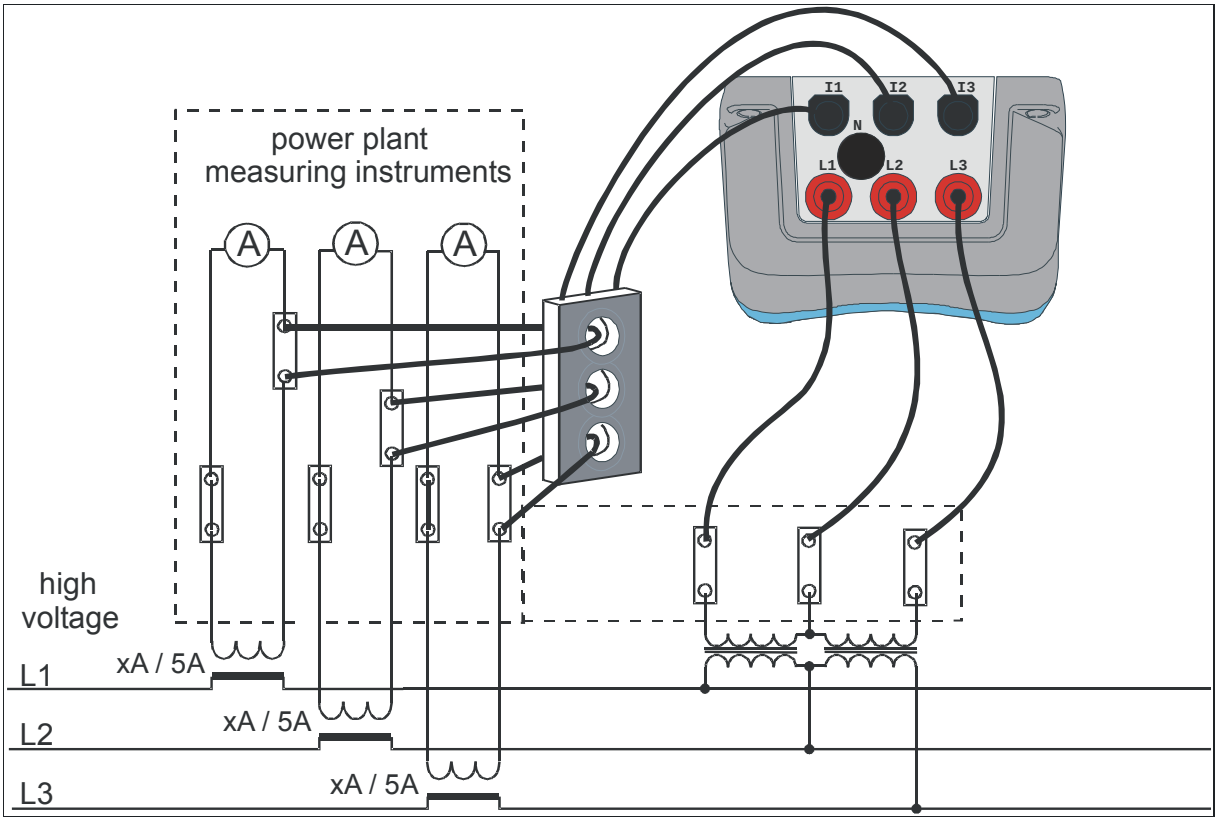


Fig. 14.4: Connecting instrument to the existing current transformers in medium voltage system

WARNING !

- **The secondary of a current transformer must not be open when it is on a live circuit.**
- **An open circuit secondary can result in dangerously high voltage across the terminals.**

14.2 Current clamp selection and transformation ratio setting

Clamp selection can be explain by two typical use cases.

14.2.1 Direct current measurement

Direct current measurement with one of following clamps: A 1033 (1000A), A1069 (100A), A1120(3000A), A1099 (3000A), etc.. Load current is this case measured **directly** by clamps.
Optionally there can be more than one parallel cable that feeds load, and can't be embraced by single clamps. In this case we measure only one part of actual current.
In **example** if 2700 A current load is feed by 3 equal parallel cables, and we can embrace only one cable with clamps, "I inp. K" should be set to: Measuring 1 of 3 cable. Therefore instrument will assume that we measure only third part of current. Figure bellow shows settings for given example. Note that measuring range can be observed by "I range" colon, which is in this case 3000A.

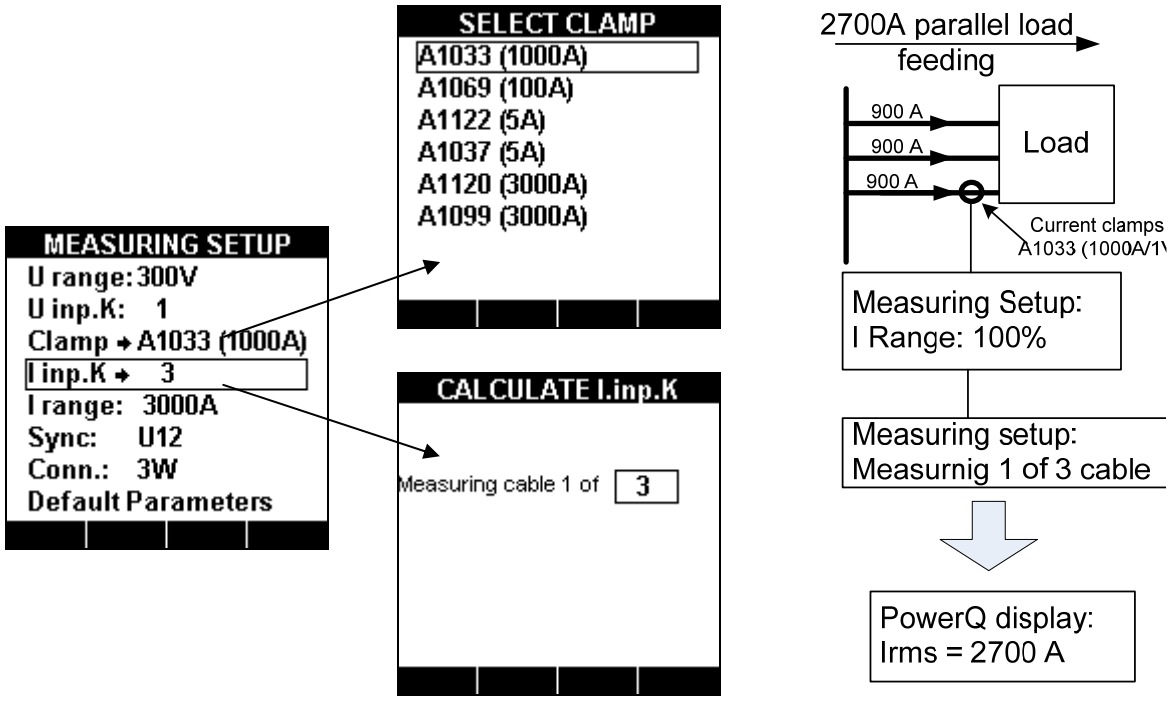


Fig. 14.5: Current clamps selection for direct current measurement

14.2.2 Indirect current measurement

Indirect current measurement is assumed if we select A 1122 or A 1037 (5A), current clamps. Load current is this case measured **indirectly** through primary current transformer. Ratio for this transformer can be defined with “I inp.K” submenu.
In **example** if we have 100A of primary current flowing through primary transformer with ratio 1000A : 5A, setting are shown in following figure.

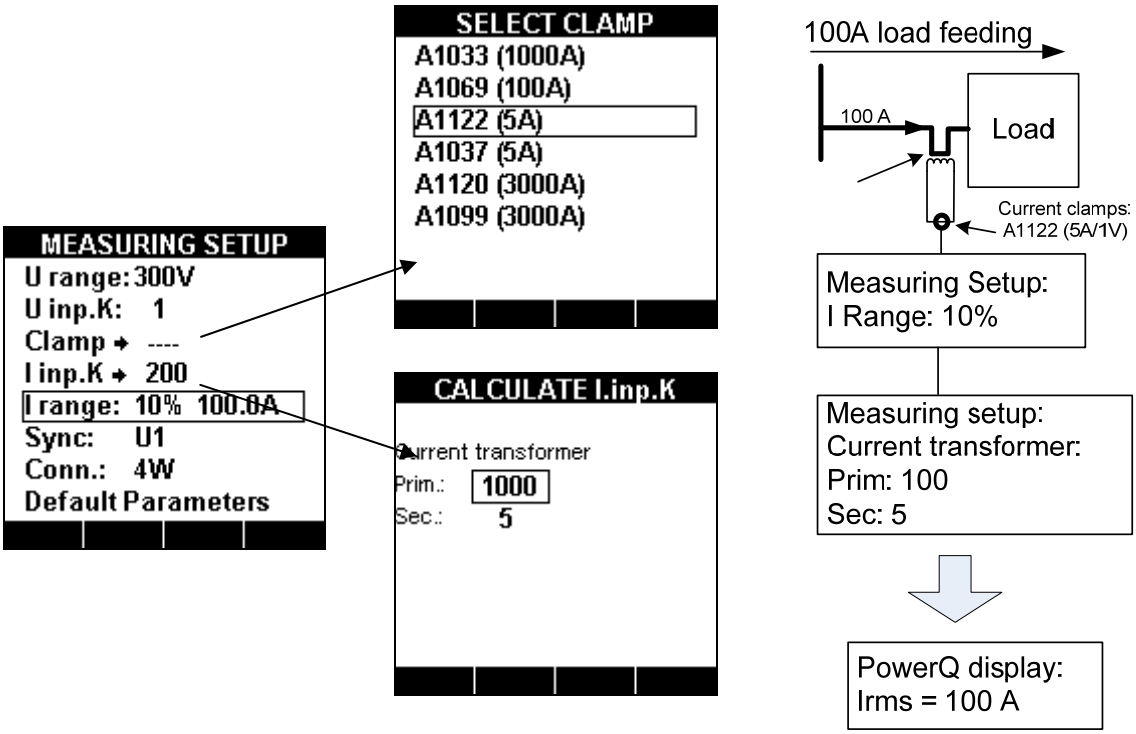


Fig. 14.6: Current clamps selection for indirect current measurement

Note that if we want to perform direct current measure with 5A clamps “I inp.K” ratio should be set to 1 A : 1A.

14.2.3 Automatically recognised current clamps

Automatically recognised current clamps are designed in order to simplify current clamps selection and settings. Following procedure should be followed for the first time:

1. Turn on instrument
2. Connect clamps (in example A 1227) into PowerQ+
3. Enter Setup ➔ Measuring setup menu
4. Clamps type should be automatically recognised by the instrument.
5. User should then enter into clamp menu, in example: Clamp ➔ A1227 and choose desired current range by pressing  keys, as shown on figure bellow.

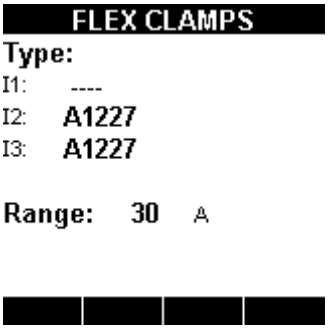


Fig. 14.7: Automatically recognised clamps setup

Instrument will remember clamps setting for the next time. Therefore, user only need to:

1. Plug clamps into the instrument
2. Turn on the instrument

Instrument will recognise clamps automatically and set up ranges as was settled on measurement before.

Note: Do not disconnect automatic clamps during recording or measurement. Clamps range will be reset if clamps are plugged out of the instrument. It is recommended to set up clamps before measurement.

14.3 Measuring set-up for current measurement

Measurement accessory	Measured values	I inp. K	I range*	Instrument Accuracy
A 1033 Current clamp 1000 A	≤ 100 A > 100 A	Measuring 1 of 1	10%: 100 A 100%:1000A	±(3 % + 0.3 A) ±(3 % + 3 A)
A 1069 Mini clamp 100 A	≤ 10 A > 10 A	Measuring 1 of 1	10%: 10 A 100%:100A	±(3 % + 0.03 A) ±(3 % + 0.3 A)
A 1122* Mini clamp 5 A	≤ 0.5 A > 0.5 A	Prim:5 Sec: 5	10%: 5 A 100%:0,5 A	±(3 % + 1.5 mA) ±(3 % + 15 mA)
A 1037* 3-Phase Curr. Transf.	≤ 0.5 A > 0.5 A	Prim:5 Sec: 5	10%: 5 A 100%:0,5 A	±(3 % + 1.5 mA) ±(3 % + 15 mA)
A 1120, A 1099 Flex kit 30 A	≤ 3 A > 3 A	Measuring 1 of 1	100%:30 A	±(3 % + 0.09 A)
A 1120, A 1099 Flex kit 300 A	≤ 30 A > 30 A	Measuring 1 of 1	100%:300 A	±(3 % + 0.9 A)
A 1120, A 1099 Flex kit 3000 A	≤ 300 A > 300 A	Measuring 1 of 1	100%:3 kA	±(3 % + 9 A)

NOTE: ‘I range ’ for iron clamps can be toggled between 10% or 100% of measured current. Use 100% in the first place, and then switch to 10% if measured current is less 10% of nominal.

* Out of range current results are shown in inverted form at currents over 7.5 A (A 1122) and 6 A (A 1037), regardless of measurement function and range.

15 Theory and internal operation

15.1 Introduction

This section contains basics theory of measuring functions and technical information of the internal operation of the Power Q series of instruments, including descriptions of measuring methods and logging principles.

15.2 MEASUREMENT METHODS

Measurement methods are based on the digital sampling of the input signals. Each input (3 voltages and 3 currents) is sampled 1024 times in 10 cycles. Duration of this cycle depends on the frequency at the synchronization input (one of the 3 voltage or current inputs). At 50 Hz the cycle period is 20 ms.
Basic measured values are calculated at the end of each sampling period and the results are available on the display or are logged.
Fast Fourier transform (FFT) based results are calculated 1,5 times / sec.

15.3 U,I,f

Voltage and current values are measured according to the following equation:

Phase voltage: $$Ux = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024} Ux_j^2} \quad [V],$$

Phase current: $$Ix = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024} Ix_j^2} \quad [A],$$

Phase-to-phase voltage: $$Uxy = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024} (Ux_j - Uy_j)^2} \quad [V],$$

The instrument offers 4 voltage measurement ranges. Middle voltage (MV) and high voltage (HV) systems can be measured with help of voltage transformers and voltage factor U inp.K.

The instrument offers 2 current measurement ranges. Current values higher then instrument input current range can be measured with help of current transformer and current factor I inp.K.

Four wire (4W) and three wire (3W) measuring systems can be inspected with the instrument.

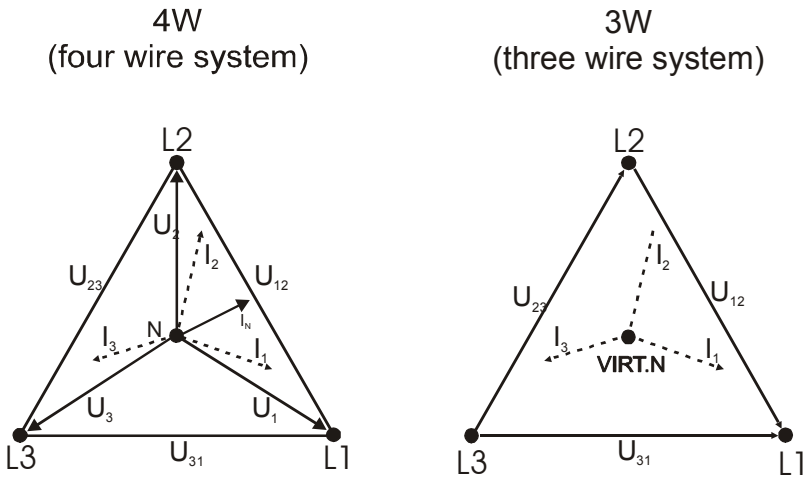


Fig. 15.1: 3W and 4W phase diagram

15.4 Power

Power is measured according to the following equation:

Phase active power: $$Px = \frac{1}{1024}\sum_{j=1}^{1024} Ux_j * Ix_j \quad [W]$$

Apparent and reactive power, voltage, crest factor and power factor are calculated according to the following equation:

Phase apparent power: $$Sx = Ux * Ix \quad [VA],$$

Phase reactive power: $$Qx = \sqrt{Sx^2 - Px^2} \quad [Var],$$

Phase voltage crest factor: $$Ux_{cr} = \frac{Ux_{max}}{Ux},$$

Phase current crest factor: $$Ix_{cr} = \frac{Ix_{max}}{Ix},$$

Phase cos φ: $$Cos\varphi_x = Cos\varphi u_x - Cos\varphi i_x,$$

Phase power factor: $$PFx = \frac{Px}{Sx}.$$

Total active, reactive and apparent power and total power factor are calculated according to the following equation:

Total active power: $Pt = P1 + P2 + P3$ [VA],

Total reactive power: $Qt = Q1 + Q2 + Q3$ [Var],

Total apparent power: $St = \sqrt{(Pt^2 + Qt^2)}$ [VA],

Total power factor: $PFtot = \frac{Pt}{St}$.

Active power is divided into two parts: import (positive-motor) and export (negative-generator). Reactive power and power factor are divided into four parts: positive inductive (+i), positive capacitive (+c), negative inductive (-i) and negative capacitive (-c).

Motor/generator and inductive/capacitive phase/polarity diagram is shown on figure below:

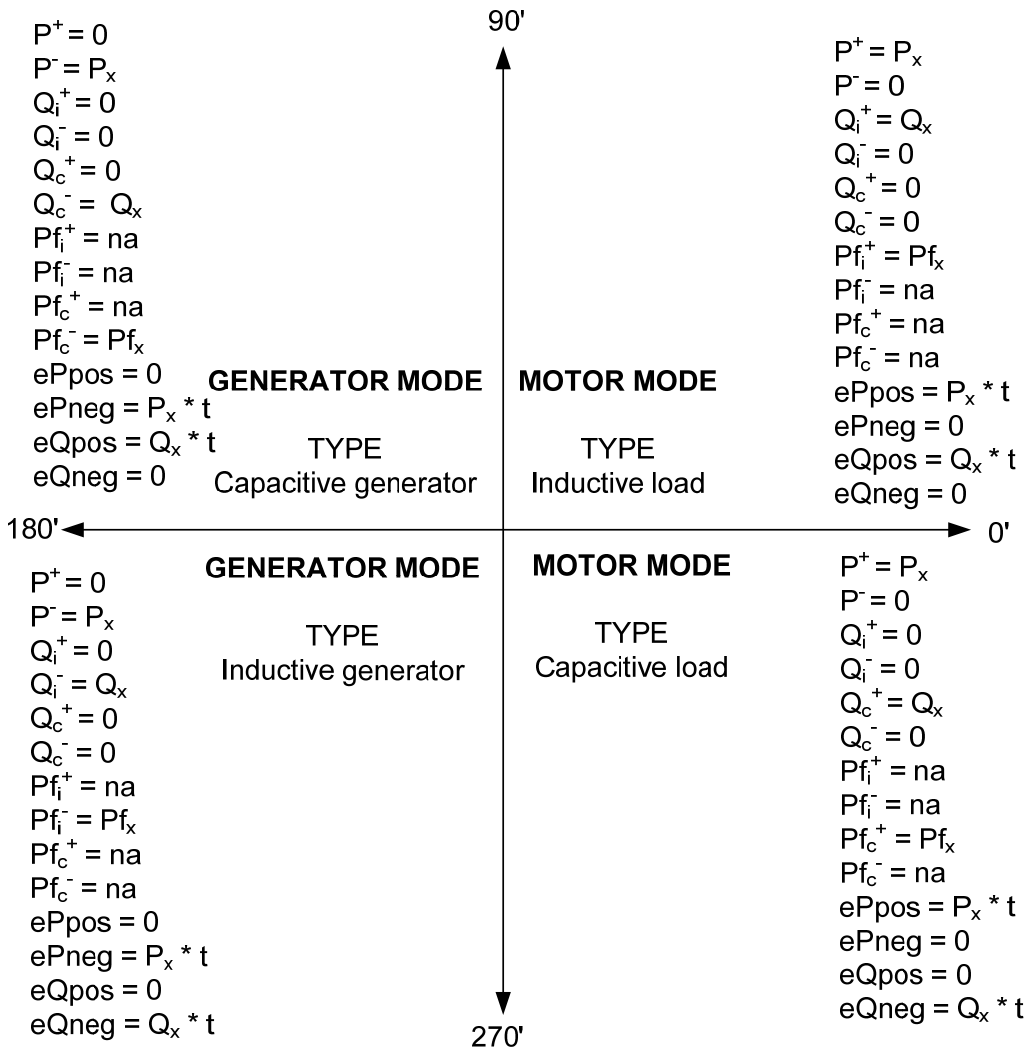


Fig. 15.2: Motor/generator and inductive/capacitive phase/polarity diagram

15.5 Harmonics

Calculation called fast Fourier transformation (FFT) is used to translate AD converted input signal to sinusoidal components. The following equation describes relation between input signal and its frequency presentation. Upper limit of sum function in equation (∞) is limited with a sampling rate. The highest harmonic frequency is approximately half of sampling frequency.

$$u(t) = c_{U0} + \sum_{n=0}^{\infty} c_{Uk} \sin(n \cdot 2\pi f_1 t + \varphi_{Un})$$

c_{U0} – DC component

c_{Un} – amplitude of n-ordered voltage harmonic

φ_{Un} – phase shift of n ordered voltage harmonic

f_1 – fundamental freqency

Phase voltage and current THD values and phase voltage and current individual harmonics are calculated according to the following equations:

Phase voltage THD:
$$THD_{Ux} = \frac{\sqrt{\sum_{n=2}^{50} hn_{Ux}^2}}{h1_{Ux}} * 100 \quad [\%],$$

Phase current THD:
$$THD_{Ix} = \frac{\sqrt{\sum_{n=2}^{50} hn_{Ix}^2}}{h1_{Ix}} * 100 \quad [\%],$$

Phase voltage and current individual harmonics are presented in absolute and percentage form. Percentage is calculated according to the following equations:

Voltage individual harmonics:
$$Hn_{Ux} = \frac{hn_{Ux}}{h1_{Ux}} * 100 \quad [\%],$$

Current individual harmonics:
$$Hn_{Ix} = \frac{hn_{Ix}}{h1_{Ix}} * 100 \quad [\%],$$

hn – n-ordered harmonic (voltage or current)

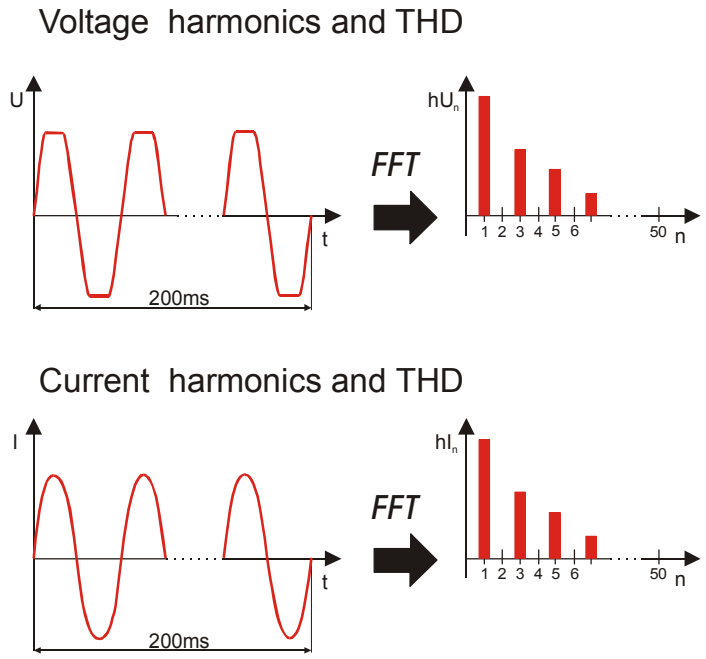


Fig. 15.3: Current and voltage harmonics

15.6 Inrushes

Inrush measurement is intended for analysis of voltage and current fluctuations when starting motors or other high power consumers. TRMS values per 10 ms (half period) are measured and average of half period results is logged in each preset interval. Inrush logger starts when the preset trigger occurs.

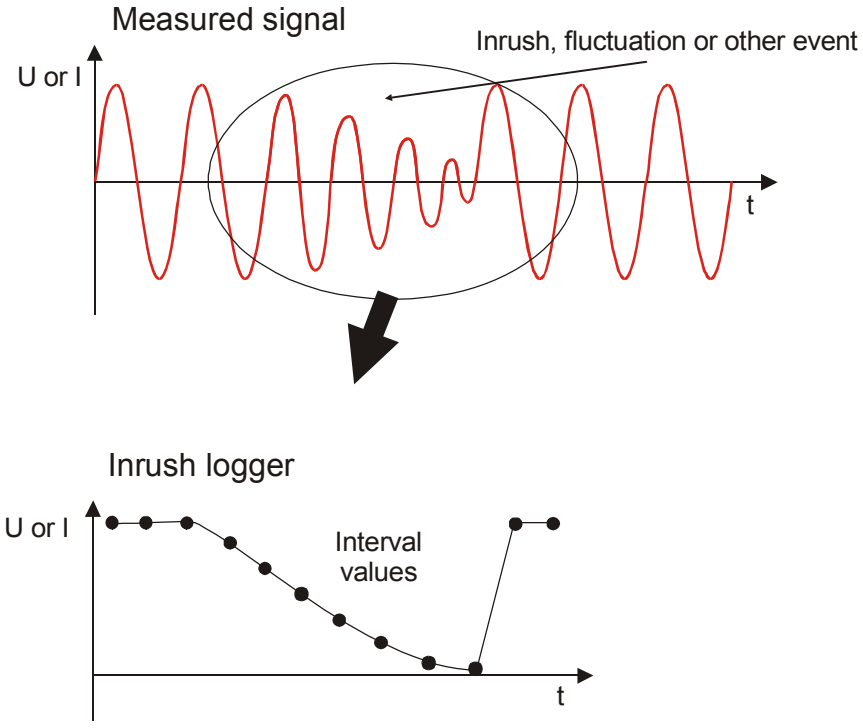
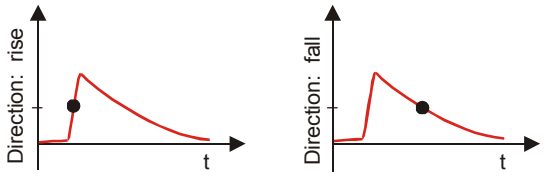


Fig. 15.4: Inrush (waveform and RMS)

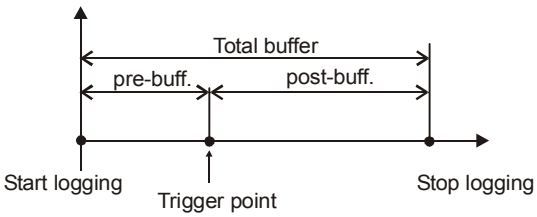
Inrush logging starts when the trigger even occurs. Storage buffer is divided into pre-buffer (measured values before trigger point) and post-buffer (measured values after trigger point).

Triggering



Input: I1, I2, I3, Ix - trigger channels
Level: predefined TRMS value
Direction: rise / fall

Pre-buffer and post-buffer



Pre-post - buffer: 20 / 80 % of total buffer
Pre - buffer is treated as negative time

Fig. 15.5: Inrush triggering

15.7 EN 50160 Standard Overview

EN 50160 standard defines, describes and specifies the main characteristics of the voltage at a network user's supply terminals in public low voltage and medium voltage electricity distribution networks under normal operating conditions. This standard describes the limits or values within which the voltage characteristics can be expected to remain over the whole of the public distribution network and does not describe the average situation usually experienced by an individual network user.

15.7.1 Power frequency

The nominal frequency of the supply voltage shall be 50 Hz, for systems with synchronous connection to an interconnected system. Under normal operating conditions the mean value of the fundamental frequency measured over 10 s shall be within a range of:
50 Hz ± 1 % (i.e. 49,5 Hz... 50,5 Hz) during 99,5 % of a year;
50 Hz + 4 % / - 6 % (i.e. 47 Hz... 52 Hz) during 100 % of the time;

15.7.2 Supply voltage variations

Under normal operating conditions, during each period of one week 95 % of the 10 min mean r.m.s. values of the supply voltage shall be within the range of *U*n ± 10 %, and all 10 min mean r.m.s. values of the supply voltage shall be within the range of *U*n + 10 % / - 15 %.

15.7.3 Voltage dips (Inidcative values)

Under normal operating conditions the expected number of voltage dips in a year may be from up to a few tens to up to one thousand. The majority of voltage dips have a duration less than 1 s and a retained voltage greater than 40 %. However, voltage dips with greater depth and duration can occur infrequently. In some areas voltage dips with a retained voltage between 85 % and 90 % of U_n can occur very frequently as a result of the switching of loads in network users' installations.

15.7.4 Short interruptions of the supply voltage (Inidcative values)

Indicative values:
Under normal operating conditions the annual occurrence of short interruptions of the supply voltage ranges from up to a few tens to up to several hundreds. The duration of approximately 70 % of the short interruptions may be less than one second.

15.7.5 Supply voltage unbalance

Under normal operating conditions, during each period of one week, 95 % of the 10 min mean r.m.s. values of the negative phase sequence component (fundamental) of the supply voltage shall be within the range 0 % to 2 % of the positive phase sequence component (fundamental). In some areas with partly single phase or two phase connected network users' installations, unbalances up to about 3 % at three-phase supply terminals occur.

15.7.6 THD voltage

Under normal operating conditions, during each period of one week, 95 % of the 10 min mean THD values of the supply voltage (including all harmonics up to the order 40) shall be less than or equal to 8 %.

15.7.7 PowerQ+ voltage quality setting according to EN 50160

The measured parameters are processed and recorded as 1, 2, 5 and 10 minute time-segments/IPs (1008 IPs up to 16h48min, 33h36min, 3.5days and 7 days).
PowerQ+ directly support EN 50160. In order to use it, user should select EN 50160 type of logger in Voltage quality menu. User can set only interrupt threshold and integration period (IP) duration. In following table PowerQ+ limits are shown for EN 50160 voltage quality measurements.

Measured value	Limits for 95% of all measured values	Limits for all measured values (100%)
RMS Voltage Voltage THD Unbalance (SYM)	±10% ±8% ±2%	+10%/-15% ±8% ±2%
Measured value	*Limits for 99.5% of all measured values*	*Limits for all measured values (100%)*
Frequency	±1%	+4%/-6%
Event	*No. of events*	*Treshold*
Dip & Swell Interrupts	100 100	±10% Definable (1÷20%)

During measurement, after each IP, all parameters deviation are sorted and two statistical values are calculated: one representing maximum value of 95% of IP values, and other representing maximum value of the rest of IP data (>95% of IP values).
Events and interrupts are not included in mentioned calculation. Number of events is only concerned.

15.7.8 PowerQ+ voltage quality custom setting

By selecting **custom** in Voltage quality menu of PowerQ+, user can select it's ofn threshold values.
RMS deviation limits, dips and swell thresholds are defined with Treshold+ and Treshold- menu items. They can be set as a percentage of the nominal voltage, and can be between 1 % and 35 % over or under the nominal voltage (10% default).

Interruption can be set by Interrupt menu item, and can vary between 1 % and 20 % of the nominal voltage(5% default)).

Dips and swells are counted together per phase representing voltage "events".
Interruptions are counted separately per phase.

After each IP, frequency, THD and symmetry deviation are sorted and statistical values are calculated: only for of 95% of IP values, and other representing maximum value of the rest of IP data (>95% of IP values). Note that on bar graph 100% limit line is not drawn. Events and interrupts are not included in mentioned calculation. Number of events is only concerned.

Menu Item	Measured value	Limits for 95% of all measured values	
Treshold+ Treshold-	RMS Voltage variation	User definable: +1% ÷ +35% User definable: -1% ÷ -35%	
- -	Voltage THD Unbalance (SYM)	Fixed: ±8% Fixed: ±2%	
Menu Item	*Measured value*	*Limits for 99.5% of all measured values*	
-	Frequency	Fixed: ±1%	
Key	*Event*	*No. of events*	*Treshold*
Treshold+ Treshold-	Dip & Swell	Fixed:100	User definable: +1% ÷ +35% User Definable: -1% ÷ -35%
Interrupt	Interrupts	Fixed: 100	User Definable: 1÷20%

Dual data presentation is used (see section 0 for details):

- graphical (in logging and stop mode), using bar graph,
- tabular (only in stop mode), where all recorded data (except frequency and symmetry) are shown for desired IP per phase.

15.8 Voltage events

Voltage anomalies (swells, dips, interruptions) occur when a voltage falls out of boundaries. The RMS voltages of each half input cycle are used for comparison. High and low limits (threshold) are set as a percentage of the nominal voltage, and can be between 1 % and 35 % over or under the nominal voltage. Interruption can be set between 1 % and 20 % of the nominal voltage. For every voltage anomaly detected the instrument stores:

- Date and time when the anomaly started,
- Minimum or maximum voltage during the anomaly,
- Duration of the anomaly.

Voltage anomaly recording is enabled on selected voltage inputs.
Note that for voltage dip with swell (swell occurs during dip), **entry dip voltage** is recorded as minimal dip value.

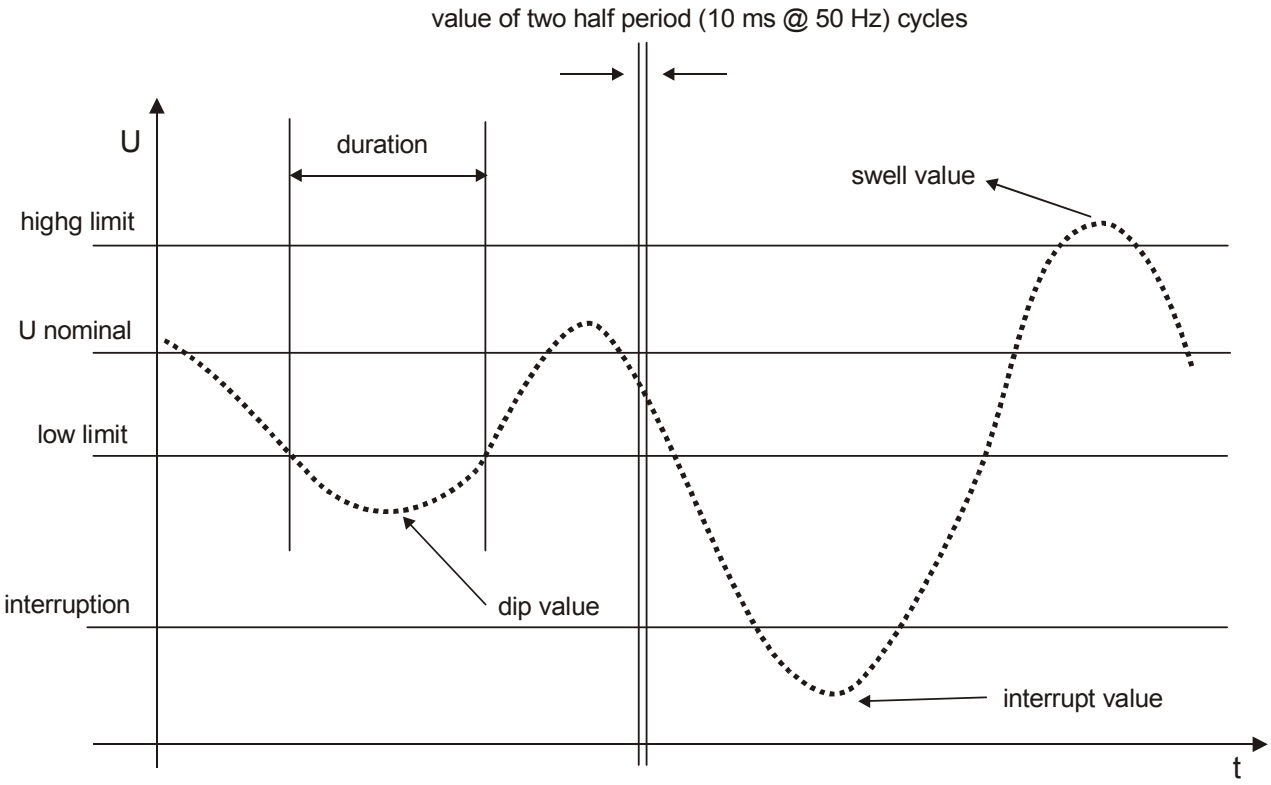


Fig. 15.6: Voltage events definition

15.9 Phase diagram

Phase diagram (U-I) is intended for vector – phase representation of voltages, and currents concerning the measuring system. It is primarily used for checking proper connection of measurement cables and current clamps.

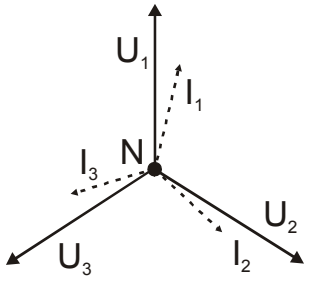


Fig. 15.7: 3 - phase diagram

Phase diagram (SYM) is intended for representation of current and voltage unbalance (symmetry) of the measuring system. It is defined using the method of symmetrical components (zero, positive and negative)

Supply voltage and current unbalance is defined as the ratio of the negative sequence component to the positive sequence component.

$$Usym = \frac{|U-|}{|U+|} \cdot 100\,\% = \frac{negative\ sequence}{postive\ sequence} \cdot 100\,\%$$

$$Isym = \frac{|I-|}{|I+|} \cdot 100\,\% = \frac{negative\ sequence}{postive\ sequence} \cdot 100\,\%$$

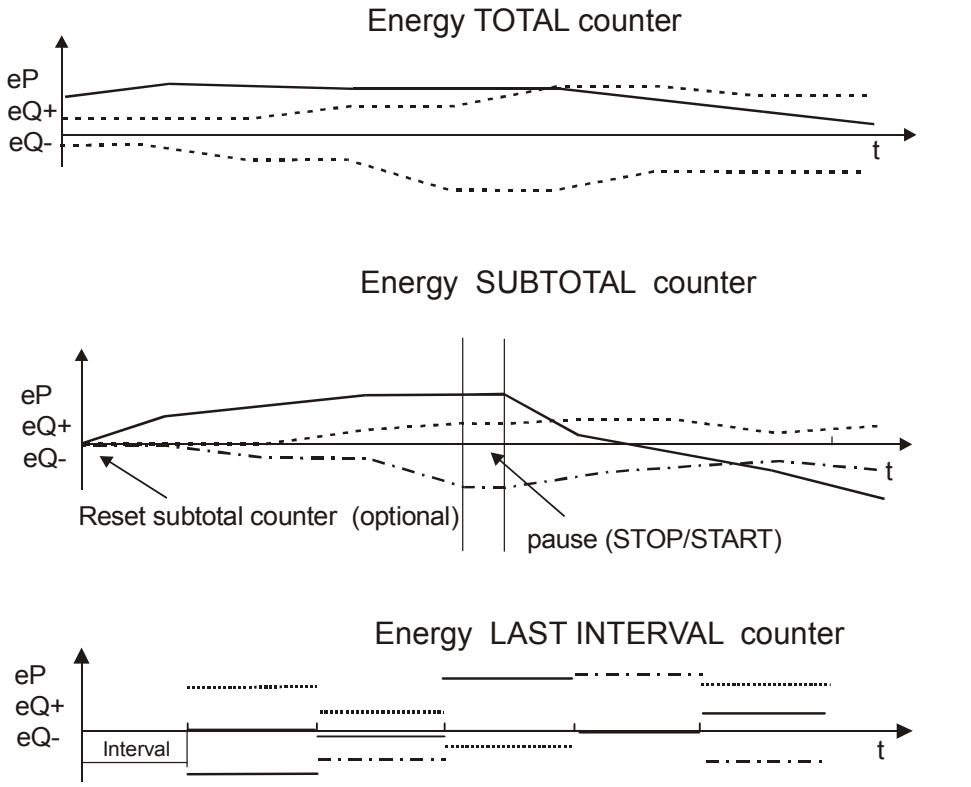
15.10 Energy

Energy logger contains three different counters for active and reactive energy. Total counter is intended for measuring energy over a wide time range. When the energy logging starts it sums the energy to existent state of the counters. They can be cleared only in the SETUP menu.

Subtotal counter is intended for measuring energy over a shorter time ranges. It can be cleared or not when the logger starts.

Last integration period (IP) counter measures energy over preset interval, which can be set from 1 to 15 minutes. It is reset at each start of the logging.

The logging can be interrupted with the *STOP* button and then continued with the *START* button.



Last interval counter always starts from zero and it is reset after each interval.
Interval can be set from 1 to 15 min.

eP - active energy
eQ+ - positive reactive energy
eQ- - negative reactive energy

Fig. 15.8: Energy counters measurements

16 PowerView PC Software

Metrel PowerView is a powerful tool for downloading, analyzing and printing recorded data for Metrel PowerQ, PowerQ+ and PowerQ4 family of instruments. Through a simple but powerful interface, PowerView helps you find your data quickly, while allowing you to easily make complex analysis and data comparison.

To get more information regarding PowerView PC SW operation, please read the instruction manual for PowerView which is included in the standard set of the instrument.