PowerQ4

MI 2592

Instruction manual

Version 1.2, Code No. 20 751 551

METREL®

Distributor:

Manufacturer:

METREL d.d.
Ljubljanska cesta 77
1354 Horjul
Slovenia

web site: http://www.metrel.si
e-mail: metrel@metrel.si

Mark on your equipment certifies that this equipment meets the requirements of the EU (European Union) concerning safety and interference causing equipment regulations

© 2009 METREL

No part of this publication may be reproduced or utilized in any form or by any means without permission in writing from METREL.

Table of Contents:

1 Introduction

PowerQ4 is handheld multifunction instrument for power quality analysis and energy efficiency measurements.

Figure 1.1: Instrument PowerQ4

1.1 Main Features

- 4 voltage channels with wide measurement range: 0 ÷ 1000 Vrms, CAT III/1000V
- 4 current channels with support for automatic clamp recognition and "on instrument" range selection[1]
- Compliance with power quality standard IEC 61000-4-30 Class S. Predefined recorder profile for EN 50160 survey.
- Power measurements compliance with IEC 61557-12 and IEEE 1448.
- Simultaneous 8 channels - 16bit AD conversion for accurate power measurements (minimal phase shift error).
- Simple to use and powerful recorder with 8MB of memory and possibility to record 509 different power quality signatures.
- Voltage events and user defined alarms capture
- 15 hour of autonomous (battery) supply.

[1] only with Metrel »Smart clamps«

- **PowerView** is a companion PC Software which provides easiest way to download, view and analyze measured data or print.
  - PowerView analyzer exposes a simple but powerful interface for downloading instrument data and getting quick, intuitive and descriptive analysis. Interface has been organized to allow quick selection of data using a Windows Explorer-like tree view.
  - User can easily download recorded data, and organize it into multiple sites with many sub-sites or locations.
  - Generate charts, tables and graphs for your power quality data analyzing, and create professional printed reports
  - Export or copy/paste data to other applications (e.g. spreadsheet) for further analysis
  - Multiple data records can be displayed and analyzed simultaneously. Merge different logging data into one measurement, synchronize data recorded with different instruments with time offsets, split logging data into multiple measurements, or extract data of interest.

1.2 Safety considerations

To ensure operator safety while using the PowerQ4 instrument 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.

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 1000 V_{RMS}. Maximum voltage between phases is 1730 V_{RMS}.

Always short unused voltage inputs (L1, L2, L3) with neutral (N) input to prevent

measurement errors and false event triggering due to noise coupling.

1.3 Applicable standards

The PowerQ4 series of instruments are designed and tested in accordance with the following standards:

Electromagnetic compatibility(EMC)	
EN 61326-2-2: 2007	Electrical equipment for measurement, control and laboratory use. • Emission: Class A equipment (for industrial purposes) • Immunity for equipment intended for use in industrial locations
Safety (LVD)	
EN 61010-1 : 2001	Safety requirements for electrical equipment for measurement, control and laboratory use
Measurements methods	
IEC 61000-4-30 : 2008 Class S	Testing and measurement techniques – Power quality measurement methods
IEC 61557-12 : 2007	Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD)
IEC 61000-4-7: 2002 Class II	General guide on harmonics and interharmonics measurements and instrumentation
IEC 61000-4-15 : 1997	Flickermeter – Functional and design specifications
EN 50160 : 2007	Voltage characteristics of electricity supplied by public distribution networks

Note about EN and IEC standards:

Text of this manual contains references to European standards. All standards of EN 6XXXX (e.g. EN 61010) series are equivalent to IEC standards with the same number (e.g. IEC 61010) and differ only in amended parts required by European harmonization procedure.

1.4 Abbreviations

In this document following symbols and abbreviations are used:

Cf_I Current crest factor, including Cf_{Ip} (phase p current crest factor) and Cf_{IN} (neutral current crest factor). See 5.1.3 for definition.

Cf_U Voltage crest factor, including Cf_{Upg} (phase p to phase g voltage crest factor) and Cf_{Up} (phase p to neutral voltage crest factor). See 5.1.2 for definition.

$Cos\varphi$, DPF Displacement factor including $Cos\varphi_p$ / DPF_p (phase p displacement factor). See 5.1.5 and 5.1.6 for definition.

eP^+, eP^- Active energy including eP_p (phase p energy) and eP_{tot} (total energy).

Minus sign indicates generated energy and plus sign, indicate consumed energy. See 5.1.7 for definition.

eQ^{i+}, eQ^{c+}, eQ^{i-}, eQ^{c-} — Reactive energy including eQ_p (phase p energy) and eP_{tot} (total energy). Minus sign indicates generated energy and plus sign, indicate consumed energy. Inductive reactive energy character is marked with "i" and capacitive reactive energy character is marked with "c". See 5.1.7 for definition.

eS^+, eS^- — Apparent power. See 5.1.7 for definition.

f, freq — Frequency, including $freq_{U12}$ (voltage frequency on U_{12}), $freq_{U1}$ (voltage frequency on U_1 and $freq_{I1}$ (current frequency on I_1). See 5.1.4 for definition.

i^- — Negative sequence current ratio (%). See 5.1.10 for definition.

i^0 — Zero sequence current ratio (%). See 5.1.10 for definition.

I^+ — Positive sequence current component on three phase systems. See 5.1.10 for definition.

I^- — Negative sequence current component on three phase systems. See 5.1.10 for definition.

I^0 — Zero sequence current components on three phase systems. See 5.1.10 for definition.

$I_{½Rms}$ — RMS current measured over each half period , including $I_{p½Rms}$ (phase p current), $I_{N½Rms}$ (neutral RMS current)

I_{Fnd} — Fundamental RMS current Ih_1 (on 1st harmonics), including I_{pFmd} (phase p fundamental RMS current) and I_{NFmd} (neutral RMS fundamental current). See 5.1.8 for definition

Ih_n — n^{th} current RMS harmonic component including I_ph_n (phase p n^{th} RMS current harmonic component) and I_Nh_n (neutral n^{th} RMS current harmonic component). See 5.1.8 for definition

I_{Nom} — Nominal current. Current of clamp-on current sensor for 1Vrms at output

I_{Pk} — Peak current, including I_{pPk} (phase p current) including I_{NPk} (neutral peak current)

I_{Rms} — RMS current, including I_{pRms} (phase p current), I_{NRms} (neutral RMS current). See 5.1.3 for definition.

$\pm P$, P^+, P^- — Active power including P_p (phase p active power) and P_{tot} (total active power). Minus sign indicates generated power and plus / no sign, indicate consumed energy. See 5.1.5 and 5.1.6 for definition.

p, pg — Indices. Annotation for parameter on phase p: [1, 2, 3] or phase-to-phase pg: [12, 23, 31]

PF, PF^{i+}, PF^{c+}, PF^{i-}, PF^{c-} — Power factor including PF_p (phase p power factor vector) and P_{tot} (total power factor vector). Minus sign indicates generated power and plus sign, indicate consumed power. Inductive power factor character is marked with "i" and capacitive power factor character is marked with "c".

Note: PF = Cos φ when no harmonics are present. See 5.1.5 and 5.1.6 for definition.

P_{lt} — Long term flicker (2 hours) including P_{ltpg} (phase p to phase g long term voltage flicker) and P_{ltp} (phase p to neutral long term voltage flicker). See 5.1.9 for definition.

P_{st} — Short term flicker (10 minutes) including P_{stpg} (phase p to phase g short term voltage flicker) and P_{stp} (phase p to neutral voltage flicker). See 5.1.9 for definition.

P_{st1min} — Short term flicker (1 minutes) including $P_{st1minpg}$ (phase p to phase g short term voltage flicker) and $P_{st1minp}$ (phase p to neutral voltage flicker). See 5.1.9 for definition.

$\pm Q$, Q^{i+}, Q^{c+}, Q^{i-}, Q^{c-} — Reactive power including Q_p (phase p reactive power) and Q_{tot} (total reactive power). Minus sign indicates generated power and plus sign, indicate consumed power. Inductive reactive character is marked with "i" and capacitive reactive character is marked with "c". See 5.1.5 and 5.1.6 for definition.

S, S^+, S^- — Apparent power including S_p (phase p active power) and S_{tot} (total apparent power). See 5.1.5 and 5.1.6 for definition. Minus sign indicates apparent power during generation and plus sign indicate apparent power during consumption. See 5.1.5 and 5.1.6 for definition.

THD_I — total harmonic distortion current related to fundamental, including THD_{Ip} (phase p current THD) and THD_{IN} (neutral current THD). See 5.1.8 for definition

THD_U — total harmonic distortion voltage related to fundamental, including THD_{Upg} (phase p to phase g voltage THD) and THD_{Up} (phase p to neutral voltage THD). See 5.1.10 for definition.

u^- — Negative sequence voltage ratio (%). See 5.1.10 for definition.

u^0 — Zero sequence voltage ratio (%). See 5.1.10 for definition.

U, U_{Rms} — RMS voltage, including U_{pg} (phase p to phase g voltage) and U_p (phase p to neutral). See 5.1.2 for definition.

U^+ — Positive sequence voltage component on three phase systems. See 5.1.10 for definition.

U^- — Negative sequence voltage component on three phase systems. See 5.1.10 for definition.

U^0 — Zero sequence voltage component on three phase systems. See 5.1.10 for definition.

U_{Dip} — Minimal $U_{Rms(1/2)}$ voltage measured during dip occurrence

U_{Fnd} — Fundamental RMS voltage (Uh_1 on 1st harmonics), including U_{pgFnd} (phase p to phase g fundamental voltage) and U_{pFmd} (phase p to neutral fundamental voltage). See 5.1.8 for definition

Uh_N — nth voltage RMS harmonic component including $U_{pg}h_N$ (phase p to phase g voltage nth RMS harmonic component) and U_ph_N (phase p to neutral voltage nth RMS harmonic component). See 5.1.8 for definition.

U_{Int} — Minimal $U_{Rms(1/2)}$ voltage measured during interrupt occurrence

U_{Nom} — Nominal voltage, normally a voltage by which network is designated or

	identified
U_{Pk}	Peak voltage, including U_{pgPk} (phase p to phase g voltage) and U_{pPk} (phase p to neutral voltage)
$U_{Rms(1/2)}$	RMS voltage refreshed each half-cycle, including $U_{pgRms(1/2)}$ (phase p to phase g half-cycle voltage) and $U_{pRms(1/2)}$ (phase p to neutral half-cycle voltage) See 5.1.11 for definition.
U_{Swell}	Swell $U_{Rms(1/2)}$ voltage measured during swell occurrence

2 Description

2.1 Front panel

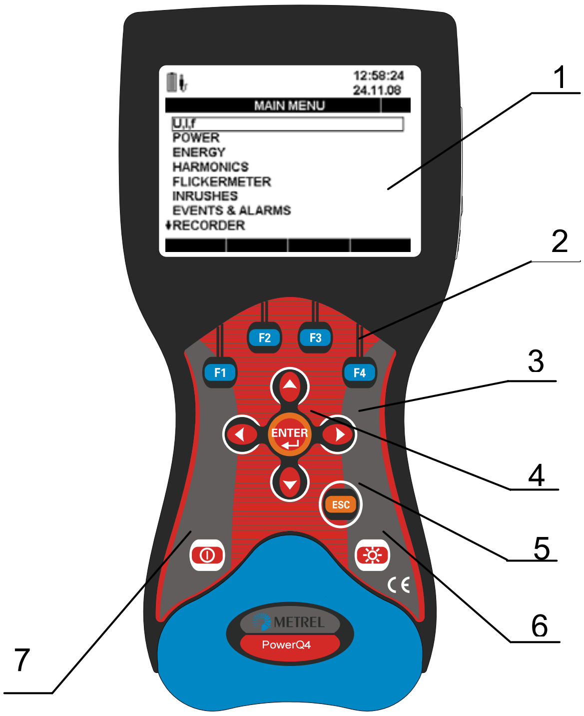


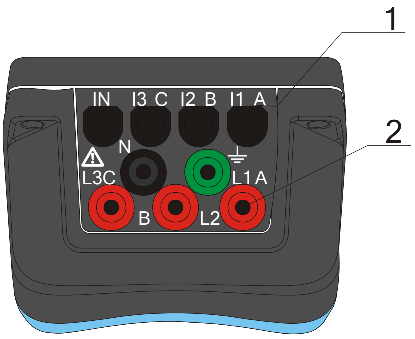
Figure 2.1: Front panel

Front panel layout:

1. LCD	Graphic display with LED backlight, 320 x 200 pixels.
2. F1 – F4	Function keys.
3. ARROW keys	Move cursor and select parameters.
4. ENTER key	Confirms new settings, step into submenu
5. ESC key	Exits any procedure, exit from submenu
6. LIGHT key	LCD backlight on/off (backlight automatically turns off after 15 minutes 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.

7. ON-OFF key Turns on/off the instrument.

2.2 Connector panel



Warning!

- Use safety test leads only!
- Max. permissible voltage between voltage input terminals and ground is 1000 V_{RMS} !

Figure 2.2: Top connector panel

Top connector panel layout:

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

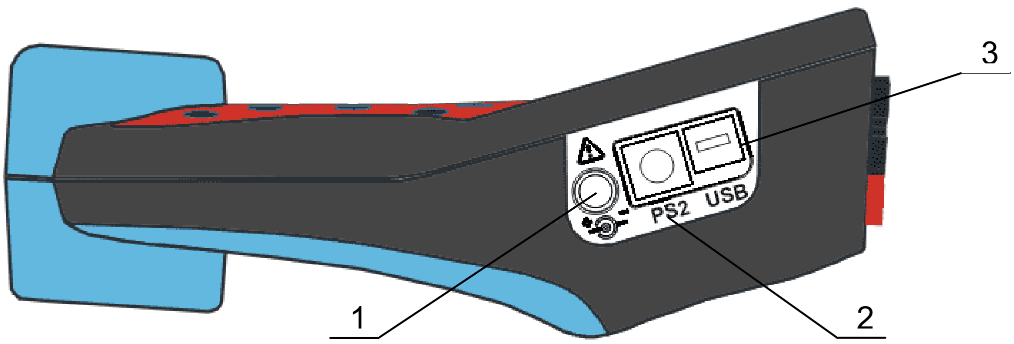


Figure 2.3: Side connector panel

Side connector panel layout:

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

2.3 Bottom view

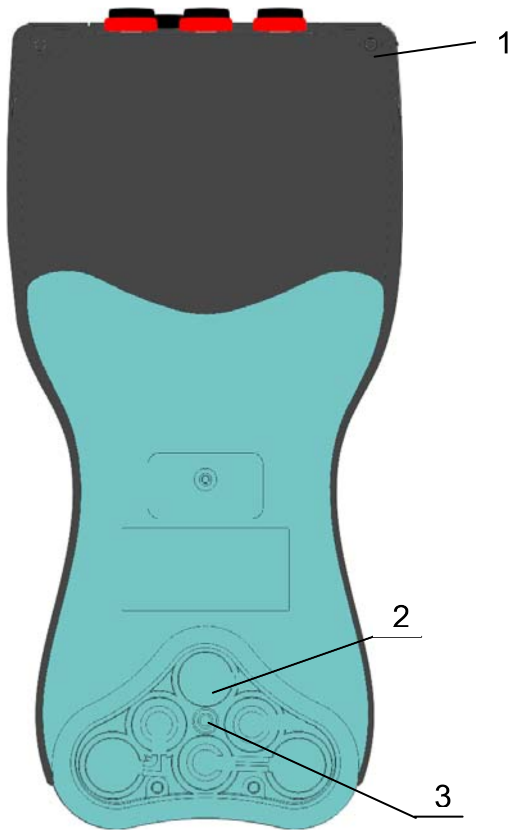


Figure 2.4: Bottom view

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

Table 2.1: PowerQ4 standard accessories

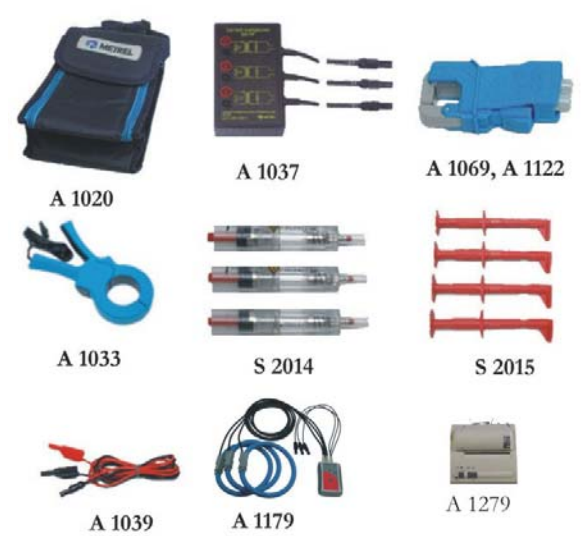
Description	Peaces
3000/300/30A Flexible current clamps A1227	4
Test tips – red	3
Test tip – black	1
Crocodile tips – red	3
Crocodile tip – black	1
Crocodile tip – green	1
Voltage measurement cables - red	3
Voltage measurement cables - black	1
Voltage measurement cables - green	1

USB cable	1
RS-232 cable	1
12V/1.2A Power supply adapter	1
Rechargeable batteries, 6 pcs.	6
Soft carrying bag	1
PowerQ4 Instruction manual	1
Compact disk contest	
• PC software PowerView with instruction manual	
• PowerQ4 Instruction manual	
• Handbook ”Modern Power Quality Measurement Techniques”	

2.4.2 Optional accessories

Table 2.2: PowerQ4 optional accessories

Ord. code	**Description**
A 1020	Small soft carrying bag
A 1033	Current clamp 1000A/1V
A 1037	Current transformer 5A/1V
A 1039	Clamp adapter
A 1069	Mini clamp 100A /1 V
A 1122	Mini clamp 5A /1 V
A 1179	3 - phase 2000 / 200 / 20 A current clamp
S 2014	Safety fuse adapters
S 2015	Safety flat clamps
A 1279	Printer DPU 414*
A 1280	Mini clamp 200mA/5A/100A*
A 1281	Current clamp 5A/100A/1000A*



* Available in Q2 2010

3 Operating the instrument

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. Basic display symbols and keys description is shown on figure bellow.

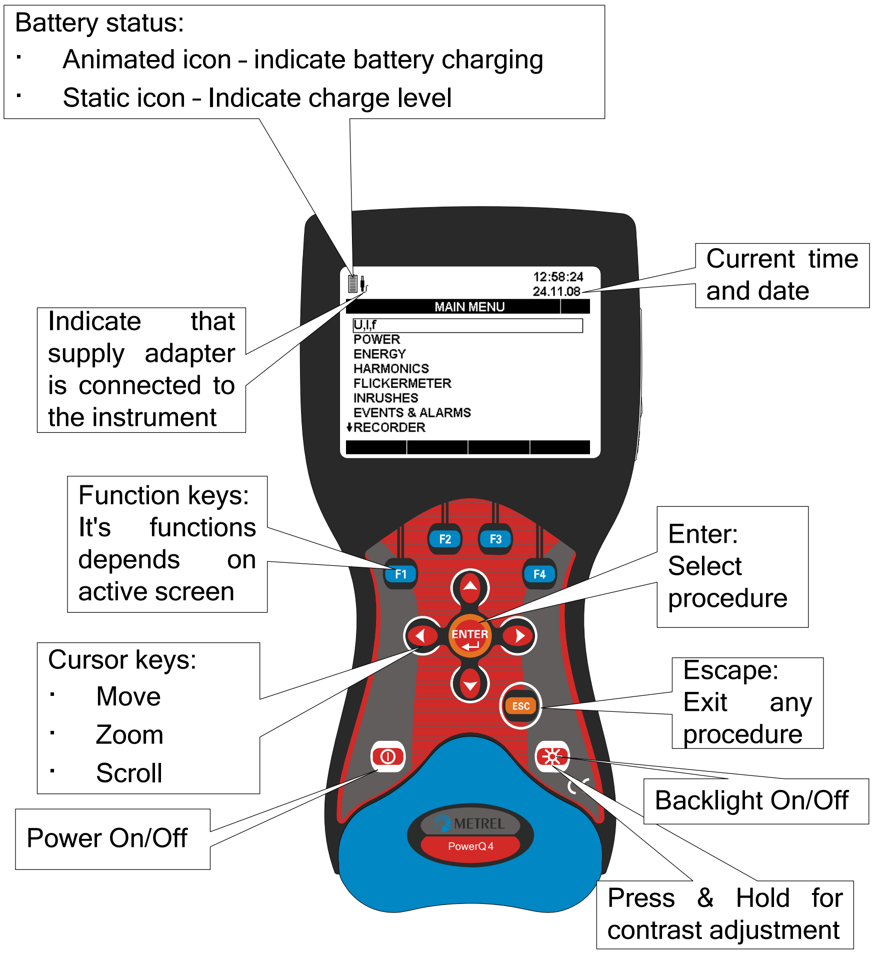


Figure 3.1: Display symbols and keys description

During measurement campaign various screens can be displayed. Most screens share common labels and symbols. These are shown on figure bellow.

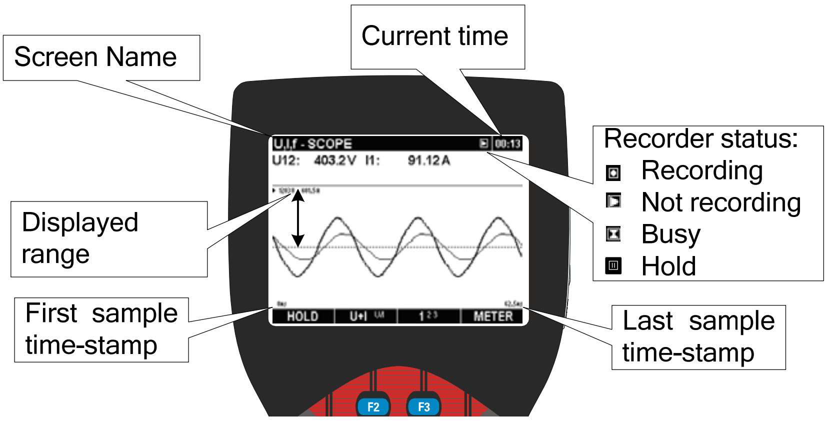


Figure 3.2: Common display symbols and labels during measurement campaign

3.1 Instrument Main Menu

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

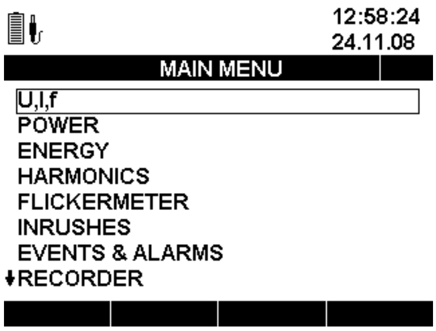


Figure 3.3: "MAIN MENU"

Table 3.1: Instrument screen symbols and abbreviations

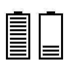
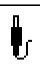
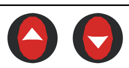
	Battery status • Animated icon – indicate battery charging • Static icon – Indicate charge level
	Indicate that charger is connected to the instrument
12:58:24 24.11.08	Current time and date

Table 3.2: Keys function

	Select function from the "MAIN MENU".
	Enter selected function.

3.2 U, I, f menu

All important voltage, current and frequency parameters can be observed in the “U, I, f” menu. Measurements results can be viewed in a tabular (METER) or a graphical form (SCOPE, TREND). TREND view is active only in RECORDING mode. See section 3.10 for details.

3.2.1 Meter

By entering U, I, f menu, the U, I, f – METER tabular screen is shown *(see figure below)*.

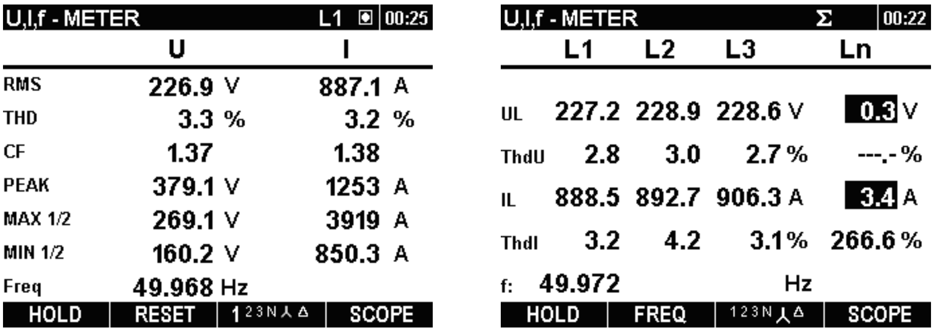


Figure 3.4: U, I, f meter table screens.

In those screens current on-line voltage and current measurements are shown. Descriptions of symbol and abbreviations used in this menu are shown in table bellow.

Table 3.3: Instrument screen symbols and abbreviations

L1 L2 L3 N ⅄ Δ	Show currently displayed channel.
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
RMS	True effective value U_{Rms} and I_{Rms}
THD	Total harmonic distortion THD_U and THD_I
CF	Crest factor Cf_U and Cf_I
PEAK	Peak value U_{Pk} and I_{Pk}
MAX 1/2	Maximal $U_{Rms(1/2)}$ voltage and maximal $I_{½Rms}$ current, measured after RESET (key: F2)
MIN ½	Minimal $U_{Rms(1/2)}$ voltage and minimal $I_{½Rms}$ current, measured after RESET (key: F2)
f	Frequency on reference channel

Note: In case of AD converter overloading current and voltage value will be displayed with inverted color 250.4 V.

Table 3.4: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F2	RESET	Reset MAX ½ and MIN ½ values ($U_{Rms(1/2)}$ and $I_{½Rms}$)
	f	Show frequency trend (available only during recording)
F3	**1** 2 3 N ⅄ Δ	Show measurements for phase L1
	1 **2** 3 N ⅄ Δ	Show measurements for phase L2
	1 2 **3** N ⅄ Δ	Show measurements for phase L3
	1 2 3 **N** ⅄ Δ	Show measurements for phase LN
	1 2 3 N **⅄** Δ	Summary of all phases measurements
	1 2 3 N ⅄ **Δ**	Show phase-to-phase voltages measurements
F4	METER	Switch to METER view.
	SCOPE	Switch to SCOPE view
	TREND	Switch to TREND view (available only during recording)
ESC		Return to the “MAIN MENU” screen.

3.2.2 Scope

Various combinations of voltage and current waveforms are displayed.

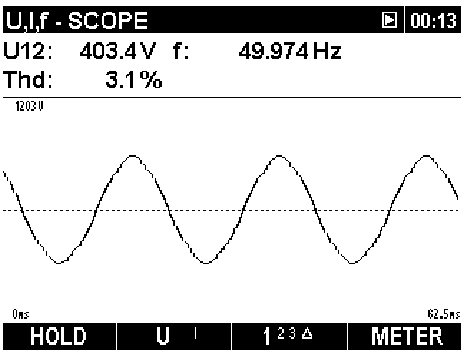


Figure 3.5: Voltage waveform

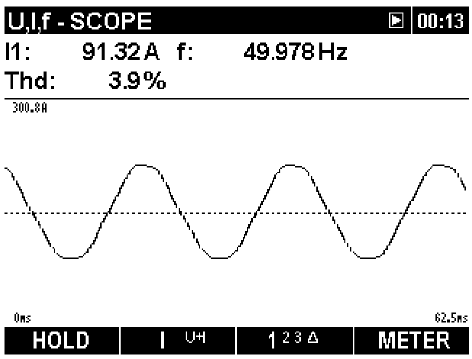


Figure 3.6: Current waveform

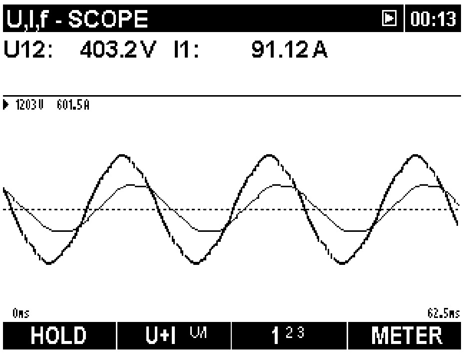


Figure 3.7: Voltage and current waveform (single mode)

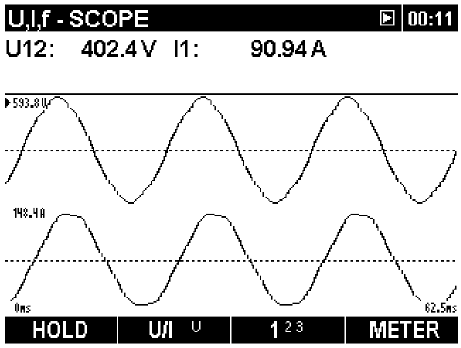


Figure 3.8: Voltage and current waveform (dual mode)

Table 3.5: Instrument screen symbols and abbreviations

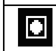
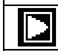
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
Up p: [1..3, N]	True effective value of phase voltage: U_{1Rms}, U_{2Rms}, U_{3Rms}, U_{NRms}
Upg pg:[12,23,31]	True effective value of phase-to-phase (line) voltage: U_{12Rms}, U_{23Rms}, U_{31Rms}
Ip p: [1..3, N]	True effective value of current: I_{1Rms}, I_{2Rms}, I_{3Rms}, I_{NRms}
Thd	Total harmonic distortion for displayed quantity (THD_U or THD_I)
F	Frequency on reference channel

Table 3.6: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F2		Select which waveforms to show:
	U I	Show voltage waveform
	I U+I	Show current waveform
	U+I U/I	Show voltage and current waveform (single mode)
	U/I U	Show voltage and current waveform (dual mode)
F3		Select between phase, neutral, all-phases and line view:
	1 2 3 N ⅄	Show waveforms for phase L1

	1 2 3 N ⅄	Show waveforms for phase L2
	1 2 3 N ⅄	Show waveforms for phase L3
	1 2 3 N ⅄	Show waveforms for phase LN
	1 2 3 N ⅄	Summary of all phases waveforms
F4	METER	Switch to METER view.
	SCOPE	Switch to SCOPE view
	TREND	Switch to TREND view (available only during recording)
ENTER	Select which waveform to zoom (only in U/I or U+I)	
▲ ▼	Set vertical zoom	
◄ ►	Set horizontal zoom	
ESC	Return to “MAIN MENU” screen	

3.2.3 Trend

While RECORDER is active, TREND view is available (see section 3.10 for instructions how to start recorder)..

Voltage and current trends

Current and voltage trends are observed by cycling function key F4 (METER-SCOPE-TREND).

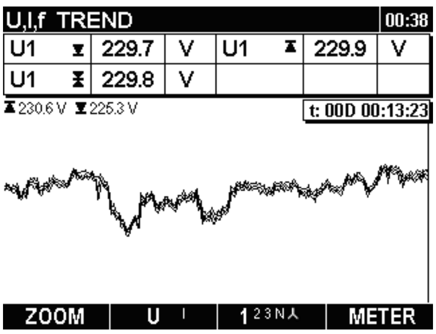


Figure 3.9: Voltage trend

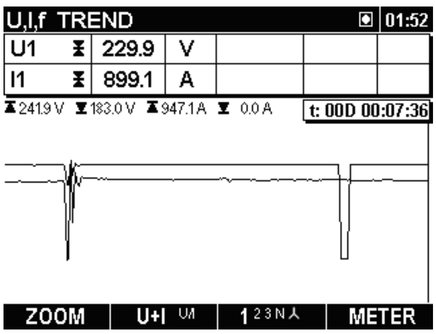


Figure 3.10: Voltage and current trend (single mode)

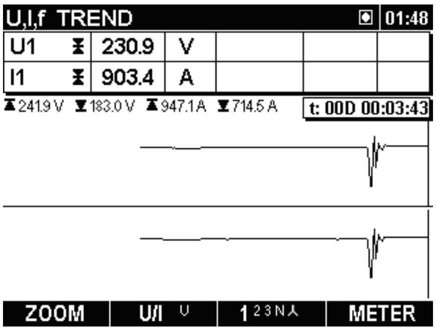


Figure 3.11: Voltage and current trend (dual mode)

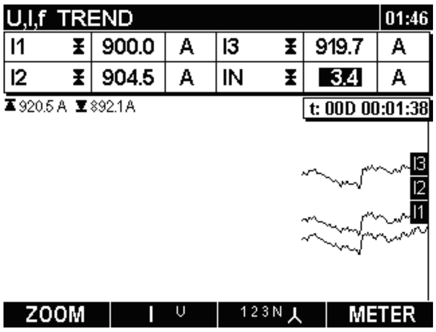


Figure 3.12: Trends of all current

Figure 3.13: Different combinations of voltage and current trends.

Table 3.7: Instrument screen symbols and abbreviations

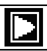
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory).
	RECORDER is not active
20:45	Current instrument time
Up, Upg p: [1..3; N]	Maximal (▲), average (⧗) and minimal (▼) value of phase voltage U_{pRms} or line voltage U_{pgRms} for last recorded time interval (IP)
Ip p: [1..3, N]	Maximal (▲), average (⧗) and minimal (▼) value of current I_{pRms} for last recorded time interval (IP)
t: 00D 00:13:23	Current RECORDER time
▲230.6 V ▼225.3 V ▲947.1 A ▼ 0.0 A	Maximal and minimal recorded voltage Maximal and minimal recorded current

Table 3.8: Keys function

F1	ZOOM-+ ZOOM+-	Zoom in Zoom out
F2	 U I I U+I U+I U/I U/I U	Select between the following options: Show voltage trend Show current trend Show voltage and current trend (single mode) Show voltage and current trend (dual mode)
F3	 1 2 3 N ⅄ 1 2 3 N ⅄	Select between phase, neutral, all-phases and view: Show trend for phase L1 Show trend for phase L2

	123N	Show trend for phase L3
	123N	Show trend for phase LN
	123N	Summary of all phases trends
F4	METER	Switch to METER view.
	SCOPE	Switch to SCOPE view
	TREND	Switch to TREND view
ENTER	Select which waveform to zoom (only in U/I or U+I)	
ESC	Return to "MAIN MENU" screen.	

Frequency trend

Frequency trend can be seen from METER screen by pressing function key F2.

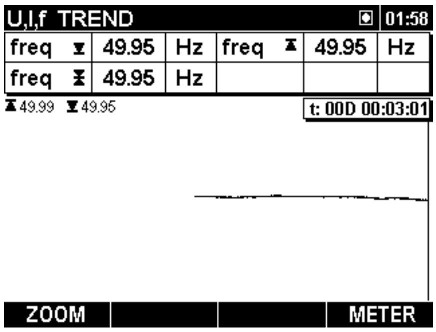


Figure 3.14: U, I, f frequency trend screen.

Table 3.9: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
f	Maximal ( ), average ( ) and minimal ( ) value of frequency at synchronization channel for last recorded time interval (IP)
t: 00D 00:13:23	Current RECORDER time
49.99 49.95	Maximal and minimal frequency on displayed graph

Table 3.10: Keys function

F1	ZOOM-+ ZOOM+-	Zoom in Zoom out
F4	METER	Return to METER view.
▲ ▼	Set vertical zoom.	
◄ ►	Set horizontal zoom.	
ESC	Return to "MAIN MENU" screen.	

3.3 Power menu

In POWER menu instrument show measured power parameters. Results can be seen in a tabular (METER) or a graphical form (TREND). TREND view is active only while RECORDER is active. See section 3.10 for instructions how to start recorder. In order to fully understand meanings of particular power parameter see sections 5.1.5 and 5.1.6.

3.3.1 Meter

By entering Power menu from MAIN MENU the POWER – METER tabular screen is shown *(see figure below)*. METER screen show power, voltage and current signatures.

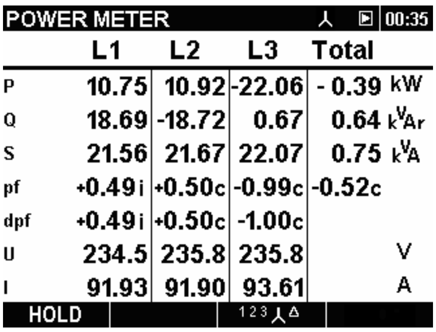


Figure 3.15: Power measurements summary

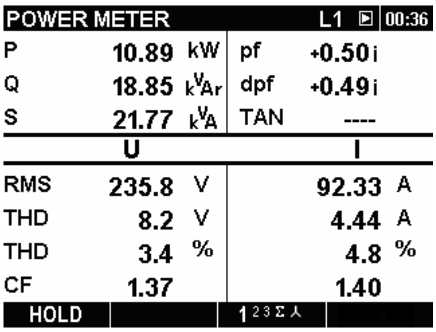


Figure 3.16: Detailed Power measurements at phase L1

Description of symbols and abbreviations used in METER screens are shown in table bellow.

Table 3.11: Instrument screen symbols and abbreviations

L1 L2 L3 ⅄ Δ	Show currently displayed channel.
	Current recorder status
⊡	RECORDER is active
⧗	RECORDER is busy (retrieving data from memory)

	RECORDER is not active
20:45	Current instrument time
P, Q, S	Instantaneous active (P), reactive(Q) and apparent (S) power
PF, DPF	Instantaneous power factor (PF) and displacement power factor (cos φ)
U	True effective value U_{Rms}
I	True effective value I_{Rms}
RMS	True effective value U_{Rms} and I_{Rms}
THD	Total harmonic distortion THD_U and THD_I
CF	Crest factor Cf_U and Cf_I

Table 3.12: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F1	HOLD	Toggle between HOLD (the results are frozen on the display) and SAVE (save the frozen results).
F3		Select between phase, neutral, all-phases and line view:
	1 2 3 人 Δ	Show measurements for phase L1
	1 2 3 人 Δ	Show measurements for phase L2
	1 2 3 人 Δ	Show measurements for phase L3
	1 2 3 人 Δ	Summary of all phases measurements
	1 2 3 人 Δ	Show phase-to-phase voltages measurements
F4	METER	Switch to METER view (available only during recording)
	TREND	Switch to TREND view (available only during recording)
ESC		Return to the MAIN MENU screen.

3.3.2 Trend

During active recording TREND view is available (see section 3.10 for instructions how to start RECORDER).

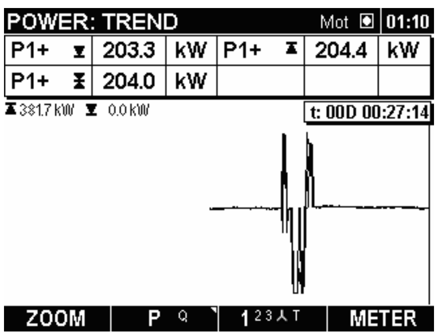


Figure 3.17: Power trend screen.

Table 3.13: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
	Show selected power mode:
Mot	Consumed power data(+) are shown
Gen	Generated power data (-) are shown
20:45	Current instrument time
Pp±, Pt± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of consumed (P_1^+, P_2^+, P_3^+, P_{tot}^+) or generated (P_1^-, P_2^-, P_3^-, P_{tot}^-) active power for last recorded time interval (IP)
Qip±, Qit± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of consumed (Q_{i1}^+, Q_{i2}^+, Q_{i3}^+, Q_{itot}^+) or generated (Q_{i1}^-, Q_{i2}^-, Q_{i3}^-, Q_{itot}^-) reactive inductive power ($Q_{i1}^\pm$, $Q_{i2}^\pm$, $Q_{i3}^\pm$, $Q_{itot}^\pm$) for last recorded time interval (IP)
Qcp±, Qct± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of consumed (Q_{c1}^+, Q_{c2}^+, Q_{c3}^+, Q_{ctot}^+) or generated (Q_{c1}^-, Q_{c2}^-, Q_{c3}^-, Q_{ctot}^-) reactive capacitive power ($Q_{c1}^\pm$, $Q_{c2}^\pm$, $Q_{c3}^\pm$, $Q_{ctot}^\pm$) for last recorded time interval (IP)
Sp±, St± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of consumed apparent power (S_1^+, S_2^+, S_3^+, S_{tot}^+) or generated apparent power (S_1^-, S_2^-, S_3^-, S_{tot}^-) for last recorded time interval (IP)
PFip±, PFit± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of inductive power factor (1st quadrant: PF_{i1}^+, PF_{i2}^+, PF_{i3}^+, PF_{itot}^+ and 3rd quadrant: PF_{i1}^-, PF_{i2}^-, PF_{i3}^-, PF_{itot}^-) for last recorded time interval (IP)
PFcp±, PFt± p: [1..3]	Maximal (▲), average (⧗) and minimal (▼) value of capacitive power factor (4th quadrant: PF_{c1}^+, PF_{c2}^+, PF_{c3}^+, PF_{ctot}^+ and 2nd quadrant: PF_{c1}^-, PF_{c2}^-, PF_{c3}^-, PF_{ctot}^-) for last recorded time interval (IP)
t: 00D 00:13:23	Current RECORDER time
▲ 331.7 kW ▼ 0.0 kW	Maximal and minimal recorded quantity

Table 3.14: Keys function

F1	ZOOM-+ Zoom in ZOOM+- Zoom out
F2 Press & Hold	Select between consumed or generated power view: Measurement source type Motor | Generator

F2		Select between trending various parameters:
	P Qi	Active power
	Qi Qc	Reactive inductive power
	Qc S	Reactive capacitive power
	S PFi	Apparent power
	PFi PFc	Inductive power factor
	PFc DPFi	Capacitive power factor
	DPFi DPFc	Inductive displacement factor (cos φ)
	DPFc P	Capacitive displacement factor (cos φ)
F3		Select between single phase, all-phases and total trend graph
	1 2 3 人 T	Power parameters for phase L1
	1 2 3 人 T	Power parameters for phase L2
	1 2 3 人 T	Power parameters for phase L3
	1 2 3 人 T	Power parameters summary for all phases and totals
	1 2 3 人 T	Power parameters for delta wired loads (3W)
F4	METER	Switch to METER view (available only during recording)
	TREND	Switch to TREND view (available only during recording)
ESC	Return to “MAIN MENU” screen.	

3.4 Energy menu

In energy menu instrument show status of energy counters. Results can be seen in a tabular (METER) form. For representing data in graph (TREND) form, download data to PC and use PowerView. Energy measurement is active only if RECORDER is active, too. See section 3.10 for instructions how to start RECORDER. In order to fully understand meanings of particular energy parameter see section 5.1.7. The meter screen is shown on figure bellow.

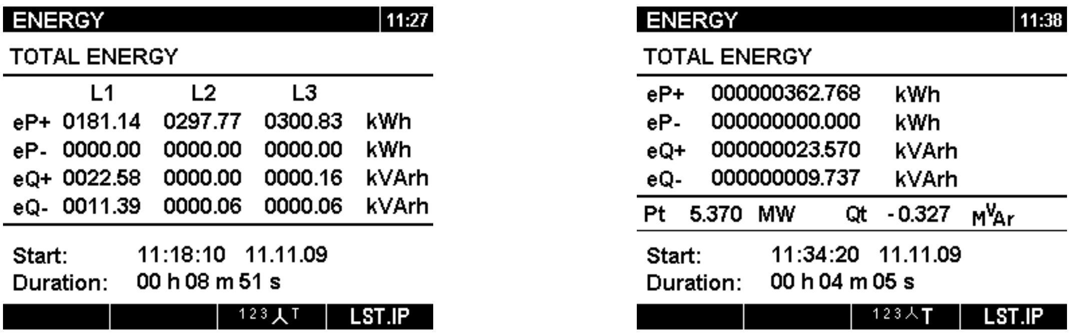


Figure 3.18: Energy counters screen.

Table 3.15: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
eP+	Consumed phase (eP_1^+, eP_2^+, eP_3^+) or total (eP_{tot}^+) active energy
eP-	Generated phase (eP_1^-, eP_2^-, eP_3^-) or total (eP_{tot}^-) active energy
eQ+	Consumed phase (eQ_1^+, eQ_2^+, eQ_3^+) or total (eQ_{tot}^+) reactive energy **Note:** eQ+ is two quadrant measurements. For separate measurements (eQ_i^+, eQ_c^-) download data to PC and use PowerView in order to observe results.
eQ-	Generated phase (eQ_1^-, eQ_2^-, eQ_3^-) or total (eQ_{tot}^-) reactive energy **Note:** eQ- is two quadrant measurements. For four quadrant measurement (eQ_i^-, eQ_c^+) download data to PC and use PowerView in order to observe results.
Pp, Pt p: [1..3]	Instantaneous phase active power (P_1, P_2, P_3) or total P_{tot} active power
Qp, Qt p: [1..3]	Instantaneous reactive power (Q_1, Q_2, Q_3, Q_{tot}) or total Q_{tot} reactive power
Start	Recorder start time
Duration	Current RECORDER time

Table 3.16: Keys function

F3		Select between single phase and total energy meter
	1 2 3 ⅄ T	Energy parameters for phase L1
	1 **2** 3 ⅄ T	Energy parameters for phase L2
	1 2 **3** ⅄ T	Energy parameters for phase L3
	1 2 3 **⅄** T	Summary for all phases energy
	1 2 3 ⅄ **T**	Energy parameters for Totals
F4	Toggle between time interval:	
	LST.IP	Show energy registers for last interval
	CUR.IP	Show energy registers for current interval
	TOT EN	Show energy registers for whole record
ESC	Return to the MAIN MENU screen.	

3.5 Harmonics menu

Harmonics 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. See 5.1.8 for details.

3.5.1 Meter

By entering HARMONICS menu from MAIN MENU the HARMONICS – METER tabular screen is shown *(see figure below)*. In this screens voltage and current harmonics and THD are shown.

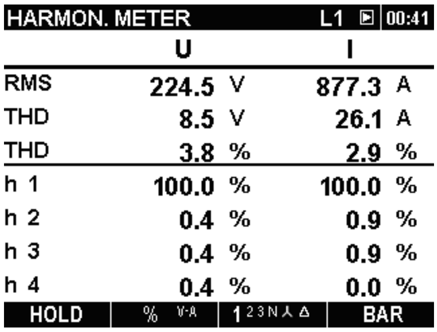


Figure 3.19: Harmonics meter table.

Description of symbols and abbreviations used in METER screens are shown in table bellow.

Table 3.17: Instrument screen symbols and abbreviations

L1 L2 L3 N ⅄ Δ	Show currently displayed channel.
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
RMS	True effective value U_{Rms} and I_{Rms}
THD	Total harmonic distortion THD_U and THD_I
hn n: 0..50	n^{th} harmonics voltage Uh_n or current Ih_n component

Table 3.18: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F2	% V-A	Represent harmonics as % of first harmonic RMS value
	V-A %	Represent values in RMS quantities (Volts, Ampere)

F3		Select between single phases, neutral, all-phases and line harmonics view
	1 2 3 N ⅄ Δ	Harmonics components for phase L1
	1 2 3 N ⅄ Δ	Harmonics components for phase L2
	1 2 3 N ⅄ Δ	Harmonics components for phase L3
	1 2 3 N ⅄ Δ	Harmonics components for neutral LN
	1 2 3 N ⅄ Δ	Summary of components on all phases
	1 2 3 N ⅄ Δ	Harmonics components for phase-to-phase voltages
F4	METER	Switch to METER view.
	BAR	Switch to BAR view
	TREND	Switch to TREND view (available only during recording)
▲ ▼		Shift through harmonic components.
ESC		Return to the “MAIN MENU” screen.

3.5.2 Bar

Bar screen displays dual bar graphs. The first shows voltage harmonics and the second shows current harmonics.

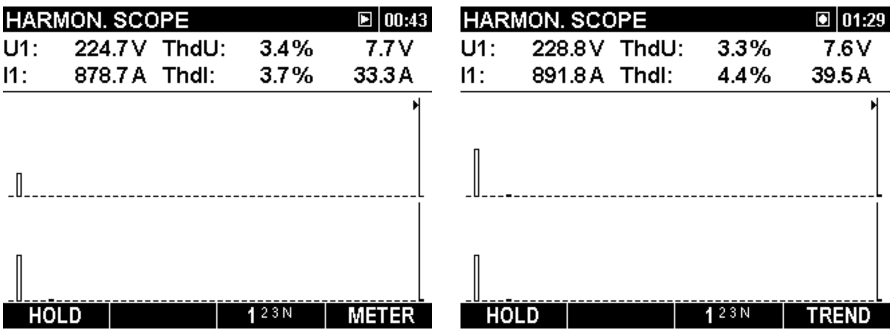


Figure 3.20: Harmonics b screens.

Description of symbols and abbreviations used in BAR screens are shown in table bellow.

Table 3.19: Instrument screen symbols and abbreviations

	Current recorder status
◙	RECORDER is active
⧗	RECORDER is busy (retrieving data from memory)
▷	RECORDER is not active
20:45	Current instrument time
▸	Show selected harmonic component

U*p*, UN *p:1..3*	True effective phase or line voltage U_{Rms}
I*p*, IN *P:1..3*	True effective phase current I_{Rms}
ThdU	Total voltage harmonic distortion THD_U and THD_I
ThdI	Total Current harmonic distortion THD_U and THD_I
h*n* *n: 0..50*	n-th voltage or current harmonic component Uh_n or Ih_n

Table 3.20: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F3		Select between single phases, neutral, harmonics bars
	1 2 3 N	Harmonics components for phase L1
	1 2 3 N	Harmonics components for phase L2
	1 2 3 N	Harmonics components for phase L3
	1 2 3 N	Harmonics components for neutral LN
F4	METER	Switch to METER view.
	BAR	Switch to BAR view
	TREND	Switch to TREND view (available only during recording)
ENTER	Select voltage or current cursor in order to move	
▲ ▼	Scale displayed waveform by amplitude.	
◄ ►	Scroll cursor left or right.	
ESC	Return to the “MAIN MENU” screen.	

3.5.3 Trend

During active RECORDER, TREND view is available (see section 3.10 for instructions how to start RECORDER). Voltage and current harmonics components can be observed by cycling function key F4 (METER-BAR-TREND).

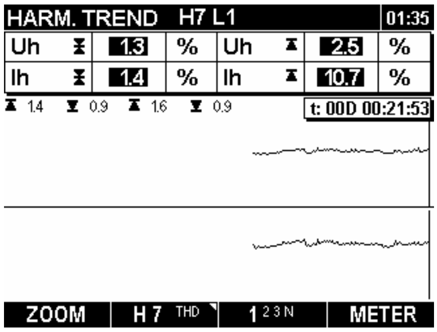
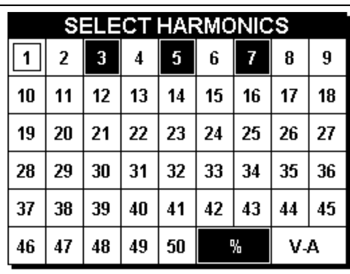


Figure 3.21: Harmonics trends screens.

Table 3.21: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
ThdU	Maximal ( ) and average ( ) value of total voltage harmonic distortion THD_U for selected phase
ThdI	Maximal ( ) and average ( ) value of total current harmonic distortion THD_I for selected phase
Uh	Maximal ( ) and average ( ) value for selected n-th voltage harmonic component for selected phase
Ih	Maximal ( ) and average ( )value of selected n-th current harmonic component for selected phase
t: 00D 00:13:23	Current RECORDER time
1.4 V 0.9 V 1.6 A 0.9 A	Maximal ( ) and minimal ( ) recorded quantity

Table 3.22: Keys function

F1	HOLD	Toggle between HOLD (the results are frozen on the display) and SAVE (save the frozen results).
F2 Press & Hold	Select: Max. 3 harmonics for observing trend Harmonics units ○ % of first harmonics, ○ absolute units (Volts/Ampere)	

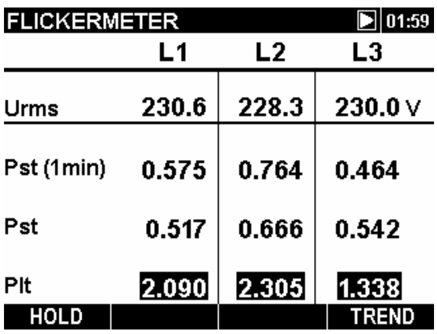
F2		Select between trending various parameters. By default these are:
	THD H3	Total harmonic distortion for selected phase ($THDU_p$)
	H3 H5	3rd harmonics for selected phase (U_ph_3)
	H5 H7	5th harmonics for selected phase (U_ph_5)
	H7 THD	7th harmonics for selected phase (U_ph_7)
F3		Select between single phase, neutral, all-phases and line harmonics view
	1 2 3 N	Harmonics components for phase L1 (U_1h_n)
	1 2 3 N	Harmonics components for phase L2 (U_2h_n)
	1 2 3 N	Harmonics components for phase L3 (U_3h_n)
	1 2 3 N	Harmonics components for neutral LN (U_Nh_n)
F4	METER	Switch to METER view.
	BAR	Switch to BAR view
	TREND	Switch to TREND view (available only during recording)
ESC		Return to “MAIN MENU” screen.

3.6 Flickermeter

Flickermeter measures the human perception of the effect of amplitude modulation on the mains voltage powering a light bulb. In Flickermeter menu instrument show measured power parameters. Results can be seen in a tabular (METER) or a graphical form (TREND). TREND view is active only while RECORDER is active, too. See section 3.10 for instructions how to start recording. In order to understand meanings of particular parameter see section 5.1.9.

3.6.1 Meter

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



FLICKERMETER 01:59

	L1	L2	L3
Urms	230.6	228.3	230.0 V
Pst (1min)	0.575	0.764	0.464
Pst	0.517	0.666	0.542
Plt	2.090	2.305	1.338

HOLD TREND

Figure 3.22: Flickermeter table screen.

Description of symbols and abbreviations used in METER screen is shown in table bellow.

Table 3.23: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
Urms	True effective value U_{Rms}
Pst(1min)	Short term (1 min) flicker P_{st1min}
Pst	Short term (10 min) flicker P_{st}
Plt	Long term flicker (2h) P_{st}
2.090	Inverted colors represent that measurement is not valid (in case of voltage overrange, voltage dips, low voltage etc..)

Table 3.24: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F4	METER	Switch to METER view. (available only during recording)
	TREND	Switch to TREND view (available only during recording)
ESC		Return to the “MAIN MENU” screen.

3.6.2 Trend

During active recording TREND view is available (see section 3.10 for instructions how to start recording). Current and voltage harmonics can be observed by cycling function key F4 (METER-TREND).

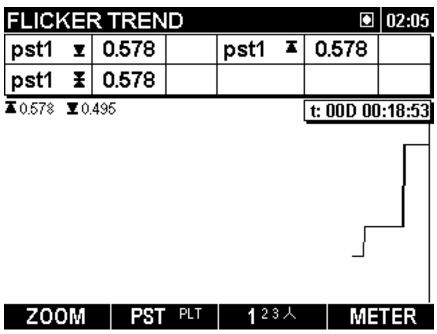


Figure 3.23: Flicker meter trend screen.

Table 3.25: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
pstm*p* *p*: [1..3]	Maximal ( ), average ( ) and minimal ( ) value of 1-minute short term flicker P_{st1min} for phase voltages U_1, U_2, U_3
pst*p* *p*: [1..3]	Maximal ( ), average ( ) and minimal ( ) value of 10-minute short term flicker P_{st3} for phase voltages U_{12}, U_{23}, U_{31}
plt*p* *p*: [1..3]	Maximal ( ), average ( ) and minimal ( ) value of 2 hour long term flicker in phase voltages U_1, U_2, U_3: P_{lt1}, P_{lt2}, P_{lt3}
t: 00D 00:13:23	Current RECORDER time
0.578 0.495	Maximal and minimal recorded flicker

Table 3.26: Keys function

F1	ZOOM-+	Zoom in
	ZOOM+-	Zoom out
F2		Select between the following options:
	PST PLT	Show 10 min short term flicker P_{st}
	PLT PSTMIN	Show long term flicker P_{lt}
	PSTMIN PST	Show 1min short term flicker P_{st1min}
F3		Select between trending various parameters:
	1 2 3 人	Show selected flicker trends for phase 1
	1 2 3 人	Show selected flicker trends for phase 2
	1 2 3 人	Show selected flicker trends for phase 3
	1 2 3 人	Show selected flicker trends for all phase (average only)
F4	METER	Switch to METER view.
	TREND	Switch to TREND view
ESC	Return to "MAIN MENU" screen.	

3.7 Inrushes

3.7.1 Setup

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

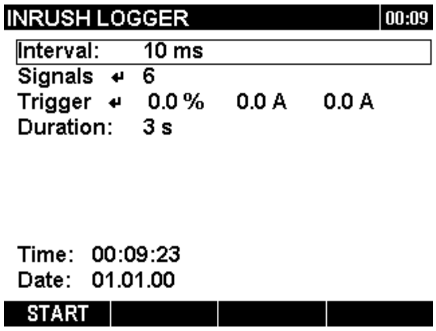


Figure 3.24: Inrush logger setup screens.

Table 3.27: Instrument screen symbols and abbreviations

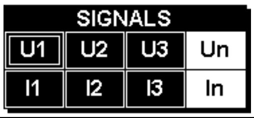
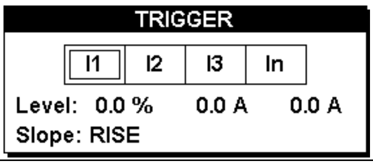
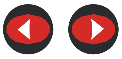
Interval	Logging interval setup (from 10 ms to 200 ms).
Duration	Total logging time is displayed in the “Duration” field (indicator only).
Signals	Select logging signals: 
Trigger	Trigger set up: • Current input for trigger source • Trigger level at which inrush logging will start • Trigger slope 

Table 3.28: Keys function

	Start logging
	Toggle between ON (selected) and OFF (deselected) for highlighted logging signals in SIGNALS dialog 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.
	Open SIGNALS dialog box (if “Signals” is selected). In this dialog box the individual signals can be selected for logging. Open 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.
	Return to the “MAIN MENU” screen or close the “Signals” or “Trigger” dialog box (if dialog box is open).

3.7.2 Capturing inrush

Following screen opens when a user starts the inrush logger.

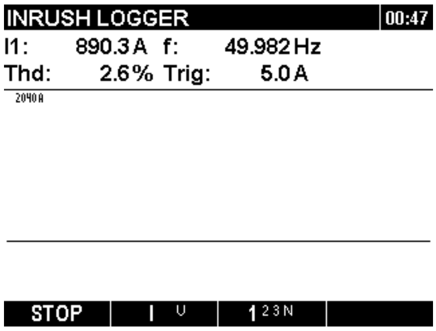


Figure 3.25: Inrush logger capture screen.

Table 3.29: Instrument screen symbols and abbreviations

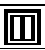
	Current recorder status
	INRUSH LOGGER is active (First beep indicates that measurement has started, next beep indicates that threshold has been reached)
	INRUSH LOGGER has finished recording
20:45	Current instrument time
U1..UN	True effective voltage value $U_{Rms(1/2)}$
I1..IN	True effective current value $I_{½Rms}$
Thd	Total harmonic distortion THD_U or THD_I
f	Frequency on reference channel
Trig	Settled trigger value
2040A	Represent current value at the top of the graph (horizontal line between graph and table values)

Table 3.30: Keys function

F1	STOP	Stop the inrush logger. ***Note:*** If user forces inrush logging to stop no data is recorded. Logging of data only occurs when trigger is activated.
F2		Toggle between voltage and current channel.
	U I	Show $U_{Rms(1/2)}$ voltage trend graph
	I U+I	Show $I_{½Rms}$ current trend graph
	U+I U/I	Show voltage $U_{Rms(1/2)}$ and current $I_{½Rms}$ trend in single graph
	U/I U	Show voltage $U_{Rms(1/2)}$ and current $I_{½Rms}$ trend in two separate graph
F3		Select between phases.
	1 2 3 N	Show graph and parameters for phase L1
	1 2 3 N	Show graph and parameters for phase L2
	1 2 3 N	Show graph and parameters for phase L3
	1 2 3 N	Show graph and parameters for phase LN
ESC	Return to the "MAIN MENU".	

3.7.3 Captured inrush

This function becomes active after 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 are saved to the instrument memory. Signals are auto scaled.

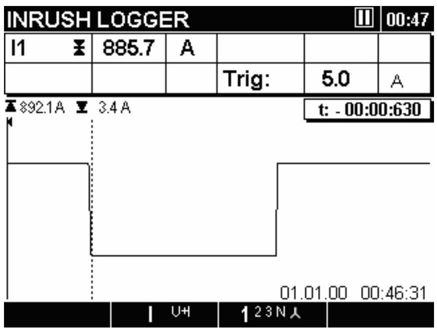


Figure 3.26: Captured inrush

Table 3.31: Instrument screen symbols and abbreviations

▥	Indicate that instrument has finished recording
20:45	Current instrument time
⁋	Indicate position of the cursor at the graph

U1..UN	True effective voltage value U_{Rms} at cursor point
I1..IN	True effective current value U_{Rms} at cursor point
Trig	Settled trigger value
892.1A 3.4A	Maximal and minimal current value on graph
01.01.00 00:46:31	Real time clock at cursor position
t: - 00:00:630	Time at cursor position

Table 3.32: Keys function

F2		Toggle between voltage and current channel.
	U I	Show $U_{rms(1/2)}$ voltage trend graph
	I U+I	Show $I_{½Rms}$ current trend graph
	U+I U/I	Show voltage $U_{rms(1/2)}$ and current $I_{½Rms}$ trend in single graph
	U/I U	Show voltage $U_{rms(1/2)}$ and current $I_{½Rms}$ trend in two separate graph
F3	1 2 3 N	Select between single phase, neutral and all-phase trend graph
ENTER		Select between scopes.
◄ ►		Scroll the cursor along logged data.
ESC		Return to the "MAIN MENU".

3.8 Events and Alarms

By entering "EVENTS&ALARMS" menu, following screen is shown *(see figure below)*. Two submenus are displayed when entering this screen:

1. Events table
2. Alarms table

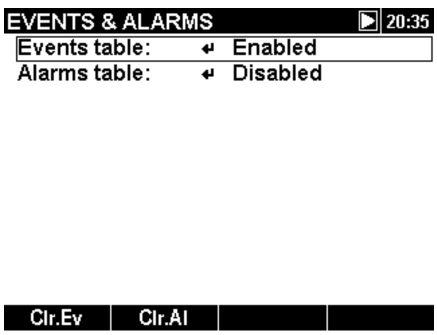


Figure 3.27: Events and alarms entry screen.

Table 3.33: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
Events table	Submenu for observing captured voltage events
Alarms table	Submenu for observing captured alarms
Enabled	Show that alarm or event capture is active
Disabled	Show that alarm or event capture is disabled

Table 3.34: Keys function

F1	Clr.Ev	Clear captured events
F2	Clr.Al	Clear captured alarms.
▲ ▼		Select between the two options.
ENTER		Confirm and enter the selected option's screen.
ESC		Return to the "MAIN MENU" screen.

3.8.1 Voltage events

In this table captured voltage dips, swells and interrupts are shown. Note that events appear in the table after finishing, when voltage return to the normal value. All events can be grouped or separated by phase. This is performed by pressing function key F1.

Group view

In this view voltage event are grouped according to IEC 61000-4-30 (see section 5.1.11 for details). Table where events are summarized is shown bellow. Each line in table represents one event, described by event number, event start time and duration and level. Additionally in colon "T" event characteristics are shown (see table bellow for details).

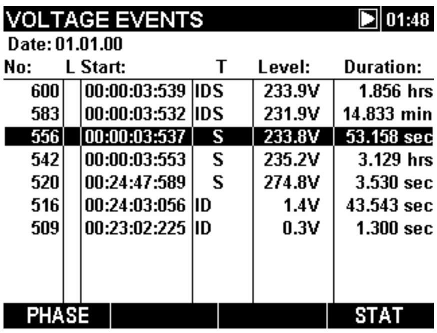


Figure 3.28: Voltage events in group view screen

By pressing “Enter” on particular events we can examine its details. Event is split on phase event sorted by start time. Colon “T” shows transition from one event state to another (see table bellow for details).

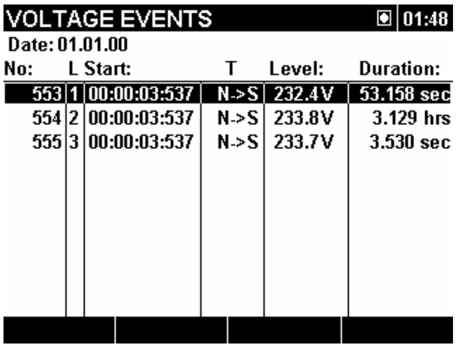


Figure 3.29: Voltage events group view screen

Table 3.35: Instrument screen symbols and abbreviations

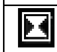
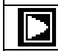
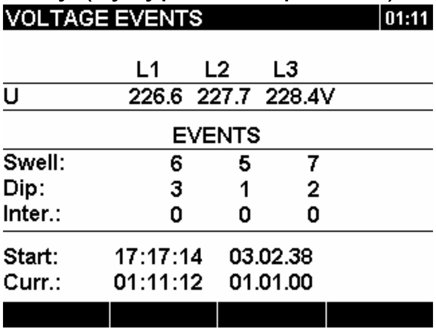
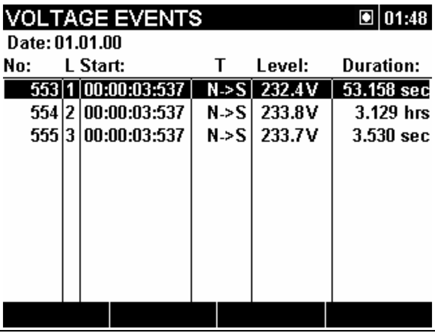
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
Date	Date when selected event has occurred
No.	Unified event number (ID)
L	Indicate phase or phase-to-phase voltage where event has occurred: 1 – event on phase U_1 2 – event on phase U_2 3 – event on phase U_3 12 – event on voltage U_{12} 23 – event on voltage U_{23} 32 – event on voltage U_{32} **Note:** this indication is shown only in event details, since one grouped event can have many phase events.
Start	Event start time (when first $U_{Rms(1/2)}$) value cross threshold.
T	Indicates type of event or transition: D – Dip I – Interrupt S – Swell N → D Transition from normal state to dip N → S Transition from normal state to swell D → I Transition from deep to interrupt
Level	Minimal or maximal value in event U_{Dip}, U_{Int}, U_{Swell}
Duration	Event duration. **Note:** Due to lack of screen space, duration is represented as decimal value. In example 2.5hrs represent 2 hours and 30 minutes. Use PowerView in order to observe events in normal time format.

Table 3.36: Keys function

<table>
<tr><td rowspan="2">F1</td><td>Σ PH</td><td>Group view is shown. Press to switch on “PHASE” view.</td></tr>
<tr><td>PH Σ</td><td>Phase view is shown. Press to switch on “GROUP” view.</td></tr>
<tr><td rowspan="2">F4</td><td>STAT</td><td>Show event summary (by types and phases):

</td></tr>
<tr><td>EVENTS</td><td>Back to Group view.</td></tr>
<tr><td>ENTER</td><td colspan="2">Show details about the selected event.

</td></tr>
<tr><td>▲ ▼</td><td colspan="2">Select event.</td></tr>
<tr><td>ESC</td><td colspan="2">Back to the “EVENTS & ALARMS” menu.</td></tr>
</table>

Phase view

In this view voltage event are separated by phases. This is convenient view for troubleshooting. Additionally user can use filters in order to observe only particular type of event on specific phase. Captured events in a table, where each line contains one event. Each event has an event number, event start time and duration and level. Additionally in colon “T” type of event is shown (see table bellow for details).

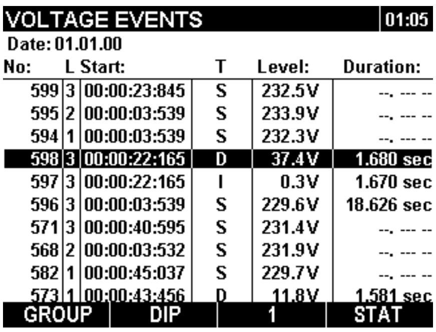


Figure 3.30: Voltage events screens.

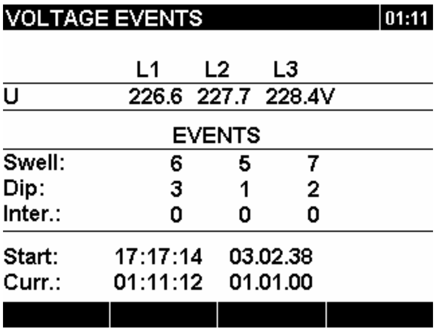
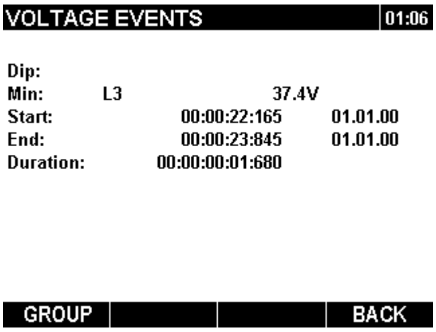
You can also see details of each individual voltage event and statistics of all events. Statistics show count registers for each individual event type by phase.

Table 3.37: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
Date	Date when selected event has occurred
No.	Unified event number (ID)
L	Indicate phase or phase-to-phase voltage where event has occurred: 1 – event on phase U_1 2 – event on phase U_2 3 – event on phase U_3 12 – event on voltage U_{12} 23 – event on voltage U_{23} 32 – event on voltage U_{32}
Start	Event start time (when first $U_{Rms(1/2)}$) value cross threshold.
T	Indicates type of event or transition: D – Dip I – Interrupt S – Swell
Level	Minimal or maximal value in event U_{Dip}, U_{Int}, U_{Swell}
Duration	Event duration. **Note:** Due to lack of screen space, duration is represented as decimal value. In example 2.5hrs represent 2 hours and 30 minutes. Use PowerView in order to observe events in normal time format.

Table 3.38: Keys function

F1	Σ PH	Group view is shown. Press to switch on “PHASE” view.
	PH Σ	Phase view is shown. Press to switch on “GROUP” view.
F2		Filter events by type:
	Σ DIP	Show all events
	DIP INT	Show dips only
	INT SWELL	Show interrupts only
	SWELL Σ	Show swells only
F3		Filter events by phase:
	1 2 3 Σ	Show only events on phase 1
	1 2 3 Σ	Show only events on phase 2
	1 2 3 Σ	Show only events on phase 3

	123Σ	Show all events
F4	STAT	Show event summary (by types and phases): 
	EVENTS	Back to Group view.
ENTER		Show details about the selected event: 
▲ ▼		Select event.
ESC		Back to the “EVENTS & ALARMS” menu.

3.8.2 Alarms list

This menu shows list of alarms which went off. Alarms are displayed in a table, where each row represents an alarm. Each alarm is associated with a start time, phase, type, slope, min/max value and duration see 5.1.12 for details.

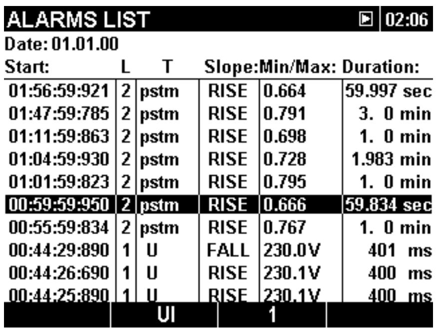


Figure 3.31: Alarms list screen.

Table 3.39: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
Date	Date when selected alarm has occurred
Start	Alarm start time (when first U_{Rms}) value cross threshold.
L	Indicate phase or phase-to-phase voltage where event has occurred: 1 – alarm on phase L_1 2 – alarm on phase L_2 3 – alarm on phase L_3 12 – alarm on line L_{12} 23 – alarm on line L_{23} 32 – alarm on line L_{32}
Slope	Indicates alarms transition: • Rise – parameter has over-crossed threshold • Fall – parameter has under-crossed threshold
Level	Minimal or maximal parameter value during alarm occurrence
Duration	Alarm duration. **Note:** Due to lack of screen space, duration is represented as decimal value. In example 2.5hrs represent 2 hours and 30 minutes. Use PowerView in order to observe alarms in normal time format.

Table 3.40: Keys function

F2		Filter alarms according to the following parameters:
	Σ Ulf	All alarms
	Ulf PWR	Voltage alarms
	PWR FLICK	Power alarms
	FLICK SYM	Flicker alarms
	SYM HARM	Unbalance alarms
	HARMS Σ	Harmonics alarms
F3		Filter alarms according to phase on which they occurred:
	1 2 3 N Σ	Show only alarms on phase 1
	1 2 3 N Σ	Show only alarms on phase 2
	1 2 3 N Σ	Show only alarms on phase 3
	1 2 3 N Σ	Show only alarms on phase N
	1 2 3 N Σ	Show alarms on all phases
F4	ACTIVE	Show active alarm list. List includes alarms which has started, but not finished yet. Notation used in this table is same as described in this section.

	Select an alarm.
	Back to the “EVENTS & ALARMS” menu screen.

3.9 Phase Diagram

Phase diagram graphically represent fundamental voltages, currents and phase angles of the network. This view is strongly recommended for checking instrument connection before measurement. Note that most measurement issues arise from wrongly connected instrument (see 4.1 for recommended measuring practice). On phase diagram instrument shows:

- Graphical presentation of voltage and current phase vectors of the measured system,
- Unbalance of the measured system.

3.9.1 Phase diagram

By entering PHASE DIAGRAM menu from MAIN MENU following screen is shown *(see figure below)*.

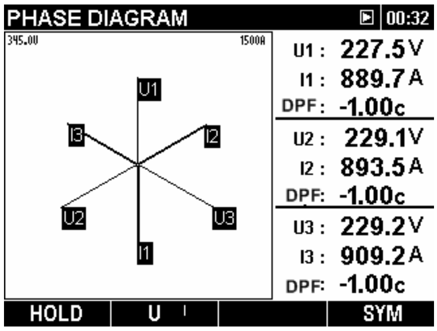


Figure 3.32: Phase diagram screen.

Table 3.41: Instrument screen symbols and abbreviations

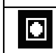
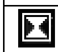
	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
U1, U2, U3	Fundamental voltages U_{1Fnd}, U_{2Fnd}, U_{3Fnd}
I1, I2, I3	Fundamental currents I_{1Fnd}, I_{2Fnd}, I_{3Fnd}
DPF	Displacement factor (cos φ) for particular phase: DPF_1, DPF_2, DPF_3
345.0V 1500A	Indicate current and voltage scaling. Value represents current or voltage value at the top of the graph (top horizontal line).

Table 3.42: Keys function

F1		Waveform snapshoot:
	HOLD	Hold measurement on display
	SAVE	Save held measurement into memory
F2	U I	Toggle voltages for scaling (with cursors)
	I U	Toggle voltages for scaling (with cursors)
F4	U-I	Switch to phase diagram
	SYM	Switch to symmetry diagram
ENTER	Show details about the selected event.	
▲ ▼	Scale displayed diagram by amplitude.	
ESC	Back to the “MAIN MENU” menu.	

3.9.2 Symmetry diagram

Symmetry diagram represent current and voltage symmetry or unbalance of the measuring system. Unbalance arises when RMS values or phase angles between consecutive phases are not equal. Diagram is shown on figure bellow.

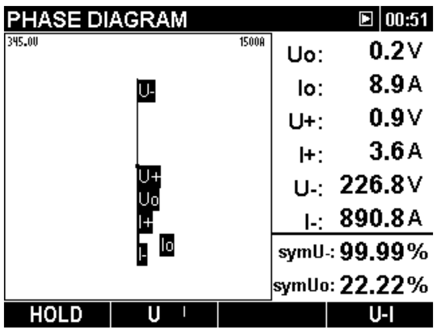


Figure 3.33: Symmetry diagram screen

Table 3.43: Instrument screen symbols and abbreviations

	Current recorder status
	RECORDER is active
	RECORDER is busy (retrieving data from memory)
	RECORDER is not active
20:45	Current instrument time
U0 I0	Zero sequence voltage component U^0 Zero sequence current component I^0
U+ I+	Positive sequence voltage component U^+ Positive sequence current component I^+
U- I-	Negative sequence voltage component U^- Negative sequence current component I^-

symU- symI-	Negative sequence voltage ratio u^- Negative sequence current ratio i^-
symU+ symI-	Zero sequence voltage ratio u^0 Zero sequence current ratio i^0
345.0U 1500A	Indicate current and voltage scaling. Value represents current or voltage value at the top of the graph (top horizontal line).

Table 3.44: Keys function

F1		Waveform snapshoot:
	HOLD	• Hold measurement on display
	SAVE	• Save held measurement into memory
F2	U I	Toggle u^-/u^0 voltages and select voltage for scaling (with cursors)
	I U	Toggle i^-/i^0 currents and select currents for scaling (with cursors)
F4	U-I	Switch to phase diagram
	SYM	Switch to symmetry diagram
▲ ▼	Scale displayed diagram by amplitude.	
ESC	Back to the “MAIN MENU” menu.	

3.10 Recorder

PowerQ4 has ability to record measurement data in the background. In RECORDER menu user can customize recorder parameters in order to meet his criteria about size, duration, and the number of signals for the recording campaign. By entering “RECORDER” menu, following screen is shown:

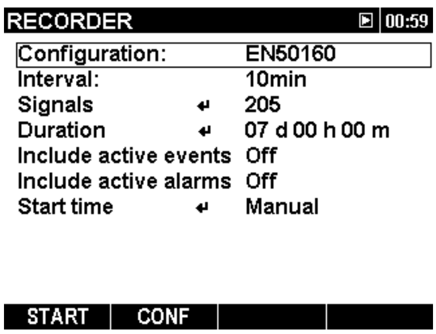
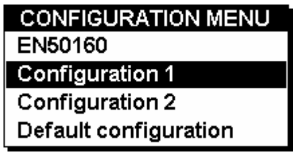
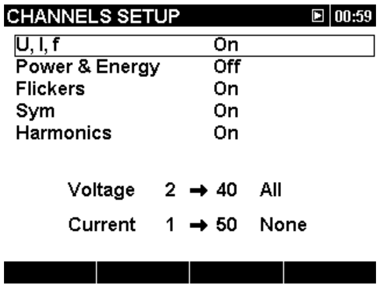
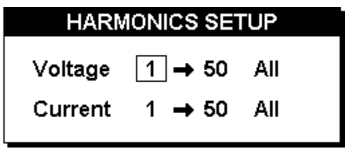


Figure 3.34: Basic recorder setup screen

In following table description of recorder settings is given:

Table 3.45: Recorder settings description

<table>
<tr><td>Configuration</td><td>Load/save one of predefined configuration.

Possible options are:
“EN50160” – predefined configuration for EN 50160 survey.
Configuration 1 - user defined configuration
Configuration 2 - user defined configuration
“Default configuration” – factory defaults
Note: EN 50160 configuration record only average values for defined time period.
Note: EN 50160 by default record voltage parameters only. Current dependent quantities are not recorded nor shown in trend graphs. Using SIGNALS menu user can add power or currents channels and perform EN 50160 and power measurement simultaneously..</td></tr>
<tr><td>Interval</td><td>Select recorder aggregation interval. For each time interval minimal, average and maximal value for will be recorded (for each signal). The smaller is the interval, more measurements will be recorded.
Note: The instrument automatically changes the duration in case there if there is not enough memory for the desired interval and duration.</td></tr>
<tr><td>Signals</td><td>Select signals to record. See 4.3 for detail channel list

U, I, f – select voltage, current and freq. parameters for recording.
Power & Energy – select power and energy parameters for recording.
Flickers – select flicker parameters for recording
Sym – select unbalance parameters for recording
Harmonics – select which voltage and current harmonics you want to include in the record.
</td></tr>
</table>

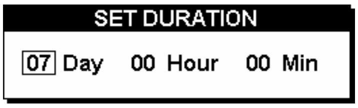
	User can choose ○ First and last voltage and current harmonic to record ○ Select even, odd or all harmonics components for recording
Duration	Select the duration of the record.  **Note:** If the duration time is set longer than memory allows it, it will be automatically shortened.
Include active events	Select whether you want or not to include active events in record.
Include active alarms	Select whether you want or not to include active alarms in record.
Start time	Define start time of recording:  • Manual, pressing function key F1 • Add predefined start time, when recorder should start

Table 3.46: Keys function

F1	START STOP	Start or stop the recorder Stop the recorder
F2	CONF	Open configuration sub menu
F3	LOAD	Load the selected configuration (Only in configuration submenu)
F4	SAVE	Save the changes to the selected configuration (Only in configuration submenu)
ENTER	Enter the selected submenu	
◄ ►	Select parameter / change value	
▲ ▼	Select parameter / change value	
ESC	Back to the previous menu	

3.11 Memory List

Using this menu user can browse through record and view recorded records. By entering this menu, information's about last record is shown.

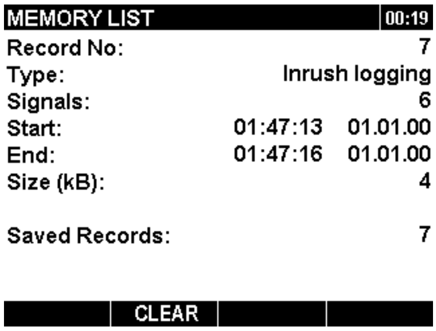


Figure 3.35: Memory list screen.

Table 3.47: Memory list description

Record No	Selected record number, for which details are shown.
Type	Indicate type of record, which can be one of following: • inrush logging, • waveform snapshoot • normal recording
Signals	Number of recorded signals.
Start	Record start time
End	Record stop time
Size (kB)	Record site in kilobytes (kB).
Saved records	Total number of records in memory

Table 3.48: Keys function

	Clear the last record. In order to clear complete memory, delete records one by one.
	Browse through records (next or previous record).
	Shows current record. See next sections for details on viewing particular type of record.
	Returns to the MAIN MENU.

3.11.1 Record

This type of record is made by RECORDER. Record front page is similar to the RECORDER menu, as shown on figure bellow.

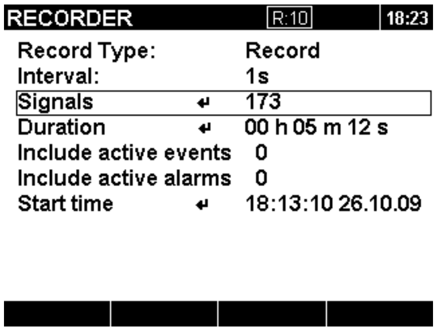
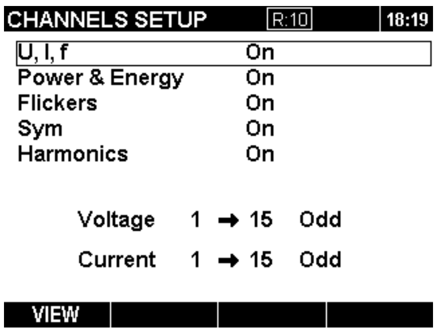


Figure 3.36: Front page of Record in MEMORY LIST menu

Table 3.49: Recorder settings description

<table>
<tr><td>20:45</td><td>Current instrument time</td></tr>
<tr><td>Record type: RECORD</td><td>Indicator that record type is made by RECORDER</td></tr>
<tr><td>Interval 1s</td><td>Show interval used for RECORDER</td></tr>
<tr><td>Signals: 173</td><td>Show number of signals in record. By pressing ENTER on Signals following screen will appear.:


User can now observe particular signal group by pressing on F1</td></tr>
<tr><td>Duration: 6m 19s</td><td>Show duration of record.</td></tr>
<tr><td>Include active events: 4</td><td>Show number of captured events</td></tr>
<tr><td>Include active alarms: 0</td><td>Show number of captured alarms</td></tr>
<tr><td>Start time</td><td>Show record start time</td></tr>
</table>

Table 3.50: Keys function

F1	VIEW View selected signal group (Active only in Signals submenu
ENTER	Enter the selected submenu.
▲ ▼	Select parameter
ESC	Back to the previous menu.

By pressing F1 VIEW in CHANNEL SETUP menu TREND screen will appear. Typical screen is shown on figure bellow.

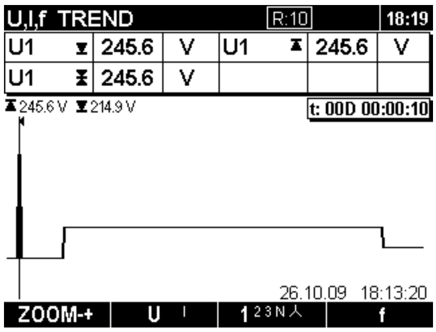


Figure 3.37: Viewing recorder U,I,f TREND data

Table 3.51: Instrument screen symbols and abbreviations

R:8	Show record number in MEMORY LIST
20:45	Current instrument time
▮	Indicate position of the cursor at the graph
Up, Upg:	Maximal (▲), average (⧗) and minimal (▼) recorded value of phase voltage U_{pRms} or line voltage U_{pgRms} for time interval selected by cursor.
Ip:	Maximal (▲), average (⧗) and minimal (▼)recorded value of current I_{pRms} for time interval selected by cursor.
t: 00D 00:13:23	Time position of cursor
▲230.6 V ▼225.3 V ▲947.1 A ▼ 0.0 A	Maximal and minimal Up/Upg on displayed graph Maximal and minimal Ip on displayed graph

Table 3.52: Keys function

F1	ZOOM-+ ZOOM+-	Zoom in Zoom out
F2	 U I I U+I U+I U/I U/I U	Select between the following options: Show voltage trend Show current trend Show voltage and current trend in single graph Show voltage and current trend in two separate graph
F3	1 2 3 N ⅄	Select between single phase, neutral and all-phase trend graph
F4	f	Show frequency trend
ENTER		Select which waveform to zoom (only in U/I or U+I trends)
◄ ►		Scroll the cursor along logged data.
ESC		Return to “MAIN MENU” screen.

Note: Other recorded data (power, harmonics, etc.) has similar manipulation principle as described in table above.

3.11.2 Waveform snapshoot

This type of record can be made by using Hold → Save procedure. His front page is similar to the screen where he was recorder, as shown on figure bellow.

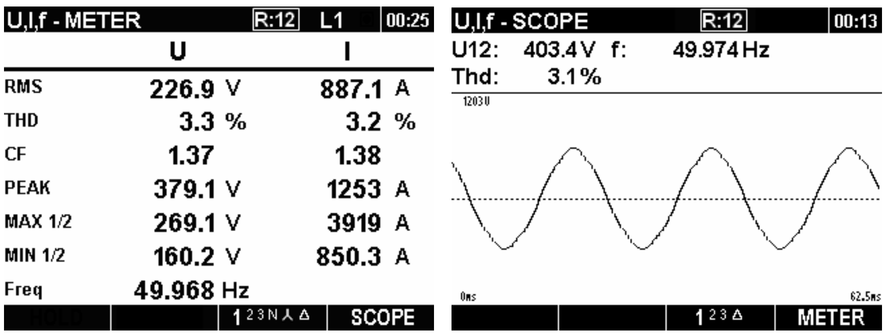


Figure 3.38: Front page of Normal record in MEMORY LIST menu

For screen symbols and key functions see corresponding METER, SCOPE, BAR graph, PHASE DIAG. description described in sections (U, I, f; Power, etc..).

3.11.3 Inrush logger

This type of record is made by Inrush logger. For details regarding manipulation and data observing see section 3.7.3.

3.12 Setup menu

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

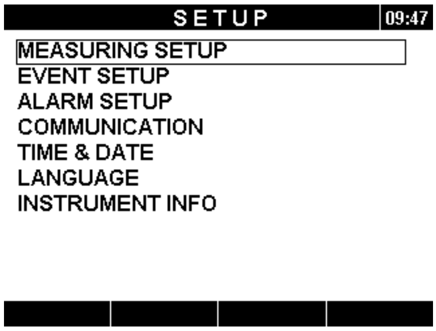


Figure 3.39: SETUP menu

Table 3.53: Description of setup options

Measuring setup	Setup measurement parameters.
Event setup	Setup event parameters.
Alarm setup	Setup alarm parameters.
Communication	Setup communication baud rate and source.
Time & Date	Set time and date.
Language	Select language.
Instrument info	Information about the instrument.

Table 3.54: Keys function

	Select function from the “SETUP” menu.
	Enter the selected item.
	Back to the “MAIN MENU” screen.

3.12.1 Measuring setup

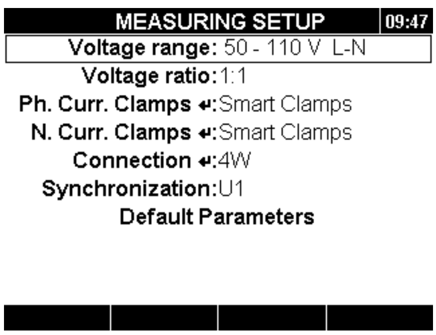
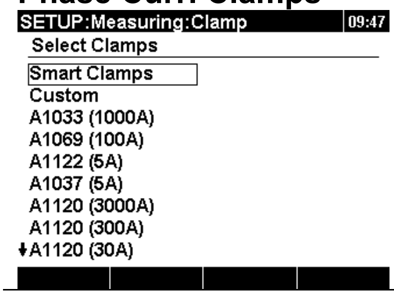
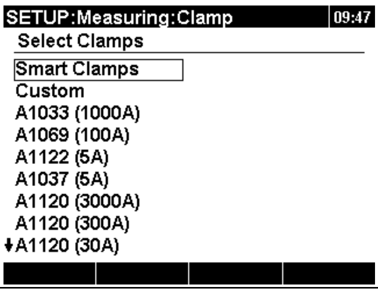


Figure 3.40: “MEASURING SETUP” screen

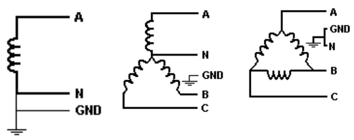
Table 3.55: Description of measuring setup

<table>
<tr><td>Voltage range</td><td>Nominal voltage range. Select voltage range according to the <u>nominal network</u> voltage.
<table>
<tr><th>1W and 4W</th><th>3W</th></tr>
<tr><td>50 ÷ 110V (L-N)</td><td>86÷190 V (L-L)</td></tr>
<tr><td>110 ÷ 240V (L-N)</td><td>190÷415 V (L-L)</td></tr>
<tr><td>240 ÷ 1000 V (L-N)</td><td>415÷1730 V (L-L)</td></tr>
</table>

Note: Instrument can accurate measure at least 50% higher than selected nominal voltage</td></tr>
<tr><td>Voltage ratio</td><td>Scaling factor for voltage transducer.
Use this factor if external voltage transformers or dividers should be taken into account. All readings are then related to the primary voltage. See 4.2.2 for connection details.
Note: scale factor can be set only when lowest Voltage range is selected!
Note: Maximum value is limited to 4000.</td></tr>
<tr><td>Phase Curr. Clamps

</td><td>Select phase clamps for phase current measurements.
Note: For Smart clamps (A1227, A1281) always select “Smart type clamps”

Note: See section 4.2.3 for details regarding further clamps settings</td></tr>
<tr><td>Neutral Curr. Clams

</td><td>Select neutral clamps for phase current measurements.

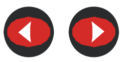
Note: For Smart clamps (A1227, A1281) always select “Smart type clamps”

Note: See section 4.2.3 for details regarding further clamps settings</td></tr>
<tr><td>Connection


1W 4W 3W</td><td>Method of connecting the instrument to multi phase systems (see 4.2.1 for details).
1W: 1-phase 2-wire system
3W: 3-phase 3-wire system
4W: 3-phase 4-wire system</td></tr>
</table>

Synchronization	Synchronization channel. This channel is used for instrument synchronization to the network frequency. Also a frequency measurement is performed on that channel. Depending on **Connection** user can select: • **1W** : U1 or I1. • **3W**: U12, or I1. • **4W**: U1, I1.
Default parameters	Set factory default. These are: U range: 110 ÷ 240V (L-N); Voltage ratio: 1 Phase current clamps: Smart Clamps Neutral current clamps: Smart Clamps Connection: 4W Synchronization: U1

Table 3.56: Keys function

	Change selected parameter value.
	Select measuring parameter.
	Enter into submenu
	Back to the “SETUP” menu screen.

3.12.2 Event setup

In this menu you can setup voltage events and their parameters. See 5.1.11 for further details regarding measurement methods. Captured events can be observed through EVENTS & ALARMS menu. See 3.8.1 for details.

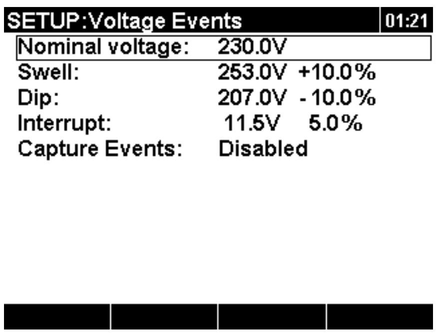
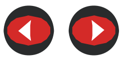


Figure 3.41: Voltage events setup screen.

Table 3.57: Description of measuring setup

Nominal voltage	Set nominal voltage
Swell	Set swell threshold value.
Dip	Set dip threshold value
Interrupt	Set interrupt threshold value
Capture Events	Enable or disable event capturing. **Note:** Enable events only if you want to capture it without recording. In case you want observe events only during recording use option: Include active events: On in RECORDER menu. **Note:** In case of Connection type: 1W, it is recommended to connect unused voltage inputs to N voltage input in order to avoid false triggering.

Table 3.58: Keys function

	Change value.
	Select parameter.
	Back to the "SETUP" menu screen.

3.12.3 Alarm setup

You can define up to 10 different alarms, based on any measurement quantity which is measured by instrument. See 5.1.12 for further details regarding measurement methods. Captured events can be observed through EVENTS & ALARMS menu. See 3.8.1 for details.

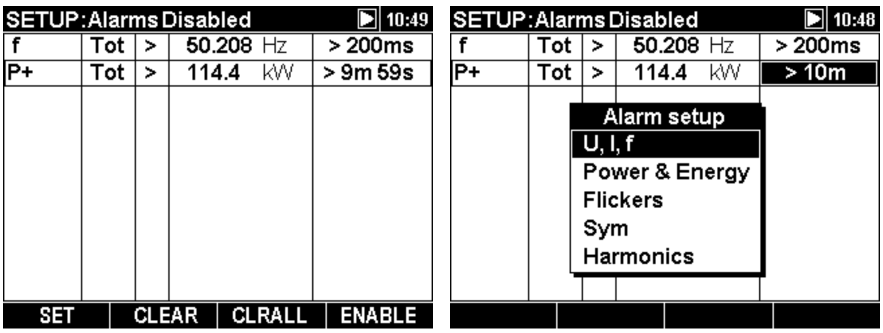


Figure 3.42: Alarms setup screen.

Table 3.59: Description of measuring setup

1st column (f, P+ on figure above)	Select alarm from measurement group and then measurement itself
2nd column (Tot on figure above)	Select phases for alarms capturing • 1 – alarms on phase L_1 • 2 – alarms on phase L_2 • 3 – alarms on phase L_3 • N – alarms on phase N • 12 – alarms t on line L_{12} • 23 – alarms on line L_{23} • 32 – alarm on line L_{32} • ALL – alarms on any phase • Tot – alarms on power totals or non phase measurements (frequency, unbalance)
3rd column (">" on figure above)	Select triggering method: < – trigger when measured quantity is lower than threshold (FALL) > – trigger when measured quantity is higher than threshold (RISE)
4th column	Threshold value
5th column	Minimal alarm duration. Trigger only if threshold is crossed for a defined period of time. **Note:** It is recommended that flicker minimal time is set according to the minimal measurement interval: Pst_{1min}>1min, Pst > 10min, Plt > 10min.

Table 3.60: Keys function

F1	Set an alarm.
F2	Clear an alarm.
F3	Clear all alarms.
F4	Disable or enable alarms. **Note:** Enable alarms only if you want to capture alarms without recording. In case you want observe alarms only during recording use option Include active alarms: On in RECORDER menu.
ENTER	Enter or exit a sub menu.
◄ ►	Select parameter.
▲ ▼	Change value.
ESC	Back to the "SETUP" menu screen.

3.12.4 Communication

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

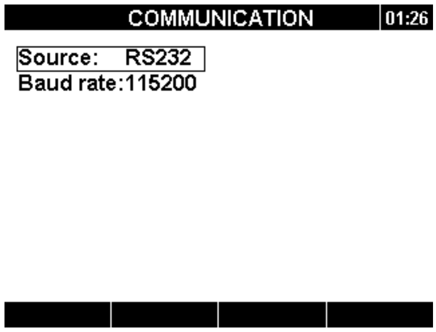
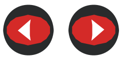


Figure 3.43: Communication setup screen.

Table 3.61: Keys function

	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.
	Confirm the selected speed.
	Back to the “SETUP” menu screen.

3.12.5 Time & Date

Time and date can be set in this menu.

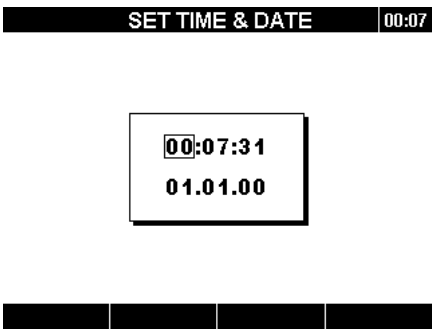
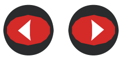


Figure 3.44: Set time & date screen.

Table 3.62: Keys function

	Select between the following parameters: hour, minute, second, day, month or year.
	Change value of the selected item.
	Return to the “SETUP” menu screen.

3.12.6 Language

Different languages can be selected in this menu.

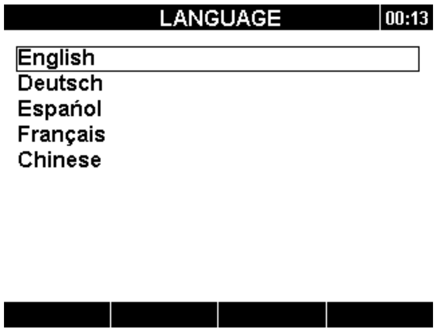


Figure 3.45: Language setup screen.

Table 3.63: Keys function

	Select language.
	Confirm the selected language.
	Back to the “SETUP” menu screen.

3.12.7 Instrument info

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

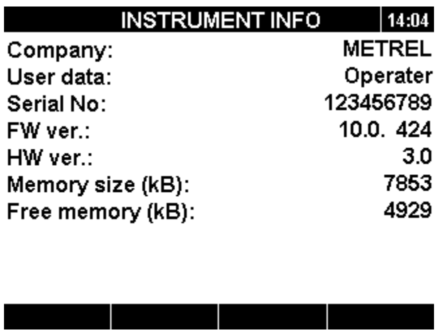


Figure 3.46: Instrument info screen.

Table 3.64: Description of instrument info

Company	Instrument manufacturer
User data	Custom user data
Serial No.	Instrument serial number
FW ver.	Firmware version
HW ver.	Hardware version
Memory size	Size of Storage memory (Flash).
Free memory	Free storage memory in kilobytes.

Table 3.65: Keys function

	Back to the “SETUP” menu screen.

4 Recommended Recording Practice and Instrument Connection

In following section recommended measurement and recording practice in described.

4.1 Measurement campaign

Power quality measurements are specific type of measurements, which can last many days, and mostly they are *performed* only once. Usually recording campaign is performed to:

- Statistically analyze some point in the network.
- Troubleshoot malfunctioning device or machine

Since mostly measurements are *performed* only once, it is very important to properly set measuring equipment. Measuring with wrong setting can lead to false or useless measurement results. Therefore instrument and user should be fully prepared before measurement begins.
In this section recommended recorder procedure is shown. We recommend to strictly follow guidelines in order to avoid common problems and measurement mistakes. Figure bellow shortly summarizes recommended measurement practice. Each step is then described in details.

Note: PowerView has ability to correct (after measurement is done):

- wrong real-time settings,
- wrong current and voltage scaling factor.

False instrument connection (messed wiring, opposite clamp direction), can’t be fixed afterwards.

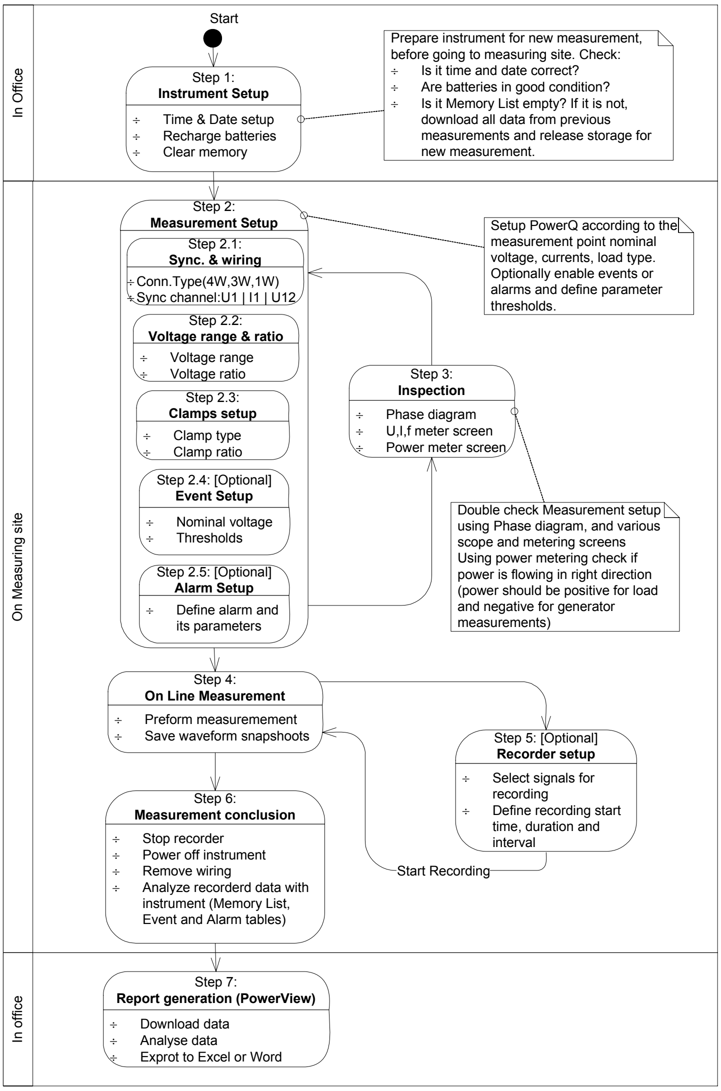


Figure 3.45: Recommended measurement practice

Step 1: Instrument setup

On site measurements can be very stressful, and therefore it is good practice to prepare measurement equipment in office. Preparation of PowerQ4 include following steps:

- Visually check instrument and accessories.
  Note: Don’t use **v**isually damaged equipment!
- Always use batteries in good condition and fully charge them before leave.
  Note: Keep your batteries in good condition. In problematic PQ environment where dips and interrupts frequently occurs instrument power supply fully depends on batteries!
- Download all previous records from instrument and clear the memory. (See section 3.11 for instruction regarding memory clearing)
- Set instrument time and date. (See section 3.12.5 for instruction regarding time and date settings)

Step 2: Measurement setup

Measurement setup adjustment is *performed* on measured site, after we find out details regarding nominal voltage, currents, type of wiring etc.

Step 2.1: Synchronization and wiring

- Connect current clamps and voltage tips to the “Device under measurement” (See section 4.2 for details).
- Select proper type of connection in “Measurement Setup” menu (See section 3.12.1 for details).
- Select synchronization channel. Synchronization to voltage is recommended, unless measurement id performed on highly distorted loads, such as PWM drives. In that case current synchronization can be more appropriate. (See section 3.12.1 for details).

Step 2.2: Voltage range and ratio

- Select proper voltage range according to the network nominal voltage.
  Note: For 4W and 1W measurement all voltages are specified as phase-to-neutral (L-N). For 3W measurements all voltages are specifies as phase-to-phase (L-L)
  Note: Instrument assures proper measurement up to 150 % of chosen nominal voltage.
- In case of indirect voltage measurement, select voltage range: 50 V ÷ 110 V and select “Voltage ratio” according to transducer ratio. (See section 3.12.1 for details).

Step 2.3: Current clamps setup

- Using “Current Clamps” menu, select proper clamps (see sections 3.12.1 for details).
- Select proper clamps parameters according to the type of connection (see section 4.2.3 for details).

Step 2.4: Event setup (optional)

Use this step only if voltage events are object of concern. Select nominal voltage and threshold values for: dip, swell and interrupts (see sections 3.12.2 and 3.8.1 for details).
Note: Enable events in EVENT SETUP only if you want to capture events, without RECORDER assistance.

Step 2.5: Alarm setup (optional)

Use this step only if you would like only to check if some quantities cross some predefined boundaries (see sections 3.8.2 and 3.12.3 for details).
Note: Enable alarms capture only if want to capture alarms, without assistance of RECORDER.

Step 3: Inspection

After setup instrument and measurement is finished, user need to recheck if everything is connected and configured properly. Following steps are recommended.

- Using PHASE DIAGRAM menu check if voltage and current phase sequence is right regarding to the system. Additionally check if current has right direction.
- Using U, I, f menu check if voltage and current value has proper value.
- Additionally check voltage and current THD.
  Note: Excessive THD can indicate that too small range was chosen!
  Note: In case of AD converter overloading current and voltage value will be displayed with inverted color 250.4 V.
- Using POWER menu check signs and indices of active, reactive power and power factor.

If any of these steps give you suspicious measurement results, return to Step 2 and double check measurement parameters.

Step 4: On-line measurement

Instrument is now ready for measurement. Observe on line parameters of voltage, current, power harmonics, etc. according to the measurement protocol or customer issues.
Note: Use waveform snapshots to capture important measurement. Waveform snapshoot capture all power quality signatures at once (voltage, current, power, harmonics, flickers).

Step 5: Recorder setup and recording

Using RECORDER menu configure recording parameters such as:

- Recorder Signals included in recording
- Time Interval for data aggregation (IP)
- Record duration
- Recording start time (optional)
- Include events and alarms capture if necessary

After setting recorder, recording can be started. (see section 3.10 for recorder details).
Note: Recording usually last few days. Assure that instrument during recording session is not reachable to the unauthorized persons.

Step 6: Measurement conclusion

Before leaving measurement site we need to

- Preliminary evaluate recorded data using TREND screens.
- Stop recorder
- Assure that we record and measure everything we needed.

Step 7: Report generation (PowerView)

Download records using PowerView and perform analysis. See PowerView manual for details.

4.2 Connection setup

4.2.1 Connection to the LV Power Systems

This instrument can be connected to the 3-phase and single phase network.

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

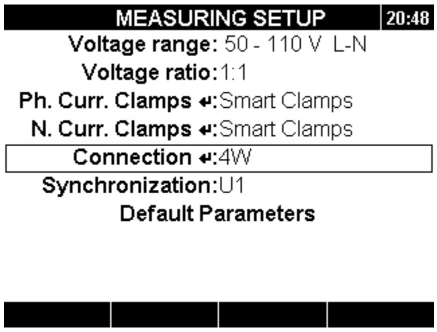


Figure 4.1: Measuring configuration menu

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.

3-phase 4-wire system

In order to select this connection scheme, choose following connection on the instrument:

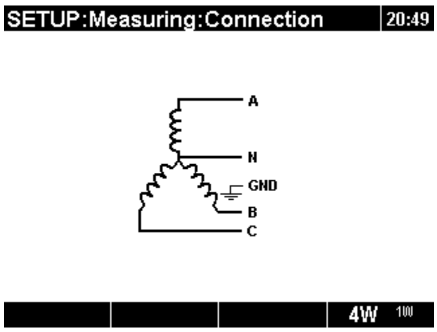


Figure 4.2: Choosing 3-phase 4-wire system on instrument

Instrument should be connected to the network according to figure bellow:

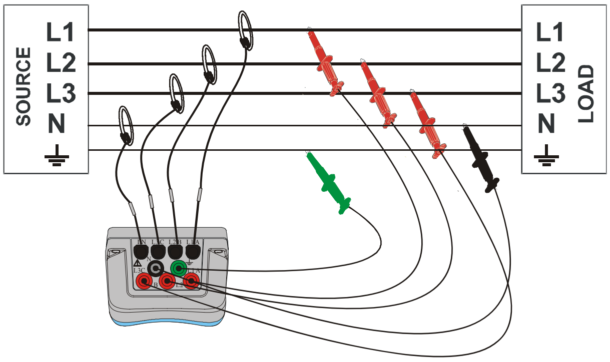


Figure 4.3: 3-phase 4-wire system

3-phase 4-wire system

In order to select this connection scheme, choose following connection on the instrument:

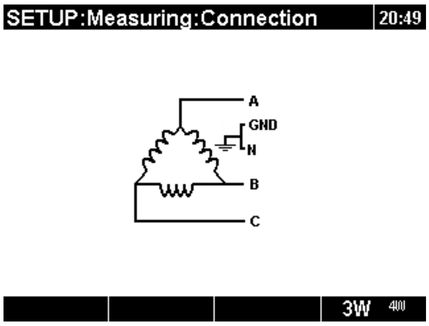


Figure 4.4: Choosing 3-phase 3-wire system on instrument

Instrument should be connected to the network according to figure bellow.

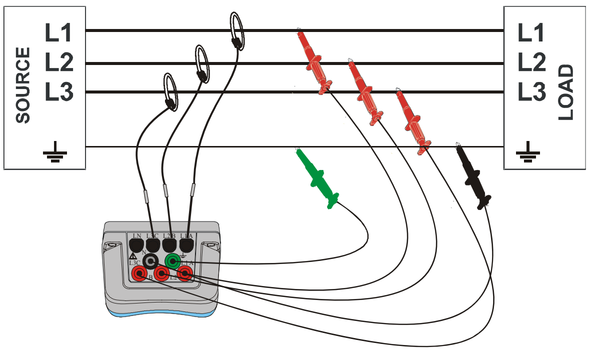


Figure 4.5: 3-phase 3-wire system

1-phase 3-wire system

In order to select this connection scheme, choose following connection on the instrument:

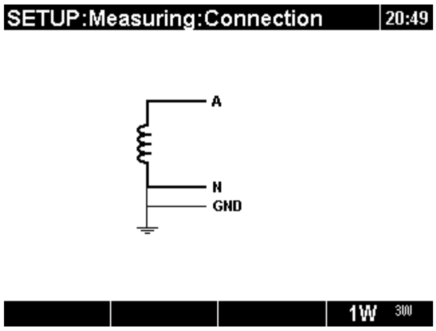


Figure 4.6: Choosing 1-phase 3-wire system on instrument

Instrument should be connected to the network according to figure bellow.

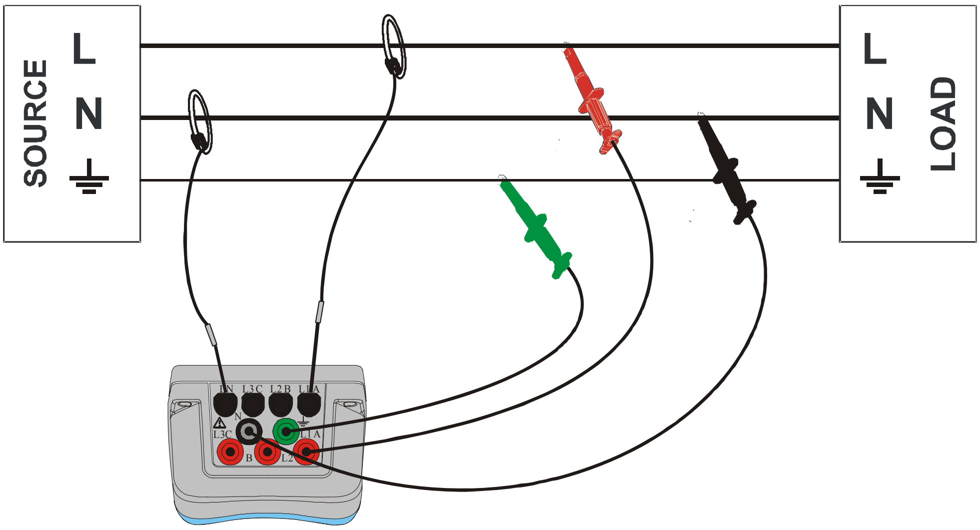


Figure 4.7: 1-phase 3-wire system

Note: In case of events capturing, it is recommended to connect unused voltage inputs to N voltage input.

4.2.2 Connection to the MV or HV Power System

In systems where voltage is measured at the secondary side of a voltage transformer (say 11 kV / 110 V), the instrument voltage range should be set to 50÷110V and scaling factor of that voltage transformer ratio has to be entered in order to ensure correct measurement. In the next figure settings for this particular example is shown.

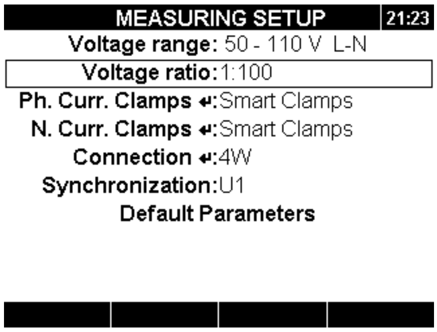


Figure 4.8: Voltage ratio for 11kV/110kV transformer example

Instrument should be connected to the network according to figure bellow.

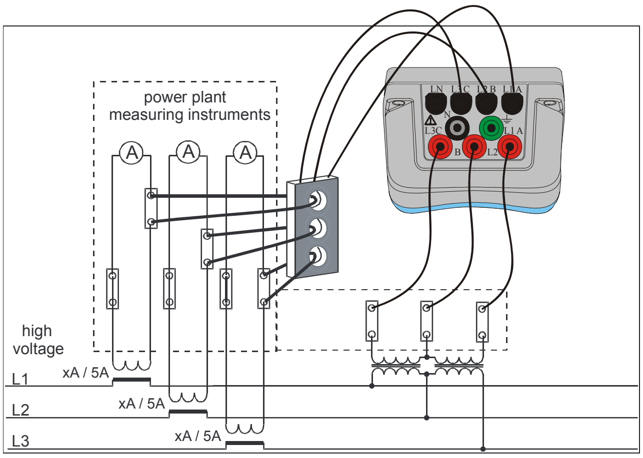


Figure 4.9: Connecting instrument to the existing current transformers in medium voltage system

4.2.3 Current clamp selection and transformation ratio setting

Clamp selection can be explained by two typical use cases: **direct current measurement** and **indirect current measurement.** In next section recommended practice for both cases is shown.

Direct current measurement with clamp-on current transformer

In this type of measurement load/generator current is measured directly with one of clap-on current transformer. Current to voltage conversion is *performed* **directly** by the clamps.
Direct current measurement can be *performed* by any clamp-on current transformer. We particularly recommend: flex clamps A 1227 and iron clamps A 1281. Also older Metrel models A 1033 (1000A), A1069 (100A), A1120 (3000A), A1099 (3000A), etc.. can be used.

In the case of large loads there can be few parallel feeders which can’t be embraced by single clamps. In this case we can measure current only through one feeder as shown on figure bellow.

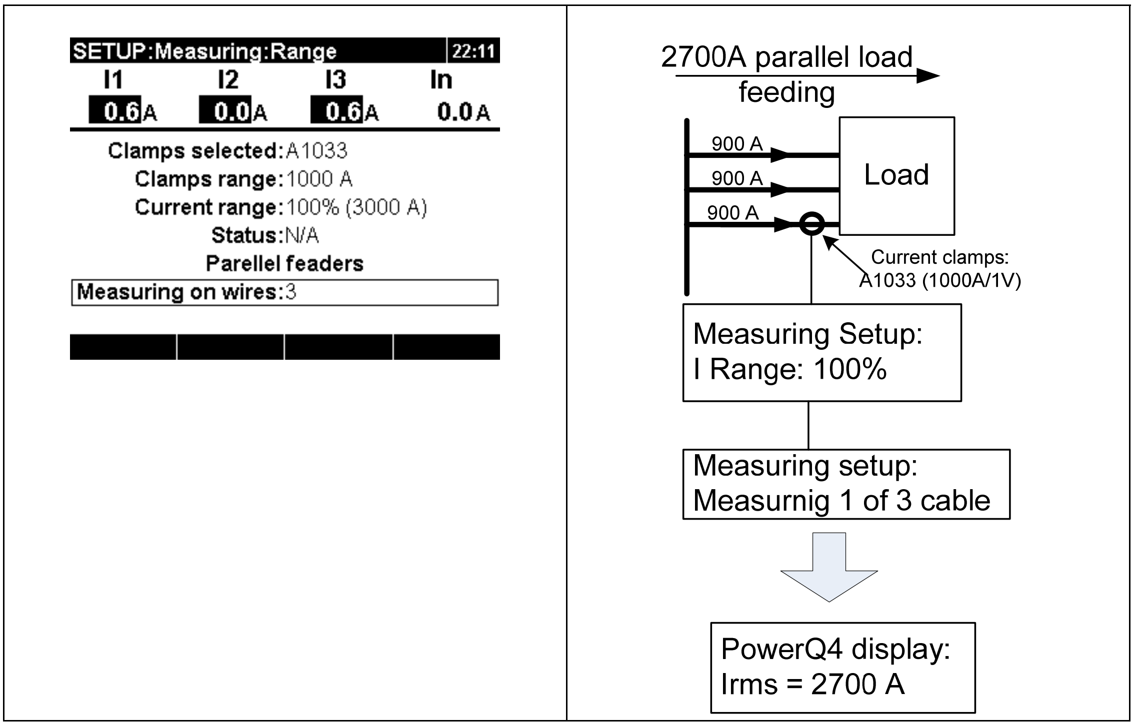


Figure 4.10: Parallel feeding of large load

Example: 2700 A current load is feed by 3 equal parallel cables. In order to measure current we can embrace only one cable with clamps, and select: Measuring on wires: 3 in clamp menu. Instrument will assume that we measure only third part of current.
Note: During setup current range can be observed by "Current range: 100% (3000 A)" row.

Indirect current measurement

Indirect current measurement with primary current transducer is assumed if we select 5A current clamps: A 1122 or A 1037. Load current is that case measured **indirectly** through additional primary current transformer.
In **example** if we have 100A of primary current flowing through primary transformer with ratio 600A:5A, settings are shown in following figure.

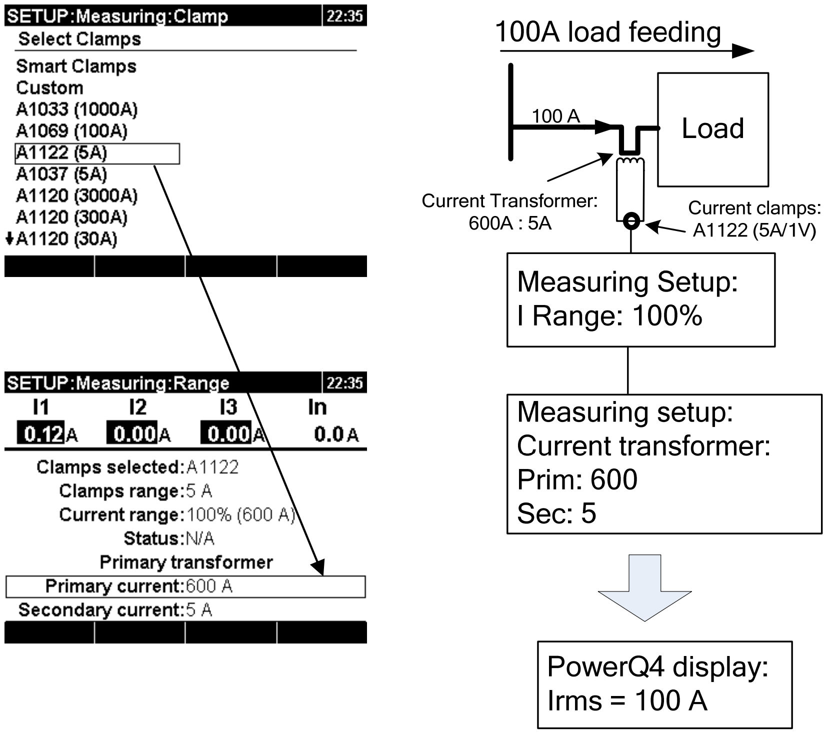


Figure 4.11: Current clamps selection for indirect current measurement

Over-dimensioned current transformer

Installed current transformers on the field are usually over-dimensioned for “possibility to add new loads in future”. In that case current in primary transformer can be less than 10% of rated transformer current. For such cases it is recommended to select 10% current range as shown on figure bellow.

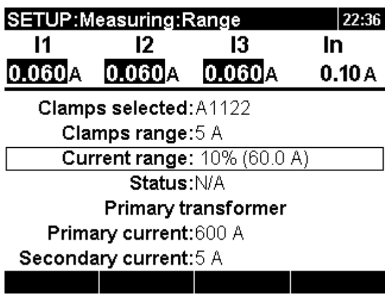


Figure 4.12: Selecting 10% of current clamps

Note that if we want to perform direct current measure with 5 A clamps, primary transformer ratio should be set to 5 A : 5 A.

WARNING !

- **The secondary winding 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.**

Automatic current clamps recognition

Metrel developed Smart current clams product family in order to simplify current clamps selection and settings. Smart clams are multi-range switch-less current clamps automatically recognized by instrument. In order to activate smart clamp recognition, following procedure should be followed for the first time:

1. Turn on instrument
2. Connect clamps (in example A 1227) into PowerQ4
3. Enter: Setup ➔ Measuring setup ➔ Current Clamps menu
4. Select: Smart clamps
5. Clamps type will be automatically recognized by the instrument.
6. User should then select clamp range and confirm settings

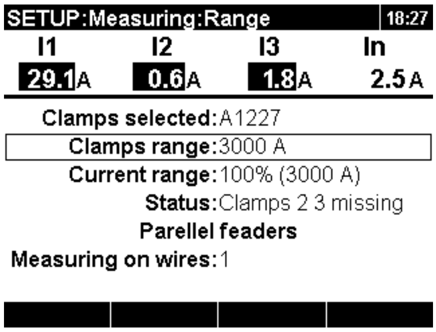


Figure 4.13: Automatically recognised clamps setup

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 recognize clamps automatically and set up ranges as was settled on measurement before. If clamps were disconnected following pop up will appear on the screen.

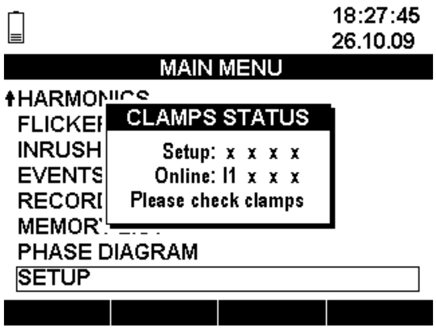


Figure 4.14: Automatically recognized clamps setup

Note: Do not disconnect automatic clamps during recording or measurement. Clamps range will be reset if clamps are plugged out of the instrument.

4.3 Number of measurements and connection type relationship

PowerQ4 displaying and measurement, mainly depends on network type, defined in MEASUREMENT SETUP menu, Connection type. In example if user choose single phase connection system, only measurement relate to single phase system will be present. Table bellows show dependencies between measurement parameters and type of network.

Table 4.1: Quantities measured by instrument

		Connection type		
Value		**1W**	**3W**	**4W**
U, I, f	**RMS**	U_{1rms} U_{Nrms}	U_{12rms} U_{23rms} U_{32rms}	U_{1rms} U_{2rms} U_{3rms} U_{Nrms} U_{12rms} U_{23rms} U_{32rms}
	THD	THD_{U1} THD_{UN}	THD_{U12} THD_{U23} THD_{U31}	THD_{U1} THD_{U2} THD_{U3} THD_{UN} THD_{U12} THD_{U23} THD_{U31}
	Cf	CfU_1 CfU_N	CfU_{12} CfU_{23} CfU_{32}	CfU_1 CfU_2 CfU_3 CfU_N CfU_{12} CfU_{23} CfU_{31}
	RMS	I_{1rms} I_{Nrms}	I_{1rms} I_{2rms} I_{3rms}	I_{1rms} I_{2rms} I_{3rms} I_{Nrms}
	THD	THD_{I1} THD_{IN}	THD_{I1} THD_{I2} THD_{I3}	THD_{I1} THD_{I2} THD_{I3} THD_{IN}
	Cf	CfI_1 CfI_N	CfI_1 CfI_2 CfI_3	CfI_1 CfI_2 CfI_3 CfI_N
	freq	$freqU_1$ $freqI_1$	$freqU_{12}$ $freqI_1$	$freqU_1$ $freqI_1$
Power & Energy	**P**	$\pm P_1$	$\pm P_{tot}$	$\pm P_1$ $\pm P_2$ $\pm P_3$ $\pm P_{tot}$
	Q	$\pm Q_1$	$\pm Q_{tot}$	$\pm Q_1$ $\pm Q_2$ $\pm Q_3$ $\pm Q_{tot}$
	S	S_1	S_{tot}	S_1 S_2 S_3 S_{tot}
	PF	$\pm PF_1$	$\pm PF_{tot}$	$\pm PF_1$ $\pm PF_2$ $\pm PF_3$ $\pm PF_{tot}$
	DPF	$\pm DPF_1$		$\pm DPF_1$ $\pm DPF_2$ $\pm DPF_3$ $\pm DPF_{tot}$
Flicker	**Pst (1min)**	Pst_{1min1}	Pst_{1min12} Pst_{1min23} Pst_{1min31}	Pst_{1min1} $Pst_{1min\,2}$ $Pst_{1min\,3}$
	Pst	Pst_1	Pst_{12} Pst_{23} Pst_{31}	Pst_1 Pst_2 Pst_3
	Plt	Plt_1	Plt_{12} Plt_{23} Plt_{31}	Plt_1 Plt_2 Plt_3
Unbalance	**%**	-	u^- i^-	u^0 i^0 u^- i^-
	RMS		U^+ U^- I^+ I^-	U^+ U^- U^0 I^+ I^- I^0
Harmonics	**$Uh_{1\div50}$**	$U_1h_{1\div50}$ $U_Nh_{1\div50}$	$U_{12}h_{1\div50}$ $U_{23}h_{1\div50}$ $U_{31}h_{1\div50}$	$U_1h_{1\div50}$ $U_2h_{1\div50}$ $U_3h_{1\div50}$ $U_Nh_{1\div50}$
	$Ih_{1\div50}$	$I_1h_{1\div50}$ $I_Nh_{1\div50}$	$I_1h_{1\div50}$ $I_2h_{1\div50}$ $I_1h_{1\div50}$	$I_1h_{1\div50}$ $I_2h_{1\div50}$ $I_3h_{1\div50}$ $I_Nh_{1\div50}$

Note: Frequency measurement depends on synchronization (reference) channel, which can be voltage or current.

In the same manner recording quantities are related to connection type too. When user selects Signals in RECORDER menu, channels selected for recording are chosen according to the Connection type, according to the next table.

Table 4.2: Quantities recorder by instrument

		Value	1-phase	3W	4W
U, I, f	Voltage	RMS	U_{1Rms} U_{NRms}	U_{12Rms} U_{23Rms} U_{32Rms}	U_{1Rms} U_{2Rms} U_{3Rms} U_{NRms} U_{12Rms} U_{23Rms} U_{32Rms}
		THD	THD_{U1} THD_{UN}	THD_{U12} THD_{U23} THD_{U31}	THD_{U1} THD_{U2} THD_{U3} THD_{UN} THD_{U12} THD_{U23} THD_{U31}
		CF	CfU_1 CfU_N	CfU_{12} CfU_{23} CfU_{32}	CfU_1 CfU_2 CfU_3 CfU_N CfU_{12} CfU_{23} CfU_{31}
	Current	RMS	I_{1rms} I_{Nrms}	I_{1rms} I_{2rms} I_{3rms}	I_{1rms} I_{2rms} I_{3rms} I_{Nrms} I_{NCrms}
		THD	THD_{I1} THD_{IN}	THD_{I1} THD_{I2} THD_{I3}	THD_{I1} THD_{I2} THD_{I3} THD_{IN}
		CF	CfI_1 CfI_N	CfI_1 CfI_2 CfI_3	CfI_1 CfI_2 CfI_3 CfI_N
	Frequency	f	$freqU_1$ | $freqI_1$	$freqU_{12}$| $freqI_1$	$freqU_1$ | $freqI_1$
Power & Energy	Power	P	P_1^+ P_1^-	P_{tot}^+ P_{tot}^-	P_1^+ P_1^- P_2^+ P_2^- P_3^+ P_3^- P_{tot}^+ P_{tot}^-
		Q	Q_1^{i+} Q_1^{c+} Q_1^{i-} Q_1^{c-}	Q_{tot}^{i+} Q_{tot}^{c+} Q_{tot}^{i-} Q_{tot}^{c-}	Q_1^{i+} Q_1^{c+} Q_1^{i-} Q_1^{c-} Q_2^{i+} Q_2^{c+} Q_2^{i-} Q_2^{c-} Q_3^{i+} Q_3^{c+} Q_3^{i-} Q_3^{c-} Q_{tot}^{i+} Q_{tot}^{c+} Q_{tot}^{i-} Q_{tot}^{c-}
		S	S_1^+ S_1^-	S_{tot}^+ S_{tot}^-	S_1^+ S_1^- S_2^+ S_2^- S_3^+ S_3^- S_{tot}^+ S_{tot}^-
	Energy	eP	eP_1^+ eP_1^-	eP_{tot}^+ eP_{tot}^-	eP_1^+ eP_1^- eP_2^+ eP_2^- eP_3^+ eP_3^- eP_{tot}^+ eP_{tot}^-
		eQ	eQ_1^{i+} eQ_1^{c+} eQ_1^{i-} eQ_1^{c-}	eQ_{tot}^{i+} eQ_{tot}^{c+} eQ_{tot}^{i-} eQ_{tot}^{c-}	eQ_1^{i+} eQ_1^{c+} eQ_2^{i+} eQ_2^{c+} eQ_3^{i+} eQ_3^{c+} eQ_{tot}^{i+} eQ_{tot}^{c+} eQ_1^{i-} eQ_1^{c-} eQ_2^{i-} eQ_2^{c-} eQ_3^{i-} eQ_3^{c-} eQ_{tot}^{i-} eQ_{tot}^{c-}
		eS	eS_1^+ eS_1^-	eS_{tot}^+ eS_{tot}^-	eS_1^+ eS_1^- eS_2^+ eS_2^- eS_3^+ eS_3^- eS_{tot}^+ eS_{tot}^-
	Power factor	Pf	PF_1^{i+} PF_1^{c+} PF_1^{i-} PF_1^{c-}	PF_{tot}^{i+} PF_{tot}^{c+} PF_{tot}^{i-} PF_{tot}^{c-}	PF_1^{i+} PF_1^{c+} PF_2^{i+} PF_2^{c+} PF_3^{i+} PF_3^{c+} PF_{tot}^{i+} PF_{tot}^{c+} PF_1^{i-} PF_1^{c-} PF_2^{i-} PF_2^{c-} PF_3^{i-} PF_3^{c-} PF_{tot}^{i-} PF_{tot}^{c-}
		DPF	DPF_1^{i+} DPF_1^{c+} DPF_1^{i-} DPF_1^{c-}	-	DPF_1^{i+} DPF_1^{c+} DPF_2^{i+} DPF_2^{c+} DPF_3^{i+} DPF_3^{c+} $DdPF_1^{i-}$ DPF_1^{c-} DPF_2^{i-} DPF_2^{c-} DPF_3^{i-} DPF_3^{c-}
Flicker		Pst (1min)	Pst_{1min1}	Pst_{1min12} Pst_{1min23} Pst_{1min31}	Pst_{1min1} Pst_{1min2} Pst_{1min3}
		Pst (10min)	Pst_1	Pst_{12} Pst_{23} Pst_{31}	Pst_1 Pst_2 Pst_3
		Plt (2h)	Plt_1	Plt_{12} Plt_{23} Plt_{31}	Plt_1 Plt_2 Plt_3
Unbalance		%	-	u^- i^-	u^0 i^0 u^- i^-
Harmonics		$Uh_{1\div50}$	$U_1h_{1\div50}$ $U_Nh_{1\div50}$	$U_{12}h_{1\div50}$ $U_{23}h_{1\div50}$ $U_{31}h_{1\div50}$	$U_1h_{1\div50}$ $U_2h_{1\div50}$ $U_3h_{1\div50}$ $U_Nh_{1\div50}$
		$Ih_{1\div50}$	$I_1h_{1\div50}$ $I_Nh_{1\div50}$	$I_1h_{1\div50}$ $I_2h_{1\div50}$ $I_1h_{1\div50}$	$I_1h_{1\div50}$ $I_2h_{1\div50}$ $I_3h_{1\div50}$ $I_Nh_{1\div50}$

5 Theory and internal operation

This section contains basics theory of measuring functions and technical information of the internal operation of the PowerQ4 instrument, including descriptions of measuring methods and logging principles.

5.1 Measurement methods

5.1.1 Measurement aggregation over time intervals

Standard compliance: IEC 61000-4-30 Class S (Section 4.4)

The basic measurement time interval for:

- Voltage
- Current
- Active, reactive and apparent power
- Harmonics
- Unbalance

is 10-cycle time interval. The 10/12-cycle measurement is resynchronized on each Interval tick according to the IEC 61000-4-30 Class S. Measurement methods are based on the digital sampling of the input signals, synchronised to the fundamental frequency. Each input (4 voltages and 4 currents) is simultaneously sampled 1024 times in 10 cycles.

5.1.2 Voltage measurement (magnitude of supply voltage)

Standard compliance: IEC 61000-4-30 Class S (Section 5.2)

All voltage measurements represent RMS values of 1024 samples of the voltage magnitude over a 10-cycle time interval. Every 10 interval is contiguous, and not overlapping with adjacent 10 intervals.

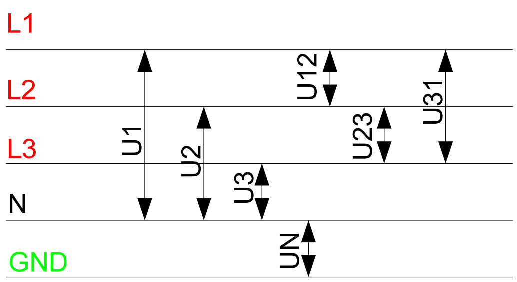


Figure 5.1: Phase and phase-to-phase (line) voltage

Voltage values are measured according to the following equation:

Phase voltage: $$U_p = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024} u_{p\,j}^{2}} \quad [V],\ p\text{: } 1,2,3,N \qquad (1)$$

Line voltage: $Upg = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024}(u_{p\,j} - u_{g\,j})^2}$ [V], *pg: 12,23,31* (2)

Phase voltage crest factor: $Cf_{Up} = \frac{U_{pPk}}{U_p}$, *p: 1,2,3,N* (3)

Line voltage crest factor: $Cf_{Upg} = \frac{U_{pgPk}}{U_{pg}}$, *pg: 12, 23, 31* (4)

The instrument has internally 3 voltage measurement ranges. Middle voltage (MV) and high voltage (HV) systems can be measured on lowest voltage range with assistance of voltage transformers. Its voltage factor should be entered into Voltage ratio: 1:1 variable in MEASURING SETUP menu.

5.1.3 Current measurement (magnitude of supply current)

Standard compliance: Class S (Section A.6.3)

All current measurements represent RMS values of the 1024 samples of current magnitude over a 10-cycle time interval. Each 10-cycle interval is contiguous and non-overlapping.
Current values are measured according to the following equation:

Phase current: $I_p = \sqrt{\frac{1}{1024}\sum_{j=1}^{1024} I_{p\,j}^2}$ [A], *p: 1,2,3,N* (5)

Phase current crest factor: $Ix_{cr} = \frac{Ix_{\max}}{Ix}$, *p: 1,2,3,N* (6)

The instrument has internally two current ranges: 10% and 100% range of nominal transducer current. Additionally Smart current clamps models offer few measuring ranges and automatic detection.

5.1.4 Frequency measurement

Standard compliance: IEC 61000-4-30 Class S (Section 5.1)

During RECORDING with aggregation time Interval: ≥10 sec frequency reading is obtained every 10 s. As power frequency may not be exactly 50 Hz within the 10 s time clock interval, the number of cycles may not be an integer number. The fundamental frequency output is the ratio of the number of integral cycles counted during the 10 s time clock interval, divided by the cumulative duration of the integer cycles. Harmonics and interharmonics are attenuated with 2-pole low pass filter in order to minimize the effects of multiple zero crossings.
The measurement time intervals are non-overlapping. Individual cycles that overlap the 10 s time clock are discarded. Each 10 s interval begin on an absolute 10 s time clock, with uncertainty as specified in 6.2.14.

For RECORDING with aggregation time Interval: <10 sec and on-line measurements, frequency reading is obtained from 10 cycles, in order to decrease instrument response time. The frequency is ratio of 10 cycle's, divided by the duration of the integer cycles.

Frequency measurement is *performed* on chosen "Synchronization channel", in "Measuring setup" menu.

5.1.5 Phase power measurements

Standard compliance: *IEEE STD 1459-2000 (Section 3.2.2.1; 3.2.2.2)*
IEC 61557-12 (Annex A)

All active power measurements represent RMS values of the 1024 samples of instantaneous power over a 10-cycle time interval. Each 10-cycle interval is contiguous and non-overlapping.

Phase active power: (7)

$$P_p = \frac{1}{1024}\sum_{j=1}^{1024} p_{pj} = \frac{1}{1024}\sum_{j=1}^{1024} U_{pj} * I_{pj}$$ [W], *p: 1,2,3*

Apparent and reactive power, power factor and displacement power factor (Cos φ) are calculated according to the following equations:

Phase apparent power: $S_p = U_p * I_p$ [VA], *p: 1,2,3* (8)

Phase reactive power: $Q_p = Sign(Q_p) \cdot \sqrt{S_p^2 - P_p^2}$ [VAr], *p: 1,2,3* (9)

Sign of reactive power: $Sign(Q_p) = \begin{cases} +1, \varphi_p \in [0^0 - 180^0] \\ -1, \varphi_p \in [180^0 - 360^0] \end{cases}$ *p: 1,2,3* (10)

Phase power factor: $PF_p = \frac{P_p}{S_p}$, *p: 1,2,3* (11)

Cos φ (Displ. factor): $Cos\varphi_p = Cos\varphi u_p - Cos\varphi i_p$, *p: 1,2,3* (12)

5.1.6 Total power measurements

Standard compliance: *IEEE STD 1459-2000 (Section 3.2.2.2; 3.2.2.6)*
IEC 61557-12 (Annex A)

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

Total active power: $Pt = P1 + P2 + P3$ [W], (13)

Total reactive power (vector): $Qt = Q1 + Q2 + Q3$ [VAr], (14)

Total apparent power (vector): $St = \sqrt{(Pt^2 + Qt^2)}$ [VA], (15) Total power factor (vector): $PFtot = \frac{Pt}{St}$. (16)

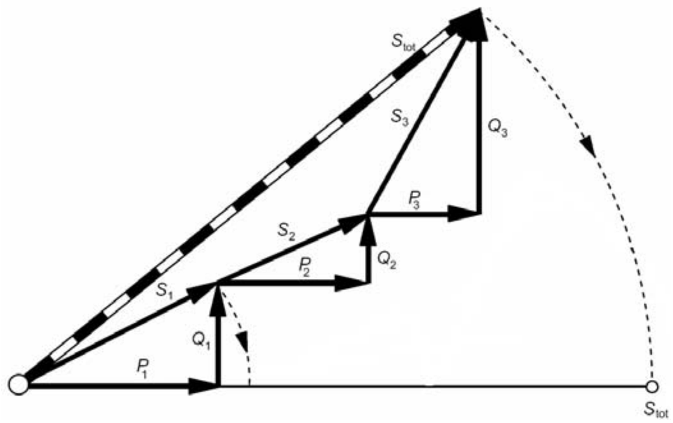


Figure 5.2: Vector representation of total power calculus

5.1.7 Energy

Standard compliance: IEC 61557-12 (Annex A)

Energy counters are linked to RECORDER functionality. Energy counters measure energy only when RECORDER is active. After power off/on procedure and before start of recording, all counters are cleared.
Instrument use 4-quadrant measurement technique which use two active energy counters (eP^+, eP^-) and two reactive (eQ^+, eQ^-), as shown on bellow.

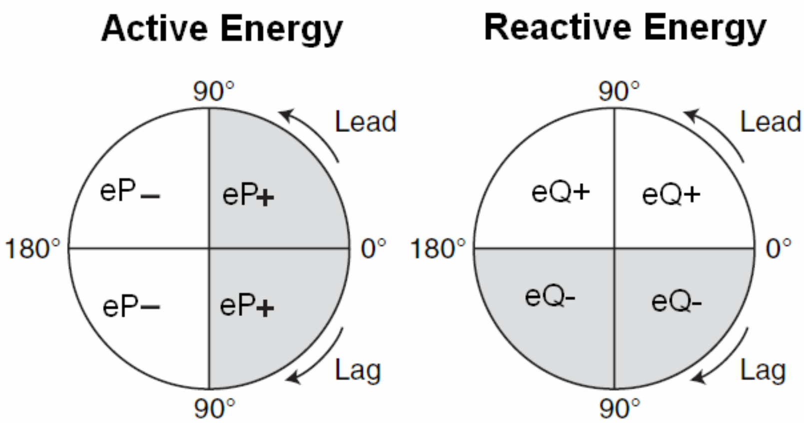


Figure 5.3: Energy counters and quadrant relationship

Instrument has 3 different counters sets:

1. Total counters TotEN are intended for measuring energy over a complete recording. When recorder starts it sums the energy to existent state of the counters.
2. Last integration period LastIP counter measures energy during recording over last interval. It is calculated at end of each interval.
3. Current integration period CurrIP counter measures energy during recording over current time interval.

5.1.8 Harmonics

Standard compliance: *IEC 61000-4-30 Class A and S (Section 5.7)*
IEC 61000-4-7 Class I

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.

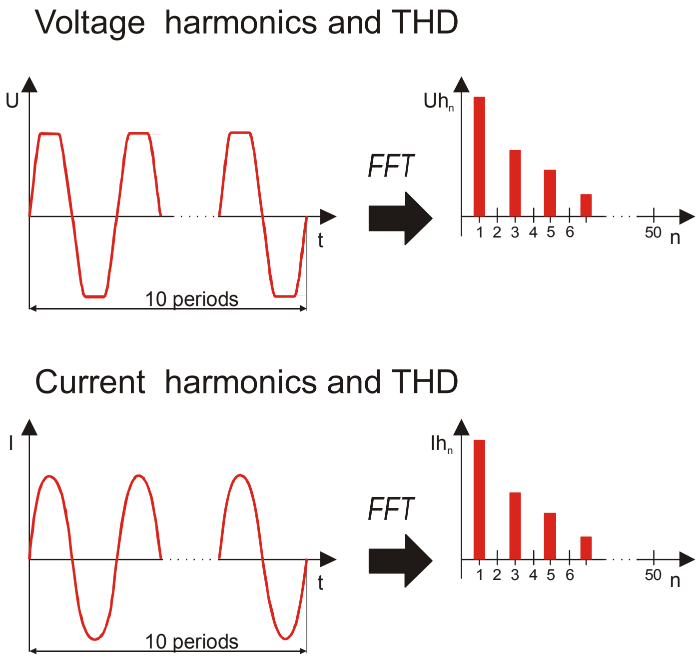


Figure 5.4: Current and voltage harmonics

$$u(t) = c_0 + \sum_{k=1}^{512} c_k \sin\left(\frac{k}{10} \cdot 2\pi f_1 t + \varphi_k\right) \qquad (17)$$

f_1 – frequency of signal fundamental (in example: 50 Hz)
c_0 – DC component
k – ordinal number (order of the spectral line) related to the frequency basis $f_{C1} = \frac{1}{T_N}$
T_N – is the width (or duration) of the time window (T_N = N*T_1; T_1 =1/f_1). Time window is that time span of a time function over which the Fourier transform is performed.
c_k – is the amplitude of the component with frequency $f_{Ck} = \frac{k}{10} f_1$
φ_k – is the phase of the component c_k
$U_{c,k}$ – is the RMS value of component c_k

Phase voltage and current harmonics are calculated as RMS value of harmonic subgroup *(sg)*: square root of the sum of the squares of the RMS value of a harmonic and the two spectral components immediately adjacent to it.

n-th voltage harmonic: $U_p h_n = \sqrt{\sum_{k=-1}^{1} U^2_{C,(10\cdot n)+k}}$ *p: 1,2,3* (18) n-th current harmonic: $I_p h_n = \sqrt{\sum_{k=-1}^{1} I_{C,(10 \cdot n+k)}^2}$ *p: 1,2,3* (19)

Total harmonic distortion is calculated as ratio of the RMS value of the harmonic subgroups to the RMS value of the subgroup associated with the fundamental:

Total voltage harmonic distortion: $THD_{U\,p} = \sqrt{\sum_{n=2}^{40} \left(\frac{U_p h_n}{U_p h_1} \right)^2}$ *, p: 1,2,3* (20)

Total current harmonic distortion: $THD_{Ip} = \sqrt{\sum_{n=2}^{50} \left(\frac{I_p h_n}{I_p h_1} \right)^2}$ *, p: 1,2,3* (21)

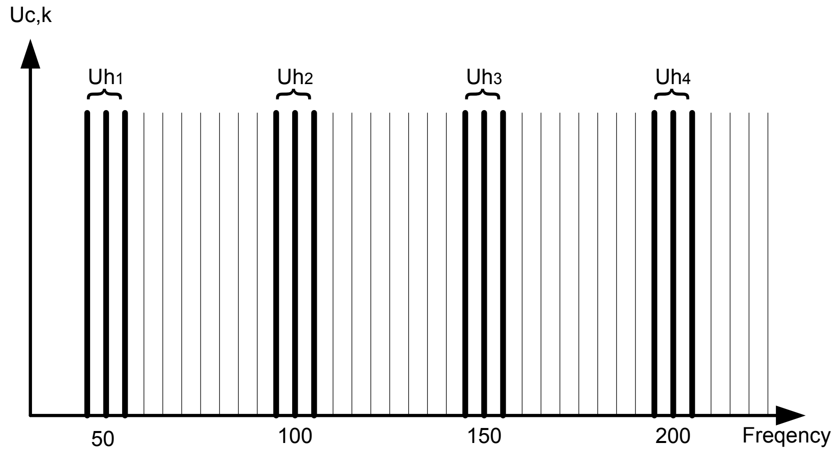


Figure 5.5: Illustration of harmonic subgroup for 50 Hz supply

5.1.9 Flicker

Standard compliance: *IEC 61000-4-30 Class S (Section 5.3)*
IEC 61000-4-15

Flicker is a visual sensation caused by unsteadiness of a light. The level of the sensation depends on the frequency and magnitude of the lighting change and on the observer.
Change of a lighting flux can be correlated to a voltage envelope on figure bellow.

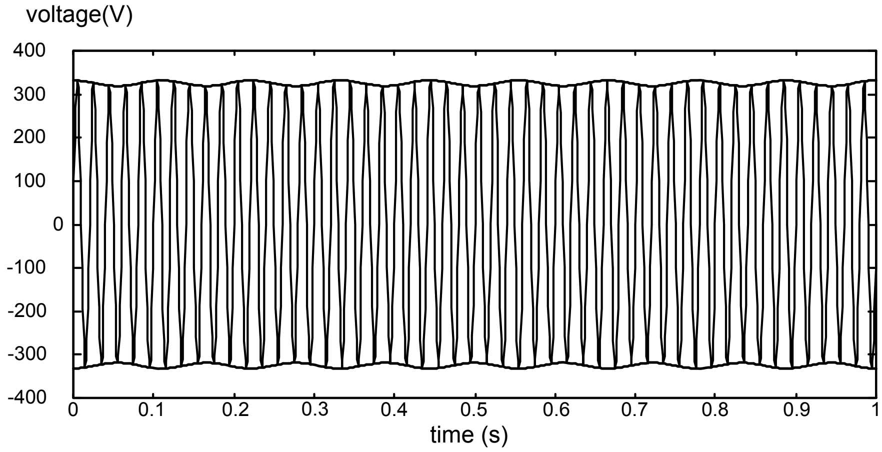


Figure 5.6: Voltage fluctuation

Flickers are measured in accordance with standard IEC 61000-4-15 "Flicker meter-functional and design specifications". It defines the transform function based on a 230V/60W lamp-eye-brain chain response. That function is a base for flicker meter implementation and is presented on figure bellow.

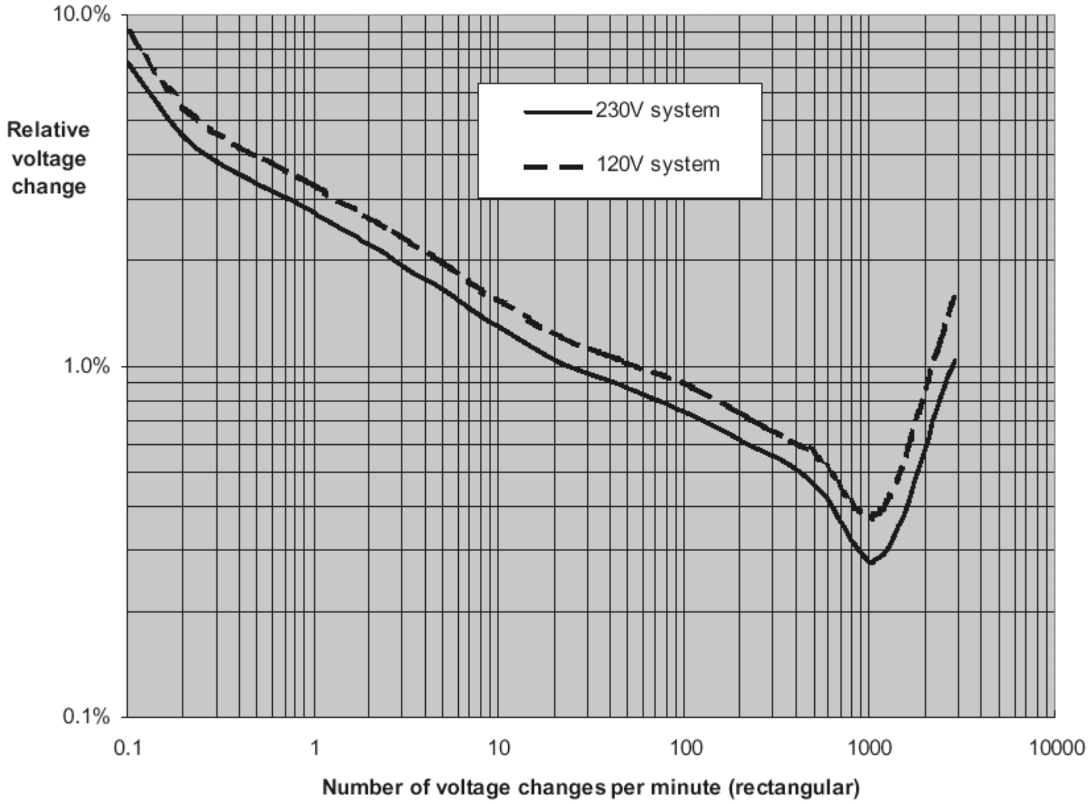


Figure 5.7: Curve of equal severity (Pst=1) for rectangular voltage changes on LV power supply systems

P_{st1min} – is a short flicker estimation based on 1-minute interval. It is calculated as running average and is used to get quick preview of 10 minutes.

P_{stp} – short term flicker is calculated according to IEC 61000-4-15

$$P_{ltp} = \sqrt[3]{\frac{\sum_{i=1}^{N} Pst_i^3}{N}} \quad p\text{: 1,2,3} \tag{22}$$

5.1.10 Voltage and current unbalance

Standard compliance: IEC 61000-4-30 Class A (Section 5.7.1)

The supply voltage unbalance is evaluated using the method of symmetrical components. In addition to the positive sequence component U^+, under unbalanced conditions there also exists negative sequence component U^- and zero sequence component U_0. These quantities are calculated according to the following equations:

$$\vec{U}^+ = \frac{1}{3}(\vec{U}_1 + a\vec{U}_2 + a^2\vec{U}_3) \tag{23}$$

$$\vec{U}_0 = \frac{1}{3}(\vec{U}_1 + \vec{U}_2 + \vec{U}_3),$$

$$\vec{U}^- = \frac{1}{3}(\vec{U}_1 + a^2\vec{U}_2 + a\vec{U}_3),$$

where $a = \frac{1}{2} + \frac{1}{2} j\sqrt{3} = 1e^{j120^0}$.

For unbalance calculus, instrument use the fundamental component of the voltage input signals (U_1, U_2, U_3), measured over a 10-cycle time interval.
The negative sequence ratio u^-, expressed as a percentage, is evaluated by:

$$u^-(\%) = \frac{U^-}{U^+} \times 100 \tag{24}$$

The zero sequence ratio u^0, expressed as a percentage, is evaluated by:

$$u^0(\%) = \frac{U^0}{U^+} \times 100 \tag{25}$$

Note: In 3W systems zero sequence component U_0 is by definition zero.

The supply current unbalance is evaluated in same fashion.

5.1.11 Voltage events

Voltage dips (U_{Dip}), swells (U_{Swell}), minimum ($U_{Rms(1/2)Min}$) and maximum ($U_{Rms(1/2)Max}$) measurement method

Standard compliance: IEC 61000-4-30 Class A& S (Section 5.4.1)
The basic measurement for event is $U_{Rms(1/2)}$.
$U_{Rms(1/2)}$ is value of the RMS voltage measured over 1 cycle, commencing at a fundamental zero crossing and refreshed each half-cycle.
The cycle duration for $U_{Rms(1/2)}$ depends on the frequency, which is determined by the last 10-cycle frequency measurement. The $U_{Rms(1/2)}$ value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

Voltage dip

Standard compliance: IEC 61000-4-30 Class S (Section 5.4.2)
The dip threshold is a percentage of Nominal voltage defined in EVENT SETUP menu. The dip threshold can be set by the user according to the use. Instrument event evaluation depends on Connection type:

- On single-phase systems, a voltage dip begins when the $U_{Rms(1/2)}$ voltage falls below the dip threshold, and ends when the $U_{Rms(1/2)}$ voltage is equal to or above the dip threshold plus the 2% of hysteresis voltage (see Figure 5.8)
- On three-phase systems two different evaluation techniques can be used for evaluation simultaneously:
    - a dip begins when the $U_{Rms(1/2)}$ voltage of one or more channels is below the dip threshold and ends when the $U_{Rms(1/2)}$ voltage on all measured channels is equal to or above the dip threshold plus the 2% of hysteresis voltage.
    - a voltage dip begins when the $U_{Rms(1/2)}$ voltage of one channel falls below the dip threshold, and ends when the $U_{Rms(1/2)}$ voltage is equal to or above the dip threshold plus the 2% of hysteresis voltage, on the same phase.

A voltage dip is characterized by a pair of data: residual voltage U_{Dip} and dip duration:

- U_{Dip} is the residual voltage, the lowest $U_{Rms(1/2)}$ value measured on any channel during the dip
- The start time of a dip is time stamped with the time of the start of the $U_{Rms(1/2)}$ of the channel that initiated the event, and the end time of the dip is time stamped with the time of the end of the $U_{Rms(1/2)}$ that ended the event, as defined by the threshold.
- The duration of a voltage dip is the time difference between the start time and the end time of the voltage dip.

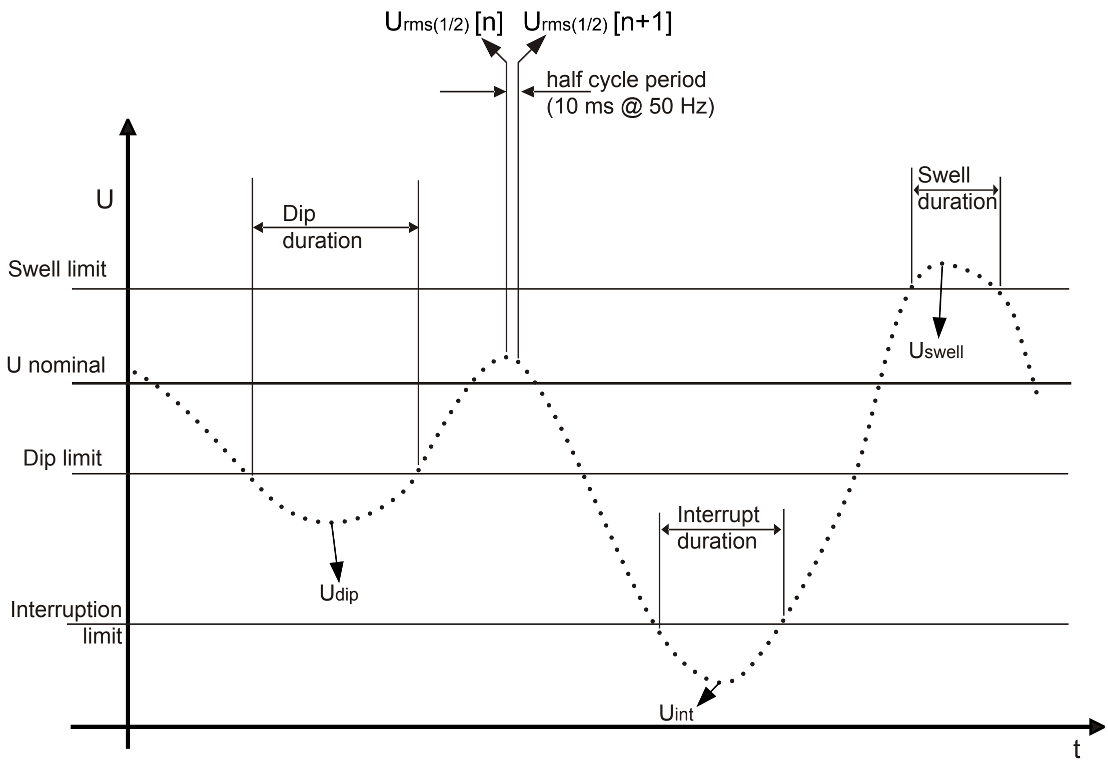


Figure 5.8 Voltage events definition

Voltage swell

Standard compliance: IEC 61000-4-30 Class S (Section 5.4.3)

The swell threshold is a percentage of nominal voltage defined in Voltage events setup menu. The swell threshold can be set by the user according to the use. Instrument permits swell evaluation:

- on single-phase systems, a voltage swell begins when the $U_{Rms(1/2)}$ voltage rises above the swell threshold, and ends when the U_{Rms} voltage is equal to or bellow the swell threshold plus the 2% of hysteresis voltage (see Figure 5.8),
- on three-phase systems two different evaluation techniques can be used for evaluation simultaneously:
  - A swell begins when the $U_{Rms(1/2)}$ voltage of one or more channels is above the swell threshold and ends when the $U_{Rms(1/2)}$ voltage on all measured channels is equal to or bellow the swell threshold plus the 2% of hysteresis voltage.
  - A swell begins when the $U_{Rms(1/2)}$ voltage of one channel rises above the swell threshold, and ends when the $U_{Rms(1/2)}$ voltage is equal to or bellow the swell threshold plus the 2% of hysteresis voltage, on the same phase.

A voltage swell is characterized by a pair of data: maximum swell voltage magnitude, and duration:

- U_{Swell} – maximum swell magnitude voltage is the largest $U_{Rms(1/2)}$ value measured on any channel during the swell.
- The start time of a swell is time stamped with the time of the start of the $U_{Rms(1/2)}$ of the channel that initiated the event and the end time of the swell is time stamped with the time of the end of the $U_{Rms(1/2)}$ that ended the event, as defined by the threshold.
- The duration of a voltage swell is the time difference between the beginning and the end of the swell.

Voltage interrupt

Standard compliance: IEC 61000-4-30 Class A & S (Section 5.5)

Measuring method for voltage interruptions detection is same as for dips and swells, and is described in previous sections.
The interrupt threshold is a percentage of nominal voltage defined in Voltage events setup menu. The interrupt threshold can be set by the user according to the use. Instrument permits interrupt evaluation:

- On single-phase systems, a voltage interruption begins when the $U_{Rms(1/2)}$ voltage falls below the voltage interruption threshold and ends when the $U_{Rms(1/2)}$ value is equal to, or greater than, the voltage interruption threshold plus the hysteresis (see Figure 5.8),
- on polyphase systems two different evaluation techniques can be used for evaluation simultaneously:
  - a voltage interruption begins when the $U_{Rms(1/2)}$ voltages of all channels fall below the voltage interruption threshold and ends when the $U_{Rms(1/2)}$ voltage on any one channel is equal to, or greater than, the voltage interruption threshold plus the hysteresis.
  - a voltage interrupt begins when the $U_{Rms(1/2)}$ voltage of one channel fall below the interrupt threshold, and ends when the $U_{Rms(1/2)}$ voltage is equal to or above the interrupt threshold plus the 2% of hysteresis voltage, on the same phase.

A voltage interrupt is characterized by a pair of data: minimal interrupt voltage magnitude, and duration:

- U_{Int} – minimum interrupt magnitude voltage is the lowers $U_{Rms(1/2)}$ value measured on any channel during the interrupt.
- The start time of a interrupt is time stamped with the time of the start of the $U_{Rms(1/2)}$ of the channel that initiated the event, and the end time of the interrupt is time stamped with the time of the end of the $U_{Rms(1/2)}$ that ended the event, as defined by the threshold.
- The duration of a voltage dip is the time difference between the start time and the end time of the voltage dip.

5.1.12 Alarms

Generally alarm can be seen as an event on arbitrary quantity. Alarms are defined in alarm table (see section 3.12.3 for alarm table setup). The basic measurement time interval for: voltage, current, active, reactive and apparent power, harmonics and unbalance alarms is 10-cycle time interval. Flicker alarms are evaluated according to the flicker algorithm (Pst_{1min}>1min, Pst > 10min, Plt > 10min).

Each alarm has attributes described in table bellow. Alarm occurs when 10-cycle measured value on phases defined as **Phase,** cross **Threshold value** according to defined **Trigger slope,** minimally for **Minimal duration** value.

Table 5.1: Alarm definition parameters

Quantity	• Voltage • Current • Frequency • Active, reactive and apparent power • Harmonics • Unbalance Flickers
Phase	L1, L2, L3, L12, L23, L31, All, Tot
Trigger slope	< - Fall , > - Rise
Threshold value	[Number]
Minimal duration	200ms ÷ 10min

Each captured alarm is described by following parameters

Table 5.2: Alarm signatures

Date	Date when selected alarm has occurred
Start	Alarm start time - when first value cross threshold.
Phase	Phase on which alarm occurred
Level	Minimal or maximal value in alarm
Duration	Alarm duration.

5.1.13 Data aggregation in RECORDING

Standard compliance: IEC 61000-4-30 Class S (Section 4.5.3)

Time aggregation period (IP) during recording is defined with parameter Interval: x min in RECORDER menu.

A new recording interval commence after previous interval run out, at the beginning of the next 10 cycle time interval. The data for the IP time interval are aggregated from 10-cycle time intervals, according to the figure bellow. The aggregated interval is tagged with the absolute time. The time tag is the time at the conclusion of the interval. There is no gap or overlap, during recording, as illustrated on figure bellow.

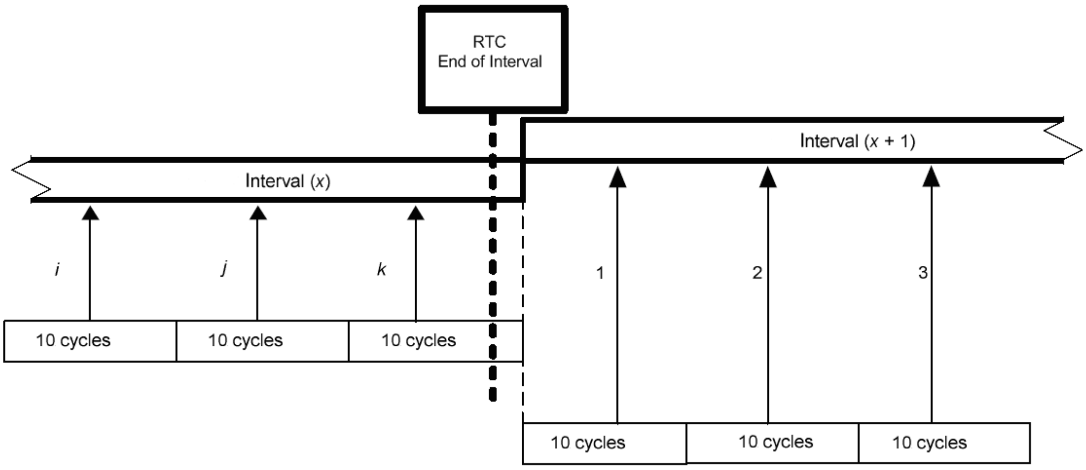


Figure 5.9: Synchronization and aggregation of 10 cycle intervals

For each aggregation interval instrument computes average value for measured quantity. Depending from the quantity, this can be (root means square) or arithmetical average. Equations for both averages are shown bellow.

RMS average $$A_{RMS} = \sqrt{\frac{1}{N}\sum_{j=1}^{N} A_j^2} \quad , \qquad (26)$$

Where:
A_{RMS} – quantity average over given aggregation interval
A – 10-cycle quantity value
N – number of 10 cycles measurements per aggregation interval.

Arithmetic average: $$A_{avg} = \frac{1}{N}\sum_{j=1}^{N} A_j \qquad (27)$$

Where:
A_{avg} – quantity average over given aggregation interval
A – 10-cycle quantity value
N – number of 10 cycles measurements per aggregation interval.

In the next table averaging method for each quantity is specified:

Table 5.3: Data aggregation methods

Group	Value	Aggregation method
Voltage	U_{Rms}	RMS
	THD_U	RMS
	U_{cf}	Arithmetic
Current	I_{Rms}	RMS

	THD_I	RMS
	I_{cf}	Arithmetic
Frequency	f	Arithmetic
Power	P	Arithmetic
	Q	Arithmetic
	S	Arithmetic
	PF	Arithmetic
	DPF (cos φ)	Arithmetic
Symmetry	U^+	RMS
	U^-	RMS
	U^0	RMS
	u-	RMS
	u0	RMS
Harmonics	$Uh_{1÷50}$	RMS
	$Ih_{1÷50}$	RMS

Parameter which will be recorded during recording session depends on Connection and synchronization channel, as shown in Table 4.2. For each parameter:

- minimum,
- average,
- maximum,
- active average,

value is recorded per time-interval.

An *active average* value is calculated upon the same principle (arithmetic or RMS) as average value, but taking in account just measurements with "active" attribute set:

RMS active average

$$A_{RMSact} = \sqrt{\frac{1}{M}\sum_{j=1}^{M} A_j^2}\ ;\ M \le N \tag{28}$$

Where:
A_{RMSact} – quantity average over active part of given aggregation interval,
A – 10-cycle quantity value marked as "active",
M – number of 10 cycles measurements with active value.

Arithmetic active average:

$$A_{avgact} = \frac{1}{M}\sum_{j=1}^{M} A_j\ ;\ M \le N \tag{29}$$

Where:
A_{avgact} – quantity average over active part of given aggregation interval,
A – 10-cycle quantity value in "active" part of interval,
M – number of 10 cycles measurements with active value.

Active attribute for particular quantity is set if:

- Phase/line RMS value is greater than lower limit of a measuring range (details in technical specification): voltage and current effective value, harmonics and THD, voltage flicker.
- Type of a load coincides with two- or four-quadrant area (details in *Power and energy recording*): active, reactive and apparent power, power factor and displacement power factor.

Frequency and unbalance measurement are always considered as active values for recording.
Table bellows show number of signal for each parameter group in RECORDER.

Table 5.4: Total number of recorded quantities

	1W	3W	4W
U,I,f	13 quantities 52 values per interval	20 quantities 80 values per interval.	35 quantities 140 values per interval.
Power & Energy	16 quantities 64 values per interval	12 quantities 48 values per interval	60 quantities 240 values per interval
Flicker	3 quantities 12 values per interval	9 quantities 36 values per interval	9 quantities 36 values per interval
Symmetry	–	2 quantities 8 values per interval	4 quantities 16 values per interva
Harmonics	202 quantities 800	303 quantities 1212 values per interval	416 quantities 1628 values per interval
Total	235	347	517

5.1.14 Power and energy recording

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:

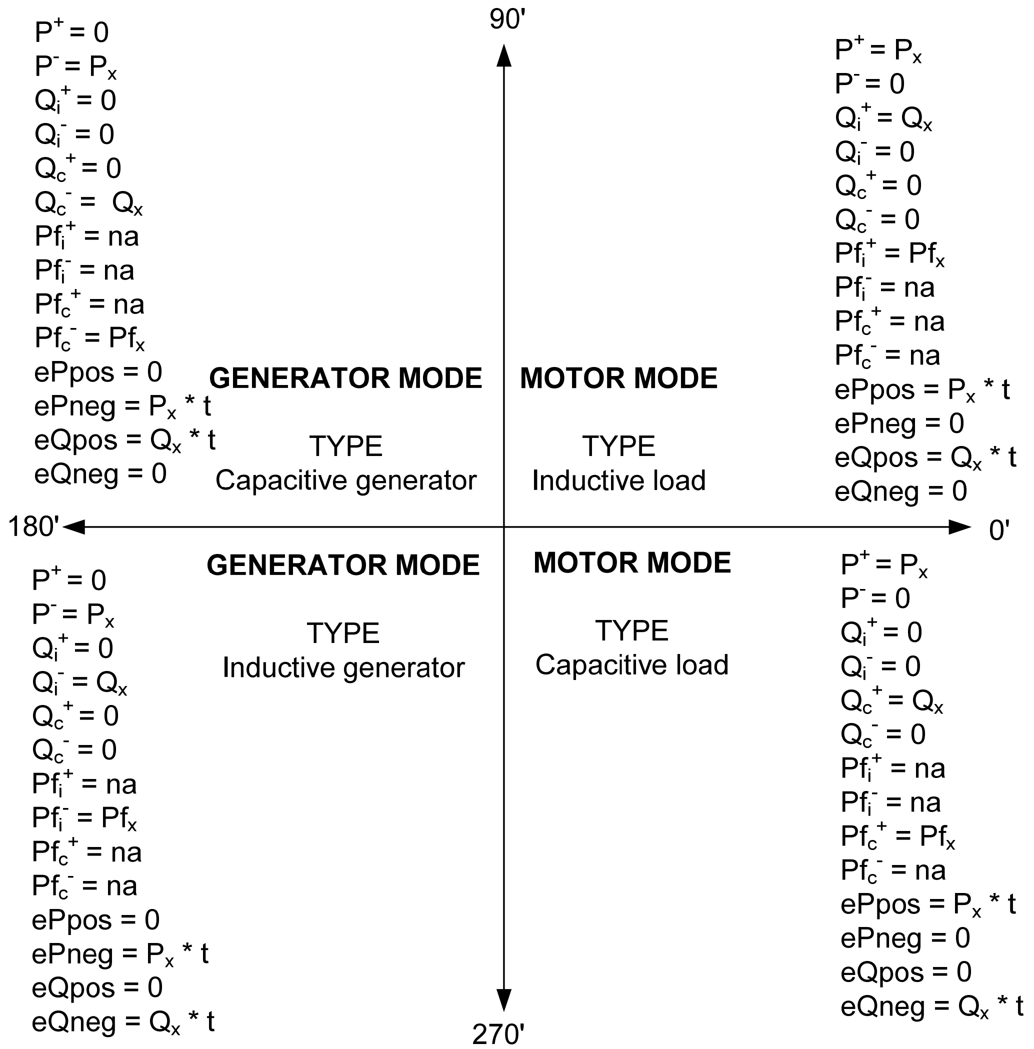


Figure 1: Motor/generator and inductive/capacitive phase/polarity diagram

5.1.15 Waveform snapshoot

During measurement campaign PowerQ4 has ability to take waveform snapshot. This is particularly useful for memorizing characteristic or extreme network behavior. Instruments internally store 10 cycles of samples which can be later observed with MEMORY LIST menu (see 3.11) or with PowerView.

Each Waveform snapshoot store:

- all displayed measurement for particular connection type (see section 4.3 for details)
- 10 cycles (1024 samples) of all measurement signals

5.1.16 Inrushes

Inrush logger is intended for analysis of voltage and current fluctuations during start of motor or other high power consumers. $I_{½Rms}$ values per 10 ms (half period) are measured and average is logged in each preset interval. Inrush logger starts when the preset trigger occurs.

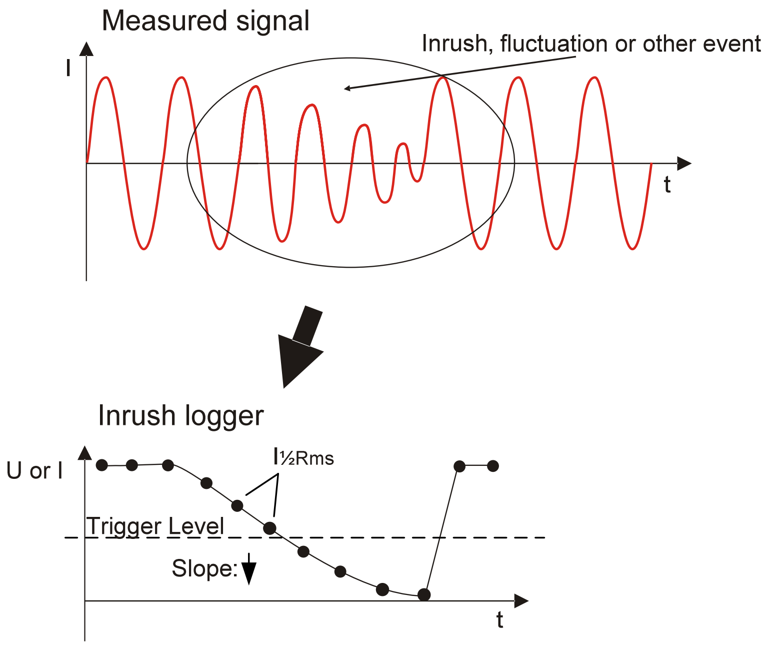
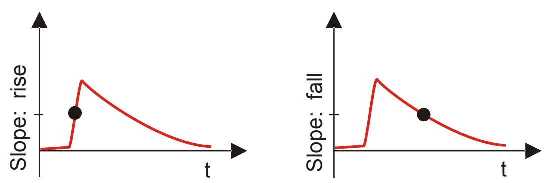


Figure 5.10: Inrush (waveform and RMS)

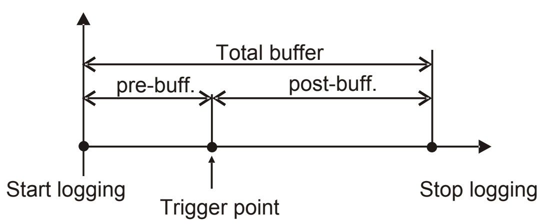
Inrush logging starts when the trigger even occurs. Storage buffer is divided into pre-buffer (measured values before trigger point) and post-buffer (measured values after trigger point).

Triggering



Input: I_1, I_2, I_3, I_N - trigger channels
Level: predefined TRMS value
Slope: rise / fall

Pre-buffer and post-buffer



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

Figure 5.11: Inrush triggering

5.2 EN 50160 Standard Overview

EN 50160 standard define, describes and specifies the main characteristics of the voltage at a network user's supply terminals in public low voltage and medium voltage 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 do not describe the average situation usually experienced by an individual network user. An overview of EN 50160 limits are presented on table bellow.

Table 5.5: EN 50160 standard overview

Supply voltage phenomenon	Acceptable limits	Meas. Interval	Monitoring Period	Acceptance Percentage
Power frequency	49.5 ÷ 50.5 Hz 47.0 ÷ 52.0 Hz	10 s	1 Week	99,5% 100%
Supply voltage variations, U_{Nom}	230V ± 10%	10 min	1 Week	95%
	230V +10% -15%			100%
Flicker severity Plt	Plt ≤ 1	2 h	1 Week	95%
Voltage Dips (≤1min)	10 to 1000 times (under 85% of U_{Nom})	10 ms	1 Year	100%
Short Interruptions (≤ 3min)	10 ÷ 100 times (under 1% of U_{Nom})	10 ms	1 Year	100%
Accidental long interruptions (> 3min)	10 ÷ 50 times (under 1% of U_{Nom})	10 ms	1 Year	100%
Voltage unbalance u-	0 ÷ 2 %, occasionally 3%	10 min	1 Week	95%
Total harm. distortion, THD_U	8%	10 min	1 Week	95%
Harmonic Voltages, Uh_n	See Table 5.6	10 min	1 Week	95%

5.2.1 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 % (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.

5.2.2 Supply voltage variations

Under normal operating conditions, during each period of one week 95 % of the 10 min mean U_{Rms} values of the supply voltage shall be within the range of U_{Nom} ± 10 %, and all U_{Rms} values of the supply voltage shall be within the range of U_{Nom} + 10 % / - 15 %.

5.2.3 Voltage dips (Indicative 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 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_{Nom} can occur very frequently as a result of the switching of loads in network users' installations.

5.2.4 Short interruptions of the supply voltage

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.

5.2.5 Long interruptions of the supply voltage

Under normal operating conditions the annual frequency of accidental voltage interruptions longer than three minutes may be less than 10 or up to 50 depending on the area.

5.2.6 Supply voltage unbalance

Under normal operating conditions, during each period of one week, 95 % of the 10 min mean RMS 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.

5.2.7 THD voltage and harmonics

Under normal operating conditions, during each period of one week, 95 % of the 10 min mean values of each individual harmonic voltage shall be less or equal to the value given in table bellow.
Moreover, THD_U values of the supply voltage (including all harmonics up to the order 40) shall be less than or equal to 8 %.

Table 5.6: Values of individual harmonic voltages at the supply

Odd harmonics				**Even harmonics**	
Not Multiples of 3		**Multiples of 3**			
Order h	**Relative voltage (U_{Nom})**	**Order h**	**Relative voltage (U_{Nom})**	**Order h**	**Relative voltage (U_{Nom})**
5	6,0 %	3	5,0 %	2	2,0 %
7	5,0 %	9	1,5 %	4	1,0 %
11	3,5 %	15	0,5 %	6..24	0,5 %
13	3,0 %	21	0,5 %		
17	2,0 %				
19	1,5 %				
23	1,5 %				
25	1,5 %				

5.2.8 4.4.2 Flicker severity

Under normal operating conditions, in any period of one week the long term flicker severity caused by voltage fluctuation should be $P_{lt} \leq 1$ for 95 % of the time.

5.2.9 PowerQ4 recorder setting for EN 50160 survey

PowerQ4 is able to perform EN 50160 surveys on all values described in previous sections. In order to simplify procedure, PowerQ4 has predefined recorder configuration (EN510160) for it. By default all current parameters (RMS, THD, etc.) are also included in survey, which can provide additional survey information's. Additionally, user can during voltage quality survey simultaneously record other parameters too, such as power, energy and current harmonics.
In order to collect voltage events during recording, Include voltage events options in recorder should be enabled. See section 3.12.2 for voltage events settings.

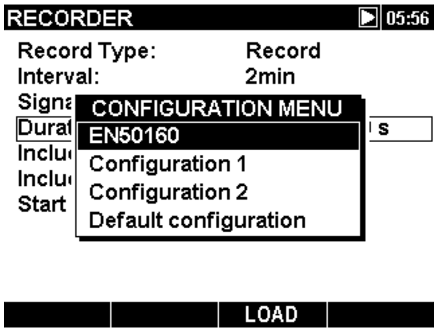


Figure 5.12: Predefined EN50160 recorder configuration

After recording is finished, EN 50160 survey is *performed* on PowerView software. See PowerView manual or details.

6 Technical specifications

6.1 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:	CAT IV 600 V / CAT III 1000 V
Protection degree:	IP 42
Dimensions:	(220 x 115 x 90) mm
Weight (without accessories):	0.65 kg
Display:	graphic liquid crystal display (LCD) with backlight, 320 x 200 dots.
Memory:	8 MB Flash
Batteries:	6 x 1.2 V NiMh rechargeable AA batteries Provide full operation for up to 15 hours*
External DC supply:	12 V, 1 A min
Maximum power consumption:	150 mA – without batteries 1 A – while charging batteries
Battery charging time:	4 hours *
Communication:	USB 1.0 – Standard USB Type B 2400 baud ÷ 921600 baud

RS-232	8 pin PS/2 – type 2400 baud ÷ 115200 baud

* The charging time and the operating hours are given for batteries with a nominal capacity of 2500mAh

6.2 Measurements

Note: In order to get resolution and accuracy specified in this section, measuring data should be observed by PowerView (Waveform Snapshoot or On-Line View). PowerQ4 display resolution is reduced due to screen space constraints and enhanced visibility of presented measurements (larger screen fonts and space between measurements).

6.2.1 General description

Max. input voltage (Phase – Neutral):	1000 V_{RMS}
Max. input voltage (Phase – Phase):	1730 V_{RMS}
Phase - Neutral input impedance:	6 MΩ
Phase – Phase input impedance:	6 MΩ
AD converter	16 bit 8 channels, simultaneous sampling
Reference temperature	23 °C ± 2 °C
Temperature influence	60 ppm/°C

NOTE: Instrument has 3 voltage ranges. Range has to be chosen according to the network nominal voltage, according to the table bellow.

Nominal phase voltage: U_{Nom}	Recommended Voltage range
50 V ÷ 110 V	Voltage Range 1: 50 V ÷ 110 V (L-N)
110 V ÷ 240 V	Voltage Range 2: 110 V ÷ 240 V (L-N)
240 V ÷ 1000 V	Voltage Range 3: 240 V ÷ 1000 V (L-N)

Nominal phase-to-phase voltage: U_{Nom}	Recommended Voltage range
86 V ÷ 190 V	Voltage Range 1: 89 V ÷ 190 V (L-L)
190 V ÷ 414 V	Voltage Range 2: 190 V ÷ 414 V (L-L)
415 V ÷ 1730 V	Voltage Range 3: 240 V ÷ 1730 V (L-L)

NOTE: Assure that all voltage clips are connected during measurement and logging period. Unconnected voltage clips are susceptible to EMI and can trigger false events. It is advisable to short them with instrument neutral voltage input.

6.2.2 Phase Voltages

***U_{pRms}*, p: [1, 2, 3, 4, N]**

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 20 V_{RMS} ÷ 150.0 V_{RMS}	10 mV	0.2 % U_{RMS}	1.5 min
Range 2: 50 V_{RMS} ÷ 360 V_{RMS}	100 mV		
Range 3: 200 V_{RMS} ÷ 1500 V_{RMS}			

***$U_{pRms(1/2)}$* p: [1, 2, 3, 4, N], AC+DC**

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 20 V_{RMS} ÷ 150.0 V_{RMS}	10 mV	0.5 %	

Range 2: 50 V_{RMS} ÷ 360 V_{RMS}		U_{RMS}	1.5 min
Range 3: 200 V_{RMS} ÷ 1500 V_{RMS}			

***Cf_{Up}*, p: [1, 2, 3, 4, N], AC+DC**

Measuring range	Resolution	Accuracy
1 ÷ 2.5	0.01	5% Cf_U

***U_{pPk}*: p: [1, 2, 3, 4, N], AC+DC**

Measuring range	Resolution	Accuracy
Range 1: 20 V ÷ 255 Vpk	100 mV	0.5 % U_{Pk}
Range 2: 50 V ÷ 510 Vpk		0.5 % U_{Pk}
Range 3: 200 V ÷ 2250 Vpk		0.5 % U_{Pk}

6.2.3 Line voltages

***U_{pgRms}*, pg: [12, 23, 31], AC+DC**

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 20 V_{RMS} ÷ 260 V_{RMS}	100 mV	0.25 % U_{RMS}	1.5 min
Range 2: 47 V_{RMS} ÷ 622 V_{RMS}			
Range 3: 346 V_{RMS} ÷ 2600 V_{RMS}			

***$U_{pRms(1/2)}$* pg: [12, 23, 31], AC+DC**

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 20 V_{RMS} ÷ 260 V_{RMS}	10 mV	0.5 % U_{RMS}	1.5 min
Range 2: 47 V_{RMS} ÷ 622 V_{RMS}			
Range 3: 346 V_{RMS} ÷ 2600 V_{RMS}			

***Cf_{Upg}*, pg: [12, 23, 31], AC+DC**

Measuring range	Resolution	Accuracy
1 ÷ 2.5	0.01	5% Cf_U

***U_{pgPk}*, pg: [12, 23, 31], AC+DC**

Measuring range	Resolution	Accuracy
Range 1: 20 V ÷ 442 Vpk	100 mV	0.5 % U_{Pk}
Range 2: 47 V ÷ 884 Vpk		
Range 3: 346V ÷ 3700 Vpk		

6.2.4 Current

Input impedance : 100 kΩ

***I_{pRms}*, p: [1, 2, 3, 4, N], AC+DC**

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 50.0 mV_{RMS} ÷ 200 mV_{RMS}	100 μV	0.25 %	1.5 min
Range 2: 50.0 mV_{RMS} ÷ 2 V_{RMS}		0.25 %	

Peak value I_{pPk}, I_{NPk}, p: [1, 2, 3, 4, N], AC+DC

Measuring range	Resolution	Accuracy
Range 1: 50 mV ÷ 280 mV_{RMS}	100 μV	2 %
Range 2: 50 mV ÷ 3 Vpk		2%

$I_{p½\ Rms}$, p: [1, 2, 3, 4, N], AC+DC

Measuring range	Resolution	Accuracy	Crest factor
Range 1: 20.0 mV_{RMS} ÷ 200 mV_{RMS}	100 μV	1 %	1.5 min
Range 2: 20.0 mV_{RMS} ÷ 2 V_{RMS}		1 %	

Crest factor Cf_{Ip} p: [1, 2, 3, 4, N], AC+DC

Measuring range	Resolution	Accuracy
1 ÷ 10	0.01	5 %

Current accuracy with clamps

Measurement accessory		Measuring range	Overall current accuracy
A 1033	1000 A	20 A ÷ 1000 A	1.3 %
A 1227	3000 A 300 A 30 A	300 A ÷ 6000 A 30 A ÷ 600 A 3 A ÷ 60 A	1.5 % 1.5 % 1.5 %
A 1122	5 A	100 mA ÷ 5 A	1.3 %

Note: Overall accuracy is calculated as:

$$SystemUncertainty = 1{,}15 \cdot \sqrt{PowerQ4Uncertainty^2 + ClampUncertainty^2}$$

6.2.5 Frequency

Measuring range	Resolution	Accuracy
10.00 Hz ÷ 70.00 Hz	2 mHz	± 10 mHz

6.2.6 Flickermeter

Fl. Type	Measuring range	Resolution	Accuracy*
P_{lt1min}	0.4 ÷ 4	0.001	5 % P_{lt1min}
P_{st}	0.4 ÷ 4	0.001	5 % P_{st}
P_{lt}	0.4 ÷ 4	0.001	5 % P_{lt}

* Guaranteed only in 49 ÷ 51Hz frequency range

6.2.7 Power

		Measuring range (W, VAr, VA)	Resolution	Accuracy
Active power P*	Excluding clamps	0.000 k ÷ 999.9 M	4 digits	± 0.5 %
	With A 1227 Flex clamps 3000A	0.000 k ÷ 999.9k		± 1.5 %
	With A 1033 1000 A	000.0 k ÷ 999.9 k		± 1.3 %
po we	Excluding clamps	0.000 k ÷ 999.9 M	4 digits	± 0.5 %

	With A 1227 Flex clamps	0.000 k ÷ 999.9k		± 1.5 %
	With A 1033 1000 A	000.0 k ÷ 999.9 k		± 1.3 %
Apparent power S***	Excluding clamps	0.000 k ÷ 999.9 M	4 digits	± 0.5 %
	With A 1227 Flex clamps	0.000 k ÷ 999.9k		± 1.5 %
	With A 1033 1000 A	000.0 k ÷ 999.9 k		± 1.3 %

**Accuracy values are valid if cos φ ≥ 0.80, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*
***Accuracy values are valid if sin φ ≥ 0.50, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*
****Accuracy values are valid if cos φ ≥ 0.50, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*

6.2.8 Power factor (Pf)

Measuring range	Resolution	Accuracy
-1.00 ÷ 1.00	0.01	±0.02

6.2.9 Displacement factor (Cos φ)

Measuring range	Resolution	Accuracy
0.00 ÷ 1.00	0.01	±0.02

6.2.10 Energy

		Measuring range (Wh, VArh, VAh)	Resolution	Accuracy
Active energy eP*	Excluding clamps	1 ÷ 9 G	12 digits	± 0.5 %
	With A 1227 Flex clamps	1 ÷ 9 G		± 1.4 %
	With A 1033 1000 A	1 ÷ 9 G		± 1.3 %
Reactive power eQ**	Excluding clamps	1 ÷ 9 G	12 digits	± 0.5 %
	With A 1227 Flex clamps	1 ÷ 9 G		± 1.4 %
	With A 1033 1000 A	1 ÷ 9 G		± 1.3 %
Apparent energy eS***	Excluding clamps	1 ÷ 9 G	12 digits	± 0.5 %
	With A 1227 Flex clamps	1 ÷ 9 G		± 1.4 %
	With A 1033 1000 A	1 ÷ 9 G		± 1.3 %

**Accuracy values are valid if cos φ ≥ 0.80, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*
***Accuracy values are valid if sin φ ≥ 0.50, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*
****Accuracy values are valid if cos φ ≥ 0.50, I ≥ 10 % I_{Nom} and U ≥ 80 % U_{Nom}*

6.2.11 Voltage harmonics and THD

Measuring range	Resolution	Accuracy
Uh_N < 3 % U_{Nom}	10 mV	0.15 % U_{Nom}
3 % U_{Nom} < Uh_N < 20 % U_{Nom}	10 mV	5 % Uh_N

U_{Nom}: nominal voltage (RMS)
Uh_N: measured harmonic current
n: harmonic component 1^{st} ÷ 50^{th}

Measuring range	Resolution	Accuracy
0 % U_{Nom} < THD_U < 20 % U_{Nom}	0,1 %	± 0.3

U_{Nom}: nominal voltage (RMS)

6.2.12 Current harmonics and THD

Measuring range	Resolution	Accuracy
Ih_n < 10 % I_{Nom}	10 mV	0.15 % I_{Nom}
10 % I_{Nom} < Ih_n < 100 %	10 mV	5 % Ih_N

I_{Nom}: Nominal current (RMS)
Ih_N: measured harmonic current
n: harmonic component 1^{st} ÷ 50^{th}

Measuring range	Resolution	Accuracy
0 % I_{Nom} < THD_I < 100 % I_{Nom}	0,1 %	± 0.6
100 % I_{Nom} < THD_I < 200 % I_{Nom}	0,1 %	± 1.5

I_{Nom}: Nominal current (RMS)

6.2.13 Unbalance

	Unbalance range	Resolution	Accuracy
u^- u^0	0.5 % ÷ 5.0 %	0.1 %	0.15 %
i^- i^0	0.0 % ÷ 17 %	0.1 %	1%

6.2.14 Time and duration uncertainty

Real time clock (RTC) uncertainty

Operating range	Accuracy	
-20 °C ÷ +70 °C	± 3.5 ppm	0.3 sec per day
0 °C ÷ +40 °C	± 2.0 ppm	0.17 sec per day

Event duration and recorder time-stamp and uncertainty

	Measuring Range	Resolution	Error
Event Duration	30 ms ÷ 7 days	1msec	± 1 cycle

6.3 Standards compliance

6.3.1 Compliance to the IEC 61557-12

General and essential characteristic

Power quality assessment function	-S	
Classification according to 4.3	SD	Indirect current and direct voltage measurement
	SS	Indirect current and indirect voltage measurement
Temperature	K50	
Humidity + altitude	Standard	

Measurement characteristic

Function symbols	Class according to IEC 61557-12	Measuring range	Measuring method IEC 61000-4-30 Class
P	1	5 % ÷ 200% I_{Nom} (1)	
Q	1	5 % ÷ 200% I_{Nom} (1)	
S	1	5 % ÷ 200% I_{Nom} (1)	
eP	1	5 % ÷ 200% I_{Nom} (1)	
eQ	2	5 % ÷ 200% I_{Nom} (1)	
eS	1	5 % ÷ 200% I_{Nom} (1)	
PF	0.5	- 1 ÷ 1	
f	0.02	10 Hz ÷ 70 Hz	S
I, I_N	0.5	5 % I_{Nom} ÷ 200 % I_{Nom}	S
U	0.2	20 V ÷ 1000 V	S
P_{st},P_{lt}	5	0.4 ÷ 4	S
U_{dip}, U_{swl}	0.5	5 V ÷ 1500 V	S
U_{int}	0.5	0 V ÷ 100 V	A
u^-, u^0	0.2	0.5 % ÷ 17 %	A
Uh_n	1	0 % ÷ 20 % U_{Nom}	S
THD_u	1	0 % ÷ 20 % U_{Nom}	S
Ih_n	1	0 % ÷ 100 % I_{Nom}	A
THD_i	2	0 % ÷ 100 % I_{Nom}	A

(1) - Measurement range depends on current sensor. However according to the IEC 61557-12, if current sensor has I_{Nom} defined as $I_{Nom} = k \cdot$ A/V, then measurement range is: 2 % I_{Nom} ÷ 200 % I_{Nom}.

6.3.2 Compliance to the to the IEC 61000-4-30

IEC 61000-4-30 Section and Parameter	PowerQ4 Parameter	Class	Measurement Method - IEC 61000-4-30 Section	Uncertainty	Measuring range[1]	Influence Quantity range[2]	Aggregation Method [3]
5.1 Frequency	freq	S	5.1.1	±10 mHz	10 Hz ~ 70 Hz	40 Hz ÷ 70 Hz	Arithmetic
5.2 Magnitude of the Supply	U_{Rms}	S	5.2.1	±0.5 % of U_{Nom}	10 %~150 % U_{Nom}	10 %~150 % U_{Nom}	RMS
5.3 Flicker	P_{st}	S	5.3.1	5 %[4]	0.4 ~ 4.0	0 ~ 10	IEC 61000-4-15
5.4 Dips and Swells	U_{Dip}, U_{Swell} duration	S	5.4.1	0.5 % ± 1 cycle	> 10 % U_{Nom} 1.5 cycle ~ 7 days	–	–
5.5 Interruptions	U_{Int} duration	S	5.4.1	0.5 % ± 1 cycle	< 150 % U_{Nom} 1.5cycle ~ 7 days	–	–
5.7 Unbalance	u^{-}, u^{0}	A	5.7.1	±0.15 %	0.5 % ~5 %	0 % ~ 5 %	RMS
5.8 Voltage Harmonics	Uh_N	S	5.8.1	IEC 61000-4-7 Class II	0 % ÷ 20 % U_{Nom}	0 % ÷ 20 % U_{Nom}	RMS
A.6.3 Magnitude of the current	I_{Rms}	S	A.6.3.1	0.5 %	2 % ÷ 200 % I_{Nom}	2 % ÷ 200 % I_{Nom}	RMS
A.6.4 Harmonic currents	Ih_n	A	A.6.5	IEC 61000-4-7 Class II	0 % ÷ 40 % I_{Nom}	0 % ÷ 40 % I_{Nom}	RMS
A.6.4 Inrush current	$I_{½Rms}$	S	A.6.4.1	1 %	2 % ÷ 200 % I_{Nom}	–	–

(1) The instrument meets the uncertainty requirements for signals within the measuring range.
(2) The instrument tolerate signals in the influence quantity range without shifting the measurement of other parameters out of their uncertainty requirement, and without instrument damage.
(3) RMS aggregation according to the IEC 61000-4-30 section 4.4 and 4.5, Arithmetic according to the section 5.1.13 in this manual.
(4) Guaranteed only in 49 ÷ 51Hz frequency range

6.4 Maintenance

6.4.1 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).

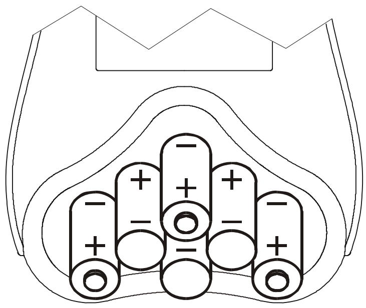


Figure 6.1: Battery placement

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

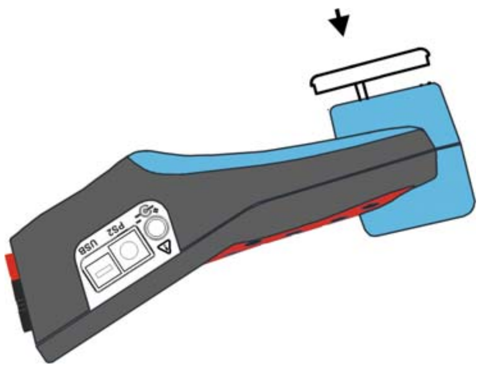


Figure 6.2: Closing the battery holder

4. Screw the cover on the instrument.

If the instrument is not going 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. 15 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 2500 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 24 hours before switching on the instrument.**

6.4.2 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
- 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.

6.4.3 Power supply considerations

⚠ **Warnings**

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

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 4 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 2 minutes, time and date settings are reset.

6.4.4 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!**

6.4.5 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.

6.4.6 Service

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

6.4.7 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